ESSAYS ON U.S. ENERGY REGULATION

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ABSTRACT

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Chapter 1: Workable Competition and Allocative Efficiency in Deregulated U.S. Petroleum Pipeline Markets

Since 1990, the Federal Energy Regulatory Commission (FERC) has quietly and gradually removed price controls from oil pipeline segments through its "market-based rate" program. Outside of individual rate cases, the FERC has not reviewed the success of this program in terms of efficiency improvement. I argue that, despite the lack of quantity data, market power and efficiency in transportation markets can be detected using available commodity price and sales data. Using a novel dataset linking oil pipeline rates and services to wholesale refined products prices, I study (1) the rate effects of oil pipeline deregulation, (2) whether deregulated pipelines exercise market power, and (3) whether deregulated rate signals result in improved allocative efficiency on deregulated lines. I find that deregulated carriers gradually increased rates up to 10 percent, or an average 5.7 percent, over the first five years. However, because commodity prices remained constant and sales increased in destination markets, the higher rates do not lead to the conclusion that firms set their deregulated rates supracompetitively. Instead, I offer evidence that rate deregulation led to efficiency improvement by allowing more higher-valued commodities to pass through the capacity constrained pipeline network in both Chicago and the broader U.S. pipeline market.

Chapter 2: Spillovers of Mixed Regulation: Evidence from U.S. Petroleum Pipeline Markets

U.S. regulatory policy of oil pipeline markets produces mixed markets where regulated firms compete with unregulated firms. In this paper, I present a novel 35-year monthly panel of pipeline services including commodity-specific refined products consumption, refinery production, and waterborne movements. Using these data, I analyze two types of spillovers in partially regu-

lated pipeline markets: spillovers within firm and spillovers across firms. I find when capacity-constrained firms are only partially deregulated, they set rates above the competitive level. Similarly, when deregulated firms compete against regulated firms, they can monopolize residual capacity in the market and reduce market efficiency.

Chapter 3: Regulatory Threat Under Administrative Litigation

Though firm behavior under price regulation has been studied extensively in economics, law, and policy, few opportunities arise to study firm behavior under just the *threat* of such regulation, a potentially effective force alone. This paper extends the Glazer and McMillan (1992) model of regulatory threat to the administrative litigation setting where bureaucratic commissioners, not legislators, decide whether to regulate rates of service providers in disputes between stakeholding parties. I find that firms should decrease their rates when they believe their regulators would rule against them in a complaint case. I empirically test the predictions of this model using FERC's 2012 challenge to deregulated rates, a perceived shift in its regulatory stance, but find that firms appear to increase prices in their most vulnerable markets.

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KEY TO ABBREVIATIONS

BEA Bureau of Economic Analysis (Areas)

BTS Bureau of Transportation Statistics

COS Cost of Service

DID Difference-in-Differences

DOJ Department of Justice

EIA Energy Information Administration

FERC Federal Energy Regulatory Commission

HHI Herfindahl–Hirschman Index

ICC Interstate Commerce Commission

MBR Market-based Rate

PADD Petroleum Administration for Defense Districts

SEDS State Energy Data System

TWFE Two-way Fixed Effects

USACE U.S. Army Corps of Engineers

CHAPTER 1

WORKABLE COMPETITION AND ALLOCATIVE EFFICIENCY IN DEREGULATED U.S. PETROLEUM PIPELINE MARKETS

1.1 Introduction

Price ceilings are set to correct inefficiencies in monopolistic or oligopolistic markets. Though never perfect, when markets are "workably" competitive (Clark, 1940), price caps can produce welfare losses of their own through both sub-optimal supply and allocative inefficiencies, where market signals are suppressed resulting in lower-valued consumers receiving services in lieu of high-valued consumers (Friedman and Stigler, 1946; Weitzman, 1977). Once relaxed, flexible pricing can produce a wide array of efficiency effects, varying based on industry, time and market concentration, among other factors. Countless studies have evaluated the effects of price regulation in many industries including airlines, natural gas markets, electricity, trucking, railroads, insurance, banking (e.g. Joskow and Rose, 1989; Winston, 1993; Peltzman and Winston, 2000), and, most popularly, in rental housing markets (e.g. Olsen, 1972). More recent empirical studies have emphasized the importance of the allocative inefficiencies associated with price controls (Davis and Kilian, 2011; Glaeser and Luttmer, 2003). This paper analyzes both competitive and allocative inefficiencies in the U.S. petroleum pipeline industry, which has been gradually transitioning toward deregulation since 1990.

In an effort to reduce regulatory costs and allow for "lighter-handed" regulation of sufficiently competitive markets, the Federal Energy Regulatory Commission (FERC) instituted a program whereby pipeline companies, called "carriers", could apply to have price controls removed from services in markets where they demonstrably lack market power. Over the first twenty years of FERC's "market-based rates" program, approximately one quarter of all carriers have applied to remove price ceilings from their services in more than 100 regional markets across the United States. Recent protests of two major U.S. carriers have introduced doubt as to whether deregulation was appropriate for certain pipeline services. However, FERC has not yet reviewed the efficacy of this program outside of individual protests despite the recent complaints. This is likely due to the prohibition of carrier-specific quantity data stipulated by the Interstate Commerce Act (ICA). To overcome this limitation, I argue that market power and welfare gains can be evaluated using publicly available price data. Using only price and market-level quantity data, I construct a comprehensive analysis of the long-run consequences of FERC's market-based rate program and characterize its welfare effects.

Specifically, I ask three questions. The first is whether transportation (tariff) rates rise or fall after deregulation. Given that regulated rates are price ceilings and carriers must incur some cost to remove them, I expect carriers to increase rates following deregulation. My second question regards market power — should these pipelines have been deregulated? Price ceilings impose inefficiencies when the quantity supplied falls below efficient levels. Reinstating the price signal in a "workably" competitive market should align supply and demand to clear the market and maximize efficiency. If, however, the market is monopolistic, the price may drastically rise such that, now, it is the quantity demanded that falls below competitive levels. Without quantity and cost data, this is difficult to analyze. However, pipelines play a vital role in distributing petroleum products across the country, dominating all other transportation alternatives for refined products. Should a deregulated carrier exercise market power, either by limiting capacity or increasing its rates, I show the lower supply to the destination market will cause commodity prices in that market to increase, inflating price differentials. Thus, despite increasing their rates, the effect on price differentials should indicate whether a carrier is doing so as an exercise of market power.

The final question regards allocative inefficiency. Price signals play a role not only in quantities transacted, but also the quality of those transactions. When set too low, rates invite market participants with lower values who might receive the good over higher-valued consumers. This *allocative* inefficiency is a lesser-studied welfare effect of price ceilings, though its policy relevance as a measure of distributional effects was highlighted in Davis and Kilian (2011). Their study of allocative costs in deregulated residential natural gas markets relies on demand estimation, which in turn relies on quantity or market share data. Although these data do not exist for U.S. pipeline markets, I argue one can infer changes in allocative efficiency from commodity price effects of deregulation. Because pipelines capture arbitrage opportunities, the value of their services is tied to the commodity price differentials between the markets they connect. When different commodities flow through the same pipelines, capacity allocation should reflect the relative commodity price differences between markets. Unregulated carriers can adjust rates to allocate capacity efficiently such that higher-valued commodities (i.e., those with higher price differentials) are allocated more capacity than lower-valued commodities. Thus, regional price differentials for all transported commodities should be equal in an efficient market. When regulatory rate caps are imposed, however, pipeline rates cannot be conductors of efficient allocation.

I attempt to answer these questions using the Chicago export market, where services from multiple carriers were deregulated between 1990 and 2002, as a case study. Using a proprietary database of FERC tariff sheets, I compile a monthly panel from 1986 to 2007 of historical pipeline services for exporting refined products out of Chicago. I then link these data to state-level commodity prices from the Energy Information Administration (EIA). By exploiting the variation in treatment timing, I estimate the effect of deregulation on pipeline rates and commodity price differentials using a staggered, dynamic difference-in-differences (DID) design. To measure allocative efficiency, for which I do not require tariff rates, I conduct a nationwide study of heterogeneous price effects of deregulation from 1986 to 2019 using data described in Terkelsen (2021a).

I find that deregulated carriers gradually increased rates up to 10 percent, or an average 5.7 percent, over the first five years. However, because commodity prices remained constant and sales quantities increased in destination markets, the higher rates do not lead to the conclusion that firms set their deregulated rates supracompetitively. Instead, I offer evidence that rate deregulation led to efficiency improvement by allowing higher-valued commodities over lower-valued commodities to pass through the capacity constrained pipeline network.

As the first empirical evaluation of FERC oil pipeline regulation, this paper revives a sparse literature on U.S. oil infrastructure regulation. Though little has been written reflectively on FERC pipeline regulation, prospective research on the subject was relatively active in the late 1970s to early 1980s likely in response to the Department of Justice's (DOJ) interest in oil pipeline reform. The only peer-reviewed research on the topic is Navarro et al. (1981), which highlights the inefficiency of various utility-type cost-based ratemaking formulas considered at the FERC, demonstrating theoretically that all exhibit intertemporal bias and generate returns that do not match those allowed by the regulator. In his book, Hansen (1983) provides a comprehensive industry snapshot based on 1977 ICC data wherein he characterizes pipeline markets in the same manner that I do in this paper (i.e., as separate origin and destination markets rather than routes). He argues that, because refined products prices were not controlled by imports in the same manner as domestic crude, refined products carriers had considerable influence over commodity prices, potentially leading to collusion regardless of how "workably competitive" the market appeared. Though nearly all researchers called for more empirical work on pipeline regulation at the time, it appears academic interest faded after the DOJ issued its report on pipeline deregulation recommending that nearly all U.S. pipelines be deregulated (Department of Justice, 1986). Since the establishment of FERC's market-based rates program in 1990, there have been no academic studies of U.S. oil pipeline regulation.

This paper also contributes to the vast empirical economic literature on the widescale regulatory reforms that characterized U.S. economic policy in the 1970's and '80s. However, this is the first to evaluate oil pipeline reforms. Countless papers have been published on both federal and state price deregulation of railroads (Levin, 1981; Boyer, 1987), airlines (Keeler, 1972), trucking (Moore, 1978), and other industries. Comprehensive literature reviews on the consequences of regulation and deregulation show that, despite the theoretical predictions that inefficiencies would vanish and rents for those benefiting from regulation would dissolve, deregulated markets proved to not be as competitive as their theoretical benchmarks (Winston, 1993; Peltzman and Winston, 2000). Joskow and Rose (1989) observes that measured price effects varied widely across industry, time, and methodology. In addition, Joskow (2005) analyzes the research methods used in such studies since the 1980s, encouraging reliance on structural models and continued research on recently deregulated industries.

More recently, economists have turned to studying market power in once regulated industries. Energy by rail has been a popular topic. Busse and Keohane (2007) find evidence of price discrimination in coal-by-rail on the basis of environmental regulation and geographic location using a DID approach to estimate how delivered prices respond to the staggered implementation of a sulfur dioxide emissions trading program. Similarly, Preonas (2019) estimates how changes in coal demand, measured using changes in competing alternative natural gas prices, affect coal-by-rail price markups using a matched DID design. Both studies use delivered prices (origin commodity price plus transportation cost) as the dependent variable to measure changes in markups. There has also been recent work on crude oil pipelines, which has dealt with demand for capacity expansion in the western crude oil pipeline network. Covert and Kellogg (2018) provide evidence that the option value of crude-by-rail has delayed expansion of much needed pipeline capacity out of the oil-rich northwestern United Status using a structural estimation of demand over destination markets. McRae (2018) measures the effect of crude infrastructure expansion on price differentials, demonstrating the increased capacity closed the gap between the world price and local markets using state-level prices. An earlier paper also observed inefficiencies from vertically integrated pipelines in the form of a delayed reversal of a line to benefit an affiliate refiner (McRae, 2015).

The next section characterizes petroleum pipeline markets and describes their regulation at the federal level, including details of the specific deregulation policy I study, called "market-based rates" (MBRs), and their history in Chicago. Section 1.3 describes the theory underlying the expected effects of pipeline deregulation, as well as the evidence that would distinguish a monopolist from a competitive firm. Sections 1.4 through 1.6 discuss the data, empirical strategy, and results.

1.2 Petroleum Pipeline Primer

Petroleum pipelines are a 200,000 mile system of mostly underground tubes that carry oil across the country. The industry is divided into two main services: crude transportation and refined products transportation.[1] Throughout my paper I will refer to a pipeline company as a "carrier," a pipeline customer as a "shipper," and a carrier's transportation of specific product(s) from an origin to a destination as a "service." For reasons I discuss below, my paper focuses on refined products pipelines, which mainly transport motor gasoline, jet fuel, diesel (distillate), and a variety of other energy and non-energy petrochemicals.

A pipeline transaction proceeds as follows. A shipper, regardless of affiliate status, will "nominate" or request volumes on a pipeline at least one month in advance of shipment. The carrier will then examine all nominations and schedule the shipments. Unlike natural gas or electricity, refined products are shipped in batches associated with the owner of the oil such that the barrels injected into a pipeline are the same barrels extracted from the other end. One exception is the *Williams Pipe Line Company* (now *Magellan*), which utilizes a banking system where shippers can avoid the usual waiting period for products to ship through the pipeline and instead extract from storage at the destination the very same day. Regardless of actual transportation, batching ensures that commodities are not contaminated or "intermixed" when shipping a variety of types. If a pipeline's nominations exceed its capacity, the carrier will then prorate the nominations in a proportional manner.[2]

My study is restricted to only refined products for four key reasons. First, while crude is a single commodity that feeds into refineries,[3] refined products pipelines serve a variety of commodity markets such as gasoline, distillate (diesel), kerosene, jet fuel, and even non-energy commodities such as plastics used in the manufacturing of carpet fibers. Because short run pipeline operations

[1] Some, though very few, are capable of shipping both crude and refined products. "Refined products" typically include finished motor gasoline, aviation gasoline, kerosene-type jet fuel, kerosene, and distillates. Natural gas liquids (e.g., ethane, propane, butanes), liquefied petroleum gas (or condensate), and intermediate petroleum products (e.g., distillation outputs) are also sometimes categorized as refined products, but are not addressed in this paper.

[2] This is true for all regulated and "deregulated" pipelines under FERC's purview. There are various carrier-specific policies to mitigate gaming of the prorationing system, including penalties for unshipped nominations, verification procedures, and weighting prorated capacity by customers' historical shipments.

[3] There is some variation within crude oil depending on its chemical properties, but its end-use is singular.

are constrained by their capacity, how capacity is allocated to these different commodities presents an interesting economic outcome of rate regulation. Second, deregulation of refined products carriers has been much swifter than for crude pipelines. Several crude pipeline applications have been appealed to district courts, their decisions pending for years. In comparison, all refined products approvals have been resolved at the FERC, spanning far fewer months. Third, the refined products network in the Midwest has remained relatively unchanged in the last three decades. Barring several changes in ownership and refinery shutdowns, the Chicago pipeline infrastructure experienced little alteration over my study period. Finally, refined products are not benchmarked to world prices like crude oil. This gives refined products pipelines significantly more potential to influence commodity prices and to exercise market power in local markets, should they possess it. Furthermore, my study area is particularly situated to ensure the dependency of commodity prices on pipeline capacity because it is landlocked (apart from the Great Lakes).

1.2.1 Refined Products Market Structure

Rather than being a *route* from regional market *A* to market *B*, a pipeline is instead considered a *receiver* of product at origin *A* and a *deliverer* of product at destination *B* (Hansen, 1983). Current precedent has defined *A* and *B* not as points, but as large geographic areas composed of counties surrounding a major city.[4] This divides the industry into two markets: (1) *refined products origin markets* in which products pipelines compete with local consumers and waterborne transportation to receive refined petroleum products produced by local refiners, and (2) *refined products destination markets* in which products pipelines compete with local refiners and waterborne transportation to deliver product to local marketers or end-users.

In addition to competition with the above-listed alternatives, pipelines may also compete with product exchanges in which oil companies agree to transfer ownership of their product without transporting it. While pipeline tariffs have anecdotally been shown to influence exchange rates,

[4]The FERC has historically used Bureau of Economic Analysis Economic Areas (BEAs), which were revised in 2004 and are now discontinued in favor of Metropolitan Statistical Areas (MSAs).

these transactions are not typically captured in market analyses submitted to or considered by the FERC. For this reason, and because the data are not available, my analysis also ignores the presence of exchanges.

1.2.2 Regulatory Framework

The Hepburn Act of 1906 brought regulation of interstate oil pipelines under the Interstate Commerce Commission (ICC), which was originally formed to regulate railroads. This power was then transferred to the FERC in 1977, where it remains today. Pipelines are classified as interstate if the "fixed and persistent transportation intent" of the barrel is across state lines (Brose, 2014). This means service *within* a state may fall under federal jurisdiction if it serves as a segment of a longer, cross-state shipment. Jurisdictional matters are still disputed before FERC, which has developed strict guidelines for determining the shippers' intent and the correct classification of inter- or intra-state services, which fall under the jurisdiction of state regulatory commissions.

1.2.3 Market-Based Rates

Market-based rates (MBRs) are a form of deregulation authorized by FERC for select carriers and markets. The stated intent of the policy is to allow pipelines that operate in competitive markets to charge rates that change with market conditions. MBRs are not, however, *complete* deregulation in that rates must be published on tariff sheets issued one month before they take effect, and all rates are still subject to non-discrimination policies. The FERC method for authorizing MBRs involves an application process through which a carrier may request a determination on market power (i.e., a formal declaration that the carrier does not possess market power) in its origin and destination markets. Currently, applications must specify all commodity markets, geographic origin markets, and destination markets for which it is requesting individual market power determinations.[5] If a carrier is found to lack market power in both its commodity-origin market and commodity-

[5]Originally only the competitive nature of destination markets were considered in applications. BEA Economic Areas (BEAs) were widely utilized and accepted as geographic market definitions.

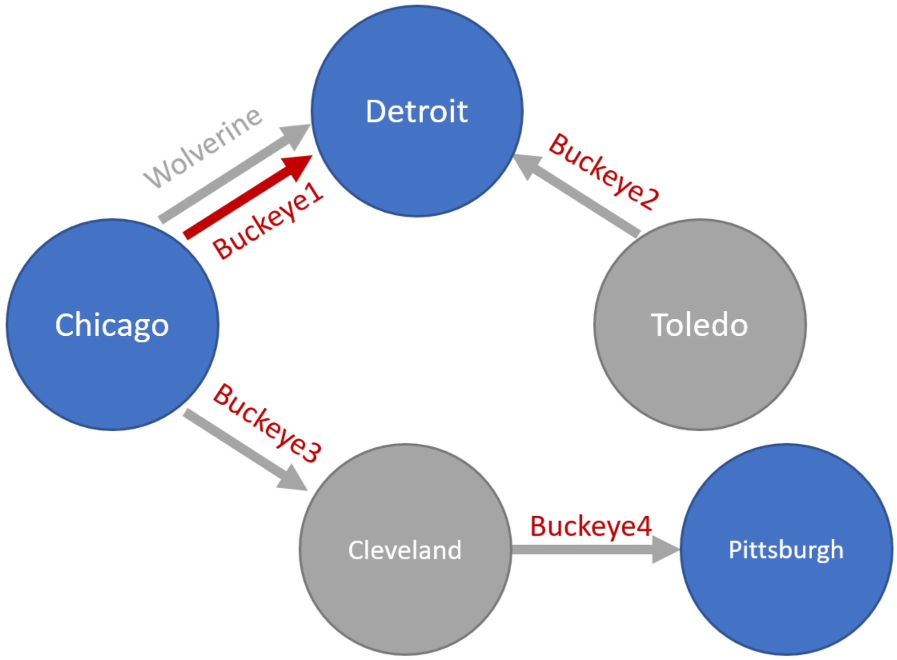
destination market, it is permitted to charge MBRs for its services *between* those markets. In refined products markets, carriers typically request permission and are granted MBRs for "all pipelineable refined petroleum products" so that all commodities are deregulated simultaneously.[6]

Consider the following example (refer to Figure 1.1). Say Buckeye, owner and operator of four pipelines shown below, was approved for market-based rates in the Chicago origin and the Detroit and Pittsburgh destination markets (in blue), but not for the Toledo origin market or Cleveland destination market (in grey). Then, the red pipeline connecting Chicago to Detroit would be approved for market-based rates and deregulated. However, Buckeye's line to Cleveland, even though it originates in an approved origin market, would not be deregulated because it is destined for an unapproved destination market. Likewise, Buckeye's line originating in Toledo is destined for an approved destination market, but would not be deregulated because it originates in an unapproved origin market. If Cleveland were en route to Pittsburgh, Buckeye3 would still remain regulated for service between Chicago and Cleveland even though it is a segment of a deregulated service. Finally, another pipeline linking Chicago and Detroit, which is owned by Wolverine, would not be deregulated even though it operates in the same approved markets as Buckeye1. To obtain market-based rates authority, it must submit its own application for these markets.

As with any litigated process, the requirements to obtain MBRs has transformed over the years, resulting in a fluctuating threshold of competitiveness for MBR approval. The current application process requires eight "statements" that define the geographic and commodity markets, identify those markets' immediate and potential alternatives, and calculate market concentration statistics. If an application or a set of specific markets within the application is not protested within a specified time frame, it is approved without contest. However, if an application is protested either in whole or in part, then the case is set for what is often a long and expensive administrative hearing on the protested markets. Some cases end in settlement, in which requests for certain markets or certain parts of markets are withdrawn, but many cases end with a FERC order that establishes new precedent, grants MBRs for at least some markets and rejects others. I am not aware of any cases

[6]The one exception to this is the 2013 Buckeye case where aviation fuels were excluded from the application following settlement.

Figure 1.1: MBR Diagram



in which applications have been wholly rejected.

This paper comes at a time when MBRs are under administrative review at the FERC. Only in recent years has MBR authority been re-examined and, in the case of two *Buckeye Pipe Line Company* markets, revoked by the FERC in Opinion No. 558. Presently before the FERC is a complaint against Colonial Pipeline, the largest refined products system in the United States. (Kelly, 2018).[7] This case will be only the second administrative review of previously granted MBRs.

1.3 Theoretical Framework

Economic regulation of natural monopolies exists to mitigate potential efficiency loss from monopolistic or monopsonistic behavior. When a natural monopoly becomes a natural *oligopoly*, as is the case in many oil pipeline markets, the fear of collusion justifies continued regulation. In the oil pipeline regulatory regime, deregulation is granted on the basis of operating in workably competitive markets. However, once a pipeline has been deregulated, there has been effectively

[7]Colonial Pipeline is one of the only five pipelines recommended by the DOJ to remain under federal regulation.

no academic or, with some exception, administrative review of subsequent firm behavior, and the *prediction* of a workably competitive market remains just that: prediction.

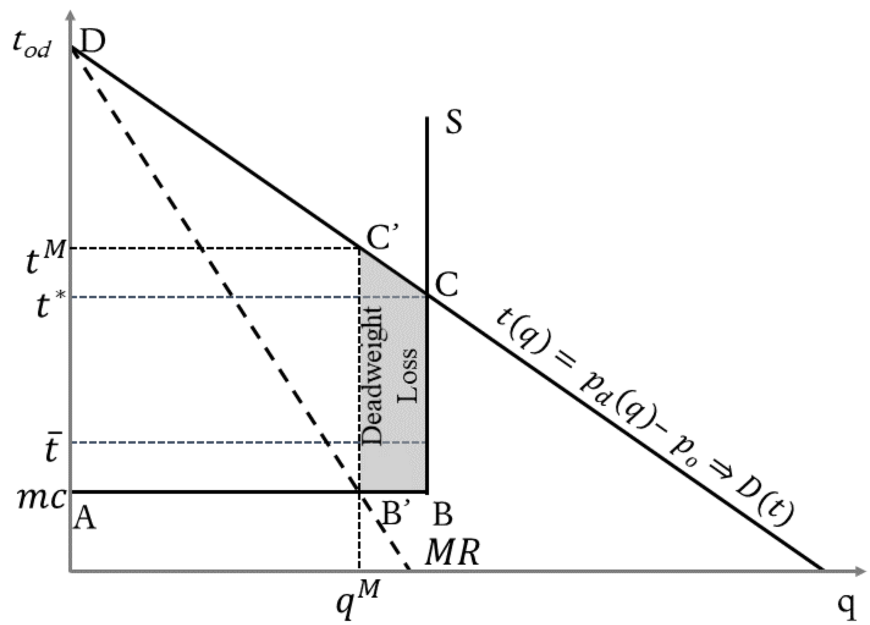
In a pipeline origin market, refiners or resellers ("shippers") of refined products demand outbound transportation from pipelines or waterborne alternatives. Considering the number of carriers that have been granted unprotested MBR authority on service out of the Chicago origin market, I assume the origin market in this case to be competitive. The key implication of this assumption is that pipeline rates do not influence local commodity prices at the origin. In addition, I assume shippers have no preference over mode of transportation or destination. The *netback* price, defined as the commodity price at the destination minus the transportation cost, is a shipper's only consideration when choosing among alternatives. In this sense, pipelines are differentiated only by the commodity prices at their destinations. This gives the inverse demand for an individual pipeline of $t(q) = p_d(q) - p_o$, where $p_d(\cdot)$ is the inverse commodity demand at the destination and p_o is the opportunity cost of shipping the barrel, as measured by the fixed commodity price at the origin. Note that I use t for transportation price and p for commodity price. I invert $t(q)$ to obtain transportation demand function $D(t)$.

One should expect deregulated pipeline rates to increase, not only because regulated rates function as price ceilings but also because pipelines must incur substantial costs to *request* deregulation, or MBRs. There exist plausible reasons for why such circumstances might produce lower deregulated rates, such as carriers preferring the one-time expense of obtaining MBRs to regularly incurring the costs of increasing rates through cost-of-service filings. Indeed several deregulated industries saw decreases in their unconstrained rates (Joskow and Rose, 1989). However, this does not appear to be the case for oil pipelines, at least not in the Chicago market. Thus, I consider only commodity price and welfare effects of increased rates.

Assuming rates rise, I can use commodity price differentials between the connected markets to determine if the increases are due to competitive or monopolistic behavior. Because I fix the origin, the price differential can be simplified to just the destination price. Consider Figure 1.2 below, which depicts the market for capacity constrained pipeline service to destination market d. Let $\bar{t}$

be the regulated price, set anywhere between marginal cost (mc) and t^*, the competitive price.

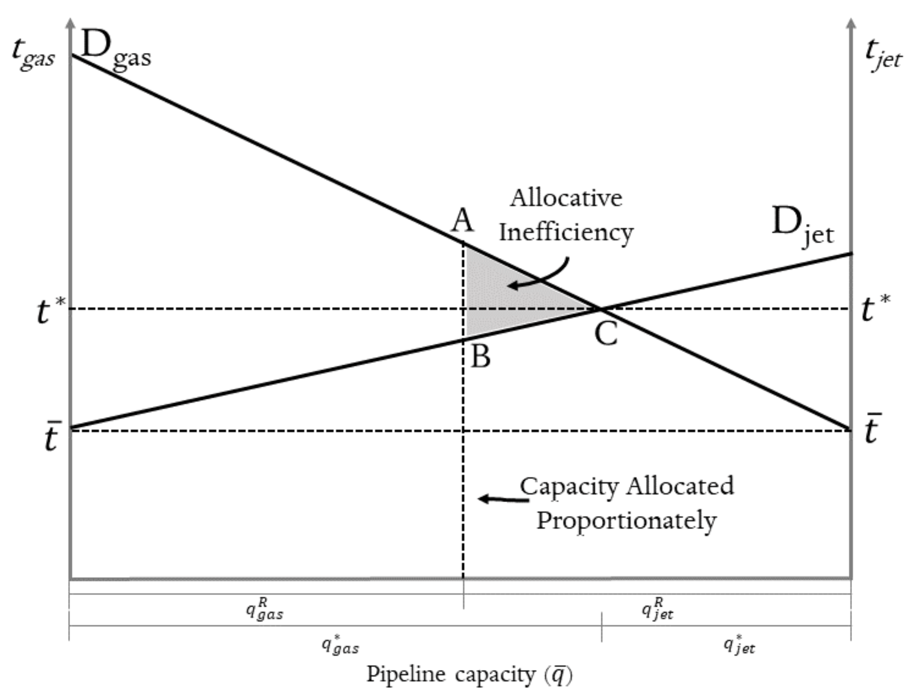
Figure 1.2: Market for Transportation to Destination Market



At the regulated price, total surplus is represented by the $ABCD$ polygon, with the area below $\bar{t}$ representing the carrier's share. In addition, the commodity price in the destination market is $p_d(k)$. I define a *competitive* pipeline as one with either competing alternatives to the same destination market or to comparable destination markets such that increasing rates above competitive levels will result in loss of market share. In this way, it behaves in accord the the Bertrand-Edgeworth oligopoly model under random proportional rationing (Tirole, 1988). Once deregulated, a competitive pipeline would price such that $D(t^*) = k$, where k is capacity. In this scenario, the total surplus remains unchanged from pre-deregulation levels, but the carriers' share increases. In addition, the destination commodity price does not change. Finally, a purely monopolistic pipeline would set its price at t^M such that its marginal revenue meets marginal cost (or capacity constraint). The total surplus shrinks to $AB'C'D$, resulting in a deadweight loss of $B'BCC'$, and the destination commodity price grows to $p_d(q^M) > p_d(k)$. Of course, a pipeline may price in the range of rates between t^* and t^M, depending on the competitiveness of the market. The more concentrated, the greater the destination commodity price is relative to the regulated commodity price.

While there is no change in total surplus between competitive and regulated markets due to capacity constraints when assuming homogeneous products, product heterogeneity, which exists in this setting, requires efficiency to be measured in other ways. Because pipelines employ a method akin to a random proportional rationing rule, allocative inefficiencies are likely to occur when price signals are suppressed. Figure 1.3 depicts capacity demand for two different services, gasoline (D_{gas}) and jet fuel (D_{jet}), from a capacity-constrained carrier to a given destination. This geometric depiction was first proposed in Layson (1988) and later updated to represent capacity constraints in Reece and Sobel (2000).

Figure 1.3: Allocative Inefficiency in Regulated Destination Market



Under regulation, rates are capped at $\bar{t}$ and shippers demand exactly 100% of existing capacity for both gasoline and jet fuel. The diagram is strategically designed to result in convenient prorationing of 50% for gasoline and 50% for jet fuel.[8] When set competitively, the rates for both services would increase to t^*, and gasoline (the higher-valued service) should receive a greater share of the capacity.[9] Increasing rates above t^* is unsustainable in competitive markets because competitors will undercut the price back to marginal cost, which in this scenario is the inverted demand (i.e., foregone marginal revenue) of the other product. The triangle ABC represents the allocative inefficiency of regulated services relative to the optimal allocation. This type of welfare loss is a consequence of transferring service away from higher-valued customers (i.e., those who ship gas) to lower-valued customers (i.e., those who ship jet fuel).

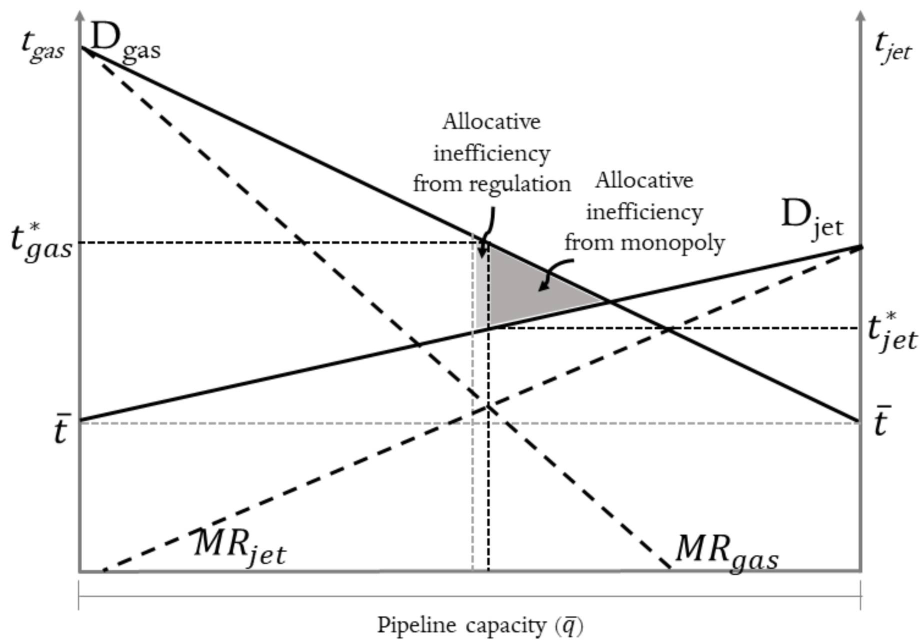
When services are deregulated, we would expect to see a subsequent increase in gasoline deliveries (q^R_{gas} to q^*_{gas}) to the destination and a decrease of jet fuel (q^R_{jet} to q^*_{jet}). I again assume that the origin market for either product is competitive, but the carrier may have market power in both commodity destination markets. Consequently, destination commodity prices for gasoline would decrease in the destination while jet fuel prices would increase. I can test this prediction by showing a negative relationship between pre-deregulation commodity values (intermarket price differentials) to heterogeneous price effect estimates of deregulation. However, if deregulation results in monopolistic rates, we would expect curtailment of deliveries of both commodities and resultant destination commodity price increases. Figure 1.4 shows how market power and third degree price discrimination would affect capacity allocation.

If the carrier is a price-discriminating monopoly, it will set rates such that the marginal revenue from shipping gasoline equals the marginal cost, which is the greater of the true marginal cost (assumed to be zero or below $\bar{t}$) and the marginal revenue from shipping jet fuel, and vice versa. Like the competitive baseline, derergulation in this monopolistic market would still result in increased rates for both services. But the optimal strategy for a monopolist is to price discriminate to achieve

[8] Most scenarios would not play out so cleanly. But a messier example would not produce a different conclusion.

[9] Though carriers are deregulated on a product-region basis, they typically request market-based rates approval for transportation of “all pipelineable refined petroleum products” rather than individual commodities. Therefore, I ignore the situation where only services for one type of commodity are deregulated.

Figure 1.4: Market Power in Heterogeneous Capacity Market



the profit-maximizing allocation. When the curves are as depicted, deregulation results in only a slight improvement in allocative efficiency than when rates were regulated, indicating a much smaller cost of regulation relative to the competitive market result. However, this is a consequence of how I have drawn the curves. Though not depicted, it is clear that under greater capacity or lower demand for either service deregulation would bring a decrease in allocative efficiency and rate regulation would be the preferred policy.

Regardless of market power, the best indication of efficiency improvement is whether commodity price differential of the high-valued and low-valued services converge following deregulation.

Note that these static models cannot explain overall destination commodity price decreases following deregulation unless there are changes to capacity. This might occur for a number of reasons. For example, carriers may withhold existing capacity when regulated rates are set below marginal cost and make it available only after price controls are relaxed. Another possibility is that carriers might prioritize pipeline capacity expansions on lines to deregulated markets,[10] or even delay expansion or retire capital for competing regulated services. For these reasons, overall commodity prices in deregulated markets would decrease relative to regulated markets.

To summarize, I make the following predictions:

1. Deregulated carriers *lacking* market power will increase their rates such that capacity is cleared, but there will be no change in quantity delivered and therefore no overall impact on commodity price differentials.[11] However, it is possible to detect market power when carriers increase their rates such that quantity demand falls below capacity and commodity prices in the destination market increase.

2. In deregulated markets, regardless of market power, convergence of commodity price differentials between pre-deregulation high-valued services and low-valued services is an indication of allocative efficiency improvement. I can measure this by estimating heterogeneous price effects of deregulation by commodity and comparing the values against their pre-deregulation levels. A negative relationship between these two indicates a decrease in allocative costs.

3. If pipelines make capacity investments in deregulated markets or remove capacity from regulated markets, overall commodity price differentials should fall in deregulated markets relative to regulated markets. Likewise, we should expect to see sales of the higher-valued commodities rise relative to low-valued commodities following deregulation.

1.4 Data

1.4.1 The Chicago Refined Products Market

Data availability necessitates that I restrict my analysis to a single market. Chicago is the perfect candidate for such a case study due to several unique features. First, six carriers have been

[10] Anecdotally, experts in the ongoing Colonial Pipeline rate case argue that Colonial has expanded capacity on its deregulated lines for this reason.

[11] This assumes products are homogeneous.

authorized market-based rates in the Chicago origin market since 1990. Second, it is historically one of the largest oil hubs in the United States with a peak annual refinery capacity of more than 900,000 barrels per day over the study period.[12] Third, it serves 32 *external* destination markets via four carriers, all of whom have been granted MBR authority in the Chicago refined products origin market. My study examines carrier behavior from 1986 (five years before the first MBR approval for Chicago) to 2007 (five years after the final MBR approval).

Though six carriers have MBRs on services originating in Chicago, only three of these carriers export product from the Chicago market using this authority. *Buckeye Pipe Line Company, L.P.* (*Buckeye*), *Williams Pipeline Company* (now *Magellan Pipeline Company, L.P.*, "*Magellan*"), and *Wolverine Pipe Line Company* (*Wolverine*) all deliver outside of Chicago to both regulated and unregulated destination markets. *West Shore Pipe Line Company* (*West Shore*) has also received MBR authority in the Chicago origin market, but only for deliveries to the Chicago destination market. Its other services out of Chicago remain subject to rate regulation. *TE Products Pipeline Company* (*TEPPCO*) and *Marathon Ashland Pipe Line LLC* (*Marathon Ashland*) were approved on July 31, 2000 and July 1, 2002, respectively, for services originating in Chicago to several destination markets. However, both companies only offer intra-market transfers within Chicago, which do not represent deliveries for end-use consumption and are therefore omitted from my analysis. *Shell Pipeline Company LP* also applied for MBRs for a set of markets including the Chicago origin in May 2002, but subsequently withdrew its application citing significant increases in costs related to the litigation process. Shell later sold its assets to *Magellan* and *Buckeye* in 2004. The remaining four carriers—*Buckeye*, *Magellan*, *Wolverine*, and *West Shore*—represent the universe of common carriers exporting refined product from Chicago during my study period. A summary of MBR cases in the Chicago Market is provided in Figure A1.1.

Buckeye, one of the largest independent carriers in the United States, operates a network of over 6,000 miles of products pipelines in the United States. On May 1, 1990, *Buckeye* proposed an experimental program for 22 markets, which laid the groundwork for all future market-based rates

[12] Based on EIA's annual Refinery Report containing crude intake capacity by individual refinery.

proceedings. Instead of the current procedure of analyzing both origin and destination markets, *Buckeye*'s approvals were based solely on characteristics in its destination markets. Its experimental program was approved with some modification on December 31, 1990 for 15 destination markets.[13] The order also identified four destination markets in which Buckeye possessed significant market power. Unlike future market-based rates approvals, Buckeye's program was unique in that services to those more concentrated markets were still allowed departure from traditional cost-based regulation. Instead, these rates were regulated by an index tied to rate changes in the more competitive markets. Additionally, Buckeye was required to submit price and revenue changes for all markets to the FERC for review in an annual confidential report. Though this "experimental" program was initially approved for three years, it remained in effect for nearly twelve years. As of 2013, the program was terminated and all markets originally deemed competitive were allowed to continue unregulated rate operations without continual review while the other less competitive markets reverted to cost-of-service ratemaking.

Magellan is another large independent pipeline, currently delivering refined products through over 9,700 miles of pipeline in the Midwest region of the United States. Using precedent set in *Buckeye*'s proceeding, *Magellan* requested MBRs in 32 refined products markets. Its MBRs were approved in two waves. On July 28, 1994, FERC issued Opinion No. 391, initially approving MBRs to 13 markets.[14] Opinion No. 391-A came less than a year later in June 1995, approving MBRs for an additional eight markets.[15]

Four years later, *Wolverine*, a joint venture between several integrated oil companies,[16] filed its

[13] They are Scranton-Wilkes Barre, Pittsburgh, Harrisburg-York-Lancaster, Philadelphia, Columbus (OH), Lima, Toledo, Detroit, Saginaw-Bay City, Fort Wayne, Kokomo-Marion, Indianapolis, Hartford-New Haven-Springfield, Seattle, and Terre Haute.

[14] The markets were Chicago, St. Louis, Oklahoma City, Tulsa, Wichita, Springfield/Decatur (IL), Peoria, Rockford, Wausau, Dubuque, Davenport, Columbia, and Minneapolis

[15] The additional markets were Springfield (MO), Kansas City, Lincoln, Quincy, Omaha, Eau Claire, Fargo, and Columbia.

[16] At the time, the interests belonged to Mobil Pipe Line Company (36.17%), Midwest Pipelines Company (31.49%), Texaco Trading & Transportation, Inc. (13.2%), CITGO Pipeline Investment Company (9.5%), Marathon Ashland Petroleum Company (5.63%), and SPL Holdings Inc., an affiliate of Shell Pipe Line Corporation (4.0%).

application for the Chicago origin market to five destination markets. Unlike previous applicants, *Wolverine* is a smaller system, operating only 600 miles of pipeline connecting Chicago to Indiana, Michigan, and Ohio destinations. Like *Magellan*, its approvals came piecemeal. On September 29, 2000, its services to Chicago, Elkhart, and Toledo were approved.[17] Half of the Detroit market was subsequently approved on June 18, 2001 after *Wolverine* withdrew is application for Grand Rapids and other central Michigan destinations.

The last pipeline in the sample is another joint venture that received MBR approval for the Chicago origin market. *West Shore*, which absorbed Badger Pipe Line Company's pipelines in 1998, applied for market power determinations in the Chicago origin and destination markets in March 2001. Its application was approved on July 1, 2002. This is the only carrier whose services are entirely cost-based, as its only deregulated rates are intra-market services in Chicago.

All four carriers are conveniently either joint ventures or independent pipelines, which subdues any fear of strategic behavior to benefit an affiliate refiner or marketer (*see* McRae, 2015 and Flexner, 1979). On the demand side, Chicago is a historical hub of refining power. Over the study period, Chicago's refineries dwindled from four to three but is still the largest refining city in the Midwest. The Premcor Blue Island facility closed in 2001, leaving only BP's Whiting facility, CITGO's Lemont Refinery, and ExxonMobil's Joliet Refinery. A map of the Chicago origin market, the discussed pipelines, and all of the destination markets they serve is provided as Figure A1.2 in the Appendix.

1.4.1.1 Tariff Data

I construct an unbalanced panel of tariff rates for every refined products carrier's service (identified by carrier-origin-destination-commodity) originating from Chicago and destined for external markets for the period 1986 to 2007. To do this, I obtained access to a proprietary database of historical oil pipeline tariff sheets compiled by Leonard B. Levine & Associates (courtesy of LawIQ) and

[17] *Wolverine* had converted its lines to Toledo to crude service in 1999, indicating a preemptive request for deregulation should it wish to revert the lines to refined products service. All refined products services to Toledo were terminated before the company received MBR approval.

tabulated all non-contract, non-incentive tariff rates for *Buckeye*, *Magellan*, *Wolverine*, and *West Shore* for services from Chicago to non-Chicago destinations over the relevant period.[18] For each rate, I identified the carrier, tariff sheet ID number, effective date, product type, product specification (if any), origin station, origin substation, origin substation ID, origin county, origin state, destination station, destination substation, destination substation ID, destination county, destination state, base rate (in cents per barrel), and any notes affiliated with that rate. Note that my analysis necessarily ignores any contract rates, volume incentive rates, other surcharges, and includes only base (or "walk-up") tariff rates.[19] The tariff database is useful not only for its pipeline rate data, but also because it informs me what services were available at any point in time. Just because a carrier has MBR authority across several markets, does not mean they offer services to all of these markets. Figure A1.3, which shows the time period over which each service is offered, reveals that many services are not available over the full time period.[20] This means carriers altered their service offering over time, adding several additional services and terminating others.

I identify treatment dates from FERC orders approving market-based rates for specific BEA markets.[21] Throughout, I assume market-based rates were applied immediately after a carrier received an order approving MBRs for specific markets. Therefore, I assign the MBR label to all rates to approved markets in the first effective tariff sheets after each carrier's order.

[18] FERC oil pipeline tariff sheets are publicly available, filed and published in PDF format on FERC's eTariff website back to the early 2000s, available here: https://etariff.ferc.gov/TariffList.aspx. However, there is no publicly available database of these or older tariffs.

[19] The Energy Policy Act of 1992 allowed carriers to negotiate contract rates with shippers. Contract rates may be based on cost-of-service, which should account for the risk-mitigation of contracted volumes, or arms-length negotiation. To avoid violation of the non-discriminatory requirements of the ICA, carriers that wish to offer contracted rates must do so through a well-publicized "open season" where all potential shippers have the opportunity to engage in negotiation. All shippers that enter the contract are then subject to the same rate, published in the tariff. Carriers are also permitted to offer discounts below the regulated price ceiling for high volume shipments. Other surcharges might include transfer fees, pumping fees, or loading fees for heavier products.

[20] Note that because my data do not perfectly capture the termination of a pipeline service, I assume rates expire one year after their last effective date.

[21] These were *Buckeye*'s Opinion Nos. 360 and 360-A, *Magellan*'s Opinion Nos. 391 and 391-A, and FERC orders on approval and withdrawal of *Wolverine* markets in 2000 and 2001.

I link the tariff rate data to regional BEA markets by origin and destination counties.[22] To control for supply and demand conditions in the destination market, I also incorporate monthly destination market × commodity refinery production, local consumption, waterborne receipt, and waterborne delivery estimates derived using data obtained from the EIA. These are all based on monthly state- and sector-level aggregate data, which I allocate to counties in proportion to sector-specific indicators of economic activity.[23] To control for cost of service that could affect tariff rates, I approximate distance using Google's distance matrix API for driving distances between terminal cities.[24] Though driving distance is not a perfect proxy for a pipeline route (see, for instance, the Buckeye route from Chicago to Detroit in Figure A1.2), this measure has been used in market-based rate cases in the same way I rely on it for this analysis. Similar to Busse and Keohane (2007), I calculate a "distance cost" by multiplying distance for each year by FERC's pipeline cost index.[25] In this way, distance varies with time.

Beyond measuring effects of MBRs on tariff rates, I am interested in follow-on effects on commodity prices and quantities in the destination markets. Thus, I obtain prime supplier commodity price and sales volumes data from Energy Information Administration (EIA) Form EIA-782C, which asks all firms that produce, import, or transport selected commodities across state borders to sell to local marketers to report their total transactions by delivery state and commodity. According to Department of Justice (1986), pipelineable products include "gasoline, jet fuel, kerosene, diesel

[22]These are the 1995 definition of *BEA* Economic Areas. I obtained the historical *BEA* mapping from county to BEA market via a FOIA request.

[23]These data are constructed from EIA SEDS data(https://www.eia.gov/state/seds), EIA plant-level fuel consumption data (Form EIA-932 at https://www.eia.gov/electricity/data/eia923/), EIA plant location data (Form EIA-860 at https://www.eia.gov/electricity/data/eia860/), EIA prime supplier data (https://www.eia.gov/dnav/pet/), U.S. Census population data (https://www.census.gov/data/tables/time-series/demo/popest/), BTS Air Traffic data (https://www.transtats.bts.gov), and BEA non-farm and manufacturing employment data (https://apps.bea.gov/regional/downloadzip.cfm.)

[24]See https://developers.google.com/maps/documentation/distance-matrix/start.

[25]Available at https://www.ferc.gov/industries/oil/gen-info/pipeline-index.asp. For the years before the index, I apply FERC's same calculation for the index:Producer Price Index for finished goods (PPI-FG) minus one percentage point. PPI-FG data is available at http://www.bls.gov/ppi/home.htm.

fuel, and distillate heating oil" but not "[r]esidual fuel, coke, and asphalt." Therefore I compile prices for gasoline, aviation gasoline, kerosene-type jet fuel, kerosene, distillate No. 1, and distillate No. 2 for each destination state. Using the commodity descriptions from the pipeline tariff sheets, I link the monthly commodity prices to each monthly pipeline rate. Where tariff sheets indicate rates are for "all refined petroleum products," I use all six commodities. Otherwise, I use only the commodities listed in the tariff sheet.

Table 1.1 below summarizes the market and service attributes comparing treatment (MBR) and control (regulated) services.[26]

My data contains 162,163 service-month observations. There are 943 unique services from Chicago to 33 destination markets, with the treatment and control groups fairly balanced (47.2% of the services ever obtain MBR status). Apart from sales, there does not appear to be a significant difference in rates or commodity prices prior to the first market-based rates approval in 1991. Pre-treatment sales align with other market factors, such as consumption, refinery production, and waterborne shipments, indicating that MBR destination markets are much larger on average than regulated markets. MBR-approved destination markets are also closer on average to their connected origins.

Because trends are important for DID designs, it is necessary to evaluate how these variables change over time. In Figures A1.4 to A1.19 I compare variables on MBR-approved services to regulated services before and after treatment dates. The top figure of each page shows rates on all services, without adjusting for their introduction or retirement. To clarify the trends, I show only services that span the entire period.[27] The rates appear to behave as predicted, rising gradually after the treatment date. *Wolverine* services see the sharpest increase following deregulation. Interestingly, *West Shore*'s rates also appear to increase exponentially over time despite regulation.

[26] Note that my analysis, discussed in the following section, includes only the 10 year window surrounding a carrier's MBR approval. While regulated services remain in the control group and are not dropped, I do drop all data for treated services that lie outside of the 10 year window. However, before I drop this data, I use it to construct a variable that accounts for cross-subsidization within a carrier's pipelines.

[27] The panel is not total balanced, as it may be missing intermediate dates for some services.

Table 1.1: Summary Statistics

	MBR	Regulated	All
Rates ($/bbl)	0.727	0.695	0.711
Rate/Mile ($/bbl-mi)	0.267	0.264	0.266
Commodity Price ($/gal)	0.639	0.636	0.637
Commodity Sales (mgpd)	3.111	2.752	2.926
% with Waterborne	0.626	0.447	0.546
Waterborne Receipts (mbpd)	1.240	0.187	0.770
Waterborne Shipments (mbpd)	0.398	0.086	0.259
% with Refinery	0.646	0.366	0.521
Refinery Production (mbpd)	16.899	9.167	13.448
Consumption (mbpd)	35.967	16.179	27.135
Distance (100 miles)	3.171	3.337	3.245
No. of Markets	19	14	33
No. of Services	498	445	943
No. of Obs	55,916	106,247	162,163

Notes: mbbl = Thousands of barrels. mbpd = Thousands of barrels per day. mgpd = Thousands of gallons per day. For comparison, rates, rates/mile, destination commodity price, and destination sales are the pre-1991 (i.e., pre-deregulation) averages. *West Shore* is the only carrier to offer only regulated rates for the full period. The outcome variables (rates, prices, and sales) are the pre-treatment averages for ease of comparison, while other variables are averaged or counted over the full period from 1986 to 2007. See full table by carrier in Table A1.1.

The graphs for commodity prices (Figures A1.14 and A1.15) offer no insight as to how treatment and control groups differ over time, as commodity prices for both groups appear to follow nearly identical trends. On the other hand, commodity sales trends appear to support the claim that carriers are not exercising market power with their deregulated services, as sales to deregulated markets increase following deregulation. The remaining graphs showing destination market changes primarily demonstrate the relative volatility of these market factors across MBR status, as well as their trends approaching the treatment dates. Overall, the trends in the balanced panels appear parallel preceding the carrier treatment dates, which lends credibility to my DID approach.

With that said, the comparison between the full panel and the mostly balanced panel indicates that carriers responded to deregulation with more than just price changes. For example, *Magellan* appears to increase the quantity of its regulated services just before treatment and retires them a couple years later. It is likely that *Magellan* was attempting to economize on scale. That is, it created services just in time for an MBR application in order to potentially get deregulated in those markets.[28] Conversely, *Wolverine* appears to unload a number of regulated services just before they acquired market-based rates authority in 2002 and then reinstated these rates after the application.

1.4.2 The U.S. Refined Products Markets

For the national analysis, I create a balanced panel of market routes (commodity-origin market-destination market, where markets are defined by 1995 BEAs) using the LawIQ dataset to examine the full pipeline network. Unlike the Chicago dataset, which observes carrier-services for which there is a unique rate (carrier-commodity-origin-destination), the unit in the U.S. dataset is the group of services transporting a given commodity between two large geographic markets. Under the assumption that the U.S. system of refined petroleum pipelines has been largely unchanged in terms of which markets are connected and the direction of flow since the 1980s, I use the earliest year of complete tariff data for each carrier to establish the existing network of pipelines. I then manually attempt to account for changes in pipeline infrastructure using news stories and press releases on new builds, closures and mergers/acquisitions, as well as oil spill data available from the Pipeline and Hazardous Materials Safety Administration. Though imperfect, it offers a clear enough picture of which carriers were operating in what markets for every month from 1986 to 2019. Using the FERC orders on market power determinations, I calculate the percentage of carriers that offer MBRs over time. This level of analysis is much more suited to the commodity and sales data, which are reported at the state level.

To each origin and destination market, I merge the state-level prime supplier commodity prices and sales volume (weighted by proportion of state origin and destination terminals in each market), consumption, production, and waterborne data described above.[29] The data is summarized in the

[28]FERC had previously denied Buckeye market power determinations in markets in which it did not operate at the time of the application. They later re-applied after establishing services in those markets.

[29]The construction of this data is described in greater detail in Terkelsen (2021a).

table below.

Table 1.2: U.S. Data Summary Stats (1986-2019)

	Mean	St. Dev.	Min.	Max.
No. of Carriers	0.949	0.686	0	6
No. of Carriers w/ MBR	0.209	0.447	0	3
% of Carriers w/ MBR	0.221	0.400	0	1.000
Consumption_O	0.236	0.536	0	7.026
Consumption_D	0.186	0.526	0	7.026
$\text{Refinery Production}_O$	0.658	1.515	-0.036	11.274
$\text{Refinery Production}_D$	0.135	0.590	-0.036	11.274
$\text{Waterborne Receipts}_O$	0.018	0.161	0	5.480
$\text{Waterborne Receipts}_D$	0.023	0.214	0	5.480
$\text{Waterborne Shipments}_O$	0.055	0.253	0	3.002
$\text{Waterborne Shipments}_D$	0.005	0.078	0	3.002
No. of Orig. × Dest. × Comm. Routes				3721
N (Orig. × Dest. × Comm. × Month)				1,562,820

All volume data is reported in thousands of barrels per day and is commodity-specific. The subscript denotes which market the volume data refers to (O = Origin, D = Destination). Refinery Production is net production, which may result in negative values.

1.5 Empirical Strategy

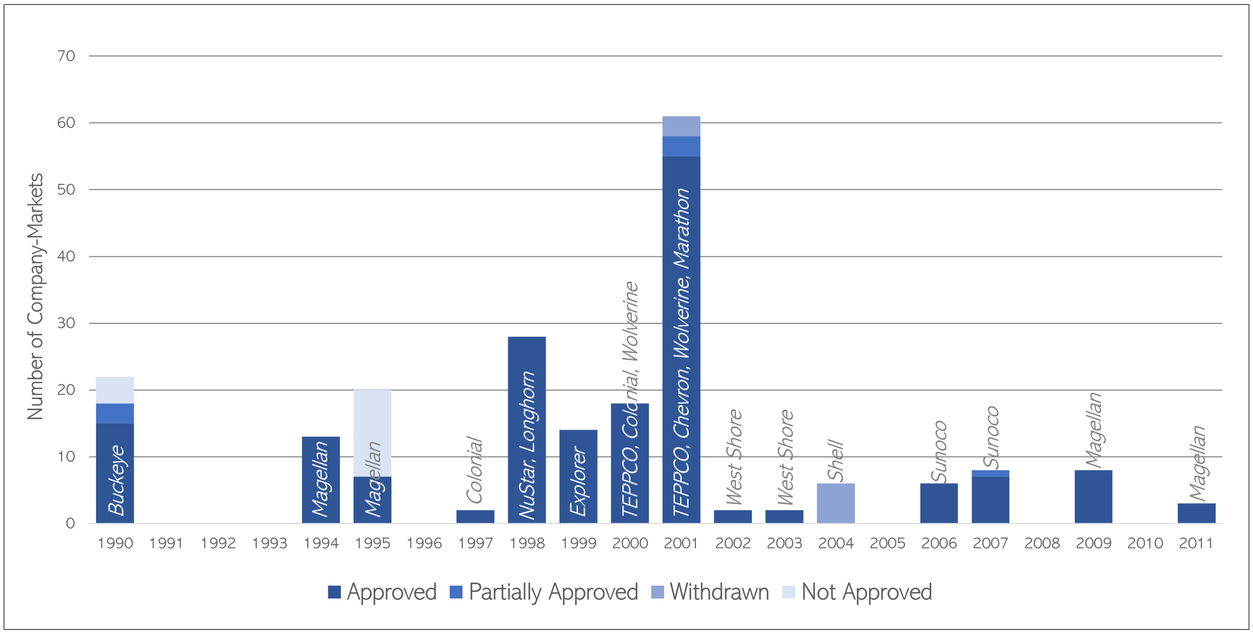
This study exploits the variation in MBR approval timing using a staggered difference-in-differences (DID) approach. Figures A1.4-A1.7 in the Appendix show that, though rates appear to rise following deregulation, there was no instantaneous jump upon MBR approval. Goodman-Bacon (2021) and Baker et al. (2021) show that when treatment effects vary over time, commonly used regression approaches to DID—namely two-way fixed effects—produced biased treatment effect estimates because already-treated units on a diverging trend are implicitly used as controls for not-yet-treated units. For this reason, my main specification for this analysis is a dynamic two-way fixed effects event study regression to estimate average treatment effects on the treated (ATTs) over the five years following a carrier's deregulation. In this study, there are five separate treatment events for the 498 MBR services, which I compare against the 445 control, or regulated, services.

To perform an event study, treatment must be discrete and irreversible (i.e., treated variables remain treated) over the study period, which it is in this case. The typical DID identifying assumptions apply. I assume (1) services across the treated and control groups would follow (conditional) parallel trends if not interrupted by the treatment, (2) treatment timing is random within unit and within time, and (3) there are no spillovers of the treatment.[30] This approach treats pipeline deregulation as a quasi-natural experiment. However, I should note that MBR approval, by virtue of following an application process, is not exogenous. I am concerned about two sources of endogeneity. First, unlike other industries in which all competitors and markets were simultaneously deregulated at the federal level, oil pipelines are assigned deregulation through a self-selected application process. Endogeneity stems from the fact that only certain carriers select into MBRs. While all carriers in my sample have *applied* for MBRs, which avoids the first source of endogeneity, they did so successively, with the larger firms leading the way. This domino effect highlights that selection into the treatment became relatively cheaper over time, as carriers learned successful strategies for convincing FERC of their competitiveness and, when markets were approved in earlier applications, carriers could easily rely on the compelling evidence that FERC had already approved the market for a larger carrier. Secondly, only certain markets are approved for market-based rates. Figure 1.5 shows FERC MBR determinations from the first in December 1990 to 2011.

This chart shows that FERC has approved a vast majority of MBR applications. It also elucidates the learning that occurred over time. The only markets to be totally denied were from the initial applications of *Buckeye* and *Magellan*. It is difficult to speculate whether later applicants were more selective with which markets to include in their request or if they learned how to better support their requests. Another possibility is that FERC became more lenient or favorable toward deregulation over time. FERC examines a number of market factors when making their MBR determinations,

[30] I ignore the effect of spillovers in this paper. However, I explore potential spillover effects of pipeline deregulation in Terkelsen (2021a).

Figure 1.5: Market-Based Rates Determinations from 1990 to 2011



Note: The approved carriers are listed by the bar of their determination year. Buckeye's partially approved markets are those that did not receive a market power determination, but were permitted flexible pricing. All other partial approvals refer to markets in which only a sub-region was approved.

including the market's capacity-based HHI and market share, local consumption, availability of waterborne transportation and refinery production. Though I do not possess the pipeline capacity data necessary to construct the relevant market power statistics for all services, I can account for changes in consumption, refinery production, and waterborne volumes. However, this does not totally address the concern that the control and treatment services are dissimilar. Fortunately, their similarity is enforced by FERC. Absent MBR policy, the rates of the MBR and regulated services would be subject to the same cost-of-service ratemaking formulas and rate cap index. As for the markets, Figures A1.9 and A1.11 show that commodity price and sales pre-treatment trends are almost identical on average across MBR and regulated services. Therefore, because I am interested in only the average treatment effect of the treated rather than the overall average treatment effect, market selection is not a particularly worrisome source of endogeneity for this study.

1.5.1 Rate Effects and Test for Market Power

I first model the effect of MBR approval on tariff rates, commodity prices, and commodity sales.

For rates, I estimate the following two-way fixed effects (TWFE) model:

$$\ln r_{cdjt} = \alpha_{cdj} + \alpha_{ct} + \sum_k \delta_k \mathbf{1}[t - E_{cdj} = k] + \beta_X \mathbf{X}_{cdt} + \beta_C C_{dt} + \eta_{jt} + \epsilon_{cdjt} \tag{1.1}$$

where r_{cdjt} is carrier j's log tariff rate for service cdj (delivery of commodity c from origin o to destination d) in month t;[31] α_{cdj} are carrier-service fixed effects; α_{ct} are commodity-time (in months) fixed effects; $\mathbf{1}[t - E_{cdj} = k]$ are time-from-treatment indicators (i.e., when carrier j receives market-based rates authority for commodity-destination cd);[32] $\mathbf{X}_{cdt}$ is a vector of time-varying commodity-destination characteristics (i.e., refinery production, consumption, and waterborne shipments and receipts); C_{dt} is the distance (in miles) of service d adjusted by an annual cost inflator specific to oil pipelines;[33] and η_{jt} are a set of carrier × month fixed effects. Carrier-service fixed effects control for unobservable individual heterogeneity that might influence differences in ratesetting between carriers or service type, while also ensuring that the identifying variation is across time within service. The commodity-time fixed effects are the second of the "two-way" fixed effects, accounting for shocks that affect all services for that commodity over time. The carrier-time fixed effects are crucial for identification since they effectively make this regression more of a "stacked" event study since it forces comparisons between treated and never-treated units for each event and then averages these estimates across events. In Section 1.6.7.3, I explain stacked event studies in more detail.

The coefficients of interest are the set of β_k's, which indicate the pre-trend (for $k < 0$) and treatment effect for $k > 0$ months after treatment. The absence of a pre-trend ($\hat{\beta}_k = 0$ for all $k < 0$) would help support the (untestable) assumption of a common trend post-treatment. The parameters

[31] Using log rates ensures that results are not driven by large fluctuations in high tariff rates. Furthermore, FERC-regulated carriers tend to adjust rates proportionately rather than in fixed increments.

[32] Note that, because I am estimating a fully dynamic model, k spans the entire time period. Never-treated services are assigned the same time-from-treatment value for all periods.

[33] This was done for coal rail in Busse and Keohane (2007) as an approximate for costs.

for $k \geq 0$ should indicate the effect of relaxing price controls in month k following the approval of market-based rates. Note that because regulated and MBR rates are permitted identical flexibility in terms of rate structure (i.e., volume incentives, contract rates, etc.), the estimate captures only the effect of allowing a pipeline to adjust price levels, not structures. Despite calculating estimates for every time-from-treatment, my event studies graphs and overall ATT only display or aggregate the first five years.[34] To obtain an overall ATT for the first five years, I calculate $\bar{\hat{\beta}} = \frac{1}{60}\sum_{k=0}^{60} \omega_s \hat{\beta_k}$ and $\bar{s\hat{e}} = \sqrt{\omega' \hat{\Omega} \omega}$, where ω is a $60x1$ weighting vector and Ω represents the variance-covariance matrix for the post-treatment effect estimates. Borusyak et al. (2021) suggests the weighting should capture sample attrition over time. I use $\omega_k = \frac{N_k}{\sum_{k=0}^{60} N_k}$, where N_k is the number of treated observations in time-from-treatment k.

I employ an identical model to estimate commodity price and sales effects. The only difference is the outcomes, $\ln p_{cdjt}$ and $\ln s_{cdjt}$, which are logged commodity prices and sales for commodities deliverable through service cd. I use state-level prime supplier price and sale provided by EIA, and perform the analysis at the carrier-service level. In addition, because all services originate from Chicago, the effect on the commodity price differential can be measured as the effect on price alone. This makes the commodity-time fixed effects crucial for identification because they ensure that I am measuring the effect on commodity price differentials rather than just destination commodity prices by capturing all commodity-specific shocks in the Chicago origin market.

The MBR effects on price and sales help detect whether carriers are exercising market power. Rising prices and declining sales would provide some evidence that carriers are increasing rates supra-competitively.

1.5.2 Test for Allocative Efficiency

To test whether MBR policy improved allocative efficiency, I analyze heterogeneous commodity price and sales effects based on commodity type and pre-MBR value. Because this does not require

[34] This was by design, as the last treated units are treated only 5 years before the end of my dataset.

rate data, I can perform this analysis for both Chicago and nationally. The Chicago analysis employs the same regression equation as above, but interacts the time-from-treatment indicators with a time invariant *value* measure, which is the pre-treatment commodity price difference between the destination and origin market. The estimated coefficients should reflect the relationship between overall ATT and the pre-treatment value of service.

In the national analysis, because treatment is no longer discrete or irreversible, an event study approach is no longer viable.[35] de Chaisemartin and D'Haultfœuille (2021) proposes a semi-parametric instrumental variable estimator which allows for both continuous and reversible treatment variables. However, the estimator does not yet easily accommodate heterogeneous effects. Therefore, I rely on the normal, but flawed, TWFE regression with continuous treatment. This model measures the effect of gradual authorization of MBRs for all refined products services in the United States. The treatment variable MBR_{codt} is continuous between 0 and 1, measuring the percentage of carriers that offer transportation for commodity c from origin market o to destination d in time t that have been granted MBRs:

$$\begin{aligned} Y_{codt} =& \alpha_{cod} + \alpha_{cot} + \delta MBR_{codt} + \delta_v MBR_{codt} * value_{cod} \\ &+ \beta_C Carriers_{codt} + \beta_X \mathbf{X}_{codt} + \alpha_{jt} + \epsilon_{codt} \end{aligned} \tag{1.2}$$

where α_{cod} are commodity-origin-destination fixed effects, α_{cot} are commodity-origin-time fixed effects, and $value_c od$ is the pre-MBR price difference between the destination and origin market. Like the previous model, I will use logged commodity prices rather than price differences as outcomes. This avoids the problem of dropping negative price differences when trying to measure proportional changes to the outcome via the natural log transformation. However, it also necessitates commodity×origin-specific time trends which will play an identical role as in the previous

[35]Though the unit of observation in this data is at the route level, there can be multiple carriers offering similar services along the route, with some being deregulated while others are not. Also, when considering the full history of MBR determinations, deregulation is no longer irreversible since Buckeye had its services to Harrisburg and Pittsburgh reverted to cost-regulation in 2017. Also, because I use a balanced panel, deregulated carriers exiting a market has the same effect as partially re-regulating that market.

regressions. Because my treatment variable might be influenced by the retirement or investment in new services, I add a $Carriers_{codt}$ covariate, which counts the number of carriers actively offering commodity c services from o to d in time t.

To obtain the heterogeneous price and sales effects, I interact the treatment variable with a value measure. If there is an improvement in allocative efficiency, we would expect a positive correlation between value and sales effects of deregulation and a negative correlation between value and commodity price effects of deregulation. I measure value as the pre-1991 (i.e., pre-first MBR) price difference ($P_{cd} - P_{co}$) between destination and origin markets. The units with the highest price difference are considered "high-valued" because shippers stand to gain the most from the service. If carriers adjust rates such that the marginal revenue from the higher-valued services match the marginal revenue from lower-valued service, then there could be more shippers of the high-valued service (and fewer shippers to the low-valued service) following deregulation. Consequently, the price gap would narrow. For example, suppose $\hat{\delta}_g$ and $\hat{\delta}_j$ are the estimated ATTs of deregulation on motor gasoline and jet fuel, respectively. If motor gasoline had a greater pre-deregulation price differential than jet fuel, an improvement in allocative efficiency would be evident if $\hat{\delta}_g < \hat{\delta}_j$. This would mean that deregulation led to greater shipments and therefore lower prices for higher-value services, relative to lower value services.

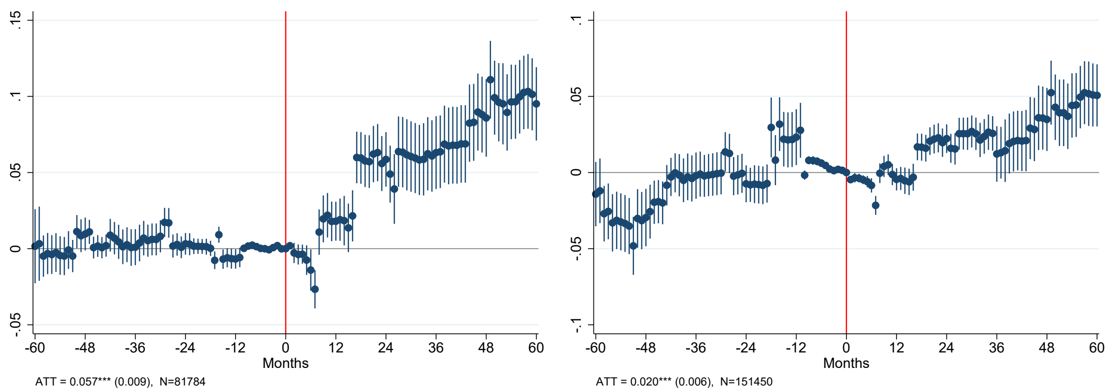
1.6 Results

1.6.1 Tariff Rate Effects

I depict the estimated ATTs graphically to show dynamic effects for the 10 year window surrounding each MBR approval. The horizontal axis is months from treatment time. Figure 1.6 reports estimated effects on log rates using both a balanced and unbalanced panel, along with their 95% confidence intervals using robust standard errors clustered by service. Because I used an unbalanced panel of services, which may not be offered for the entire study period (see Figure A1.3), I run the analysis on both the full panel and a balanced subset.[36]

Figure 1.6: MBR Rate Effects

(a) Balanced Panel (b) All Data



Robust standard errors clustered by service. Panel (a) shows estimates using a balanced panel of services. Panel (b) estimates use all services active at any point over the study period. The ATT is the average of post-treatment dynamic effects weighted by the number of treated units.

Both analyses show rates increasing after deregulation. The weighted ATT from the balanced panel is 0.057 (0.009), which is significant at the 95% level. This is interpreted as an average 5.7 percent increase in deregulated rates following MBR approval. The flat pre-trends support a causal interpretation that MBR policy results in higher tariff rates that increase over time. The full data analysis supports this conclusion, but is not sufficient evidence by itself. The inclusion of new and retired services evidently skews the ATT downward to only 2 percent and results in suspicious pre-trends. These are likely due to the sensitivity of time fixed effects to the coming and going of units.

These results comport with my priors discussed in Section 1.3, but are not alone indicative of market power or welfare effects because rates may rise to meet competitive, market-clearing conditions.

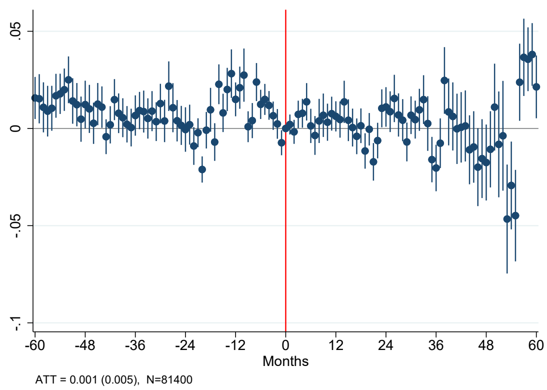
[36]The balanced subset includes all four carriers, but cuts the data in half. Rather than the 33 destination markets in the original dataset, the balanced panel contains 19.

1.6.2 Commodity Price and Sales Effects

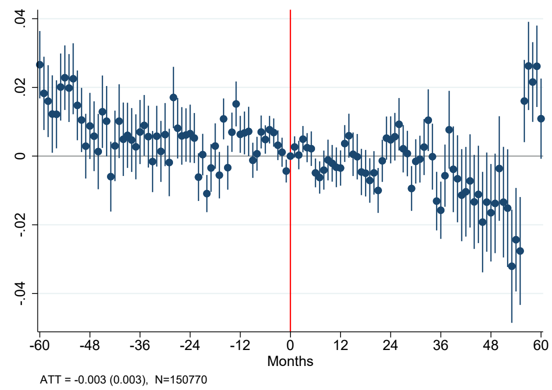
I estimate Chicago price and sales volumes effects using Equation (1.1). Figure 1.7 presents event studies for ATT of MBR on commodity prices and sales. Again, I present results from both the balanced panel and the full dataset.

Figure 1.7: MBR Market Effects

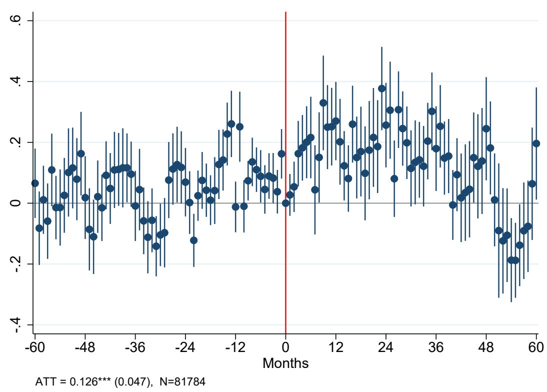
(a) Commodity Prices (Balanced)



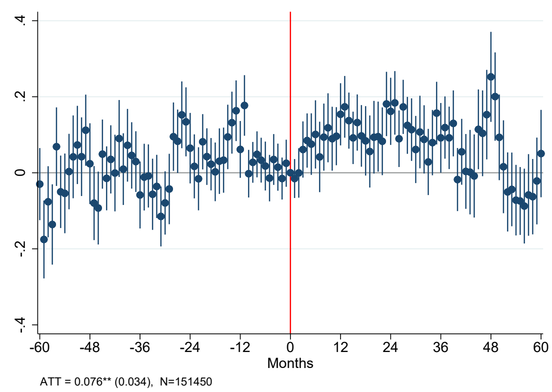
(b) Commodity Prices (All Data)



(c) Commodity Sales (Balanced)



(d) Commodity Sales (All Data)



Robust standard errors clustered by service. Panels (a) and (c) show estimates using a balanced panel of services. Panel (b) and (d) estimates use all services active at any point over the study period. The ATT is the average of post-treatment dynamic effects weighted by the number of treated units.

Commodity price effects across both analyses appear to be null and decreasing (except for an odd spike in the final months). Despite the difference in rate effects between the balanced and unbalanced samples, the commodity price effects appear similar across analyses. The pre-trends are less tidy than the rate analysis given the volatility and imprecision in the price data. Regardless, these results align with carriers competitively pricing at full capacity. If, indeed, commodity prices are decreasing as they appear to be in the full data event study, this could indicate that carriers are expanding capacity over time.

The commodity sales effects tell a similar story. Both balanced and full data analyses calculate positive ATTs on commodity sales, of 12.8% and 7.8%, respectively. Commodity sales increase in states more exposed to deregulated markets and maintain a somewhat constant ATT before falling 5 years after treatment.

If MBR approval causes no or negative change to destination commodity prices and has positive effects on commodity sales, as these result show, we can conclude that carriers are not exercising market power in these markets.

1.6.3 Allocative Efficiency

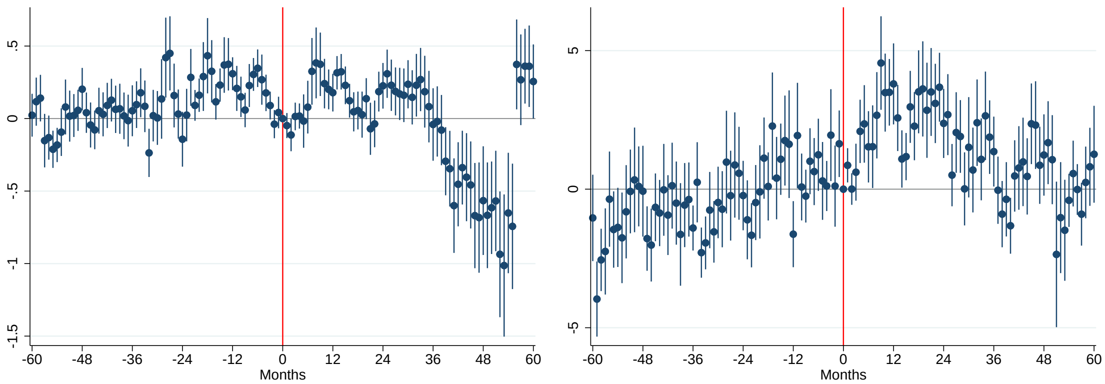
1.6.3.1 Chicago Market

Figure 1.8 reports the heterogeneous treatment effect based on pre-treatment valuation estimated by interacting the pre-1991 price differential with the time-from-treatment indicators in Equation (1.1). The average pre-1991 price differential is 0.233 with a standard deviation of 0.066. Then one standard deviation greater in pre-treatment value is associated with 0.066 percent higher ATT of deregulation. The commodity price results show the effect of deregulation is more negative in the long-run for higher-valued services. This is consistent with an improvement in allocative efficiency. The commodity sales results support this conclusion, as higher-valued services also saw higher destination sales following deregulation.

In sum, these results indicate that deregulation in Chicago allowed tariff rates to behave as price signals of service value. Without having actual quantity data for the pipelines, the available destination market commodity price and sales data offer sufficient evidence for a welfare improvement of MBR policy.

Figure 1.8: Allocative Efficiency Effects

(a) Commodity Prices (Balanced) (b) Commodity Sales (Balanced)



Robust standard errors clustered by service. Panels (a) and (b) show estimates using a balanced panel of services.

1.6.3.2 All U.S. Markets

Table 1.3 presents results from regression (1.2) with log destination market commodity prices as the outcome. Markets are defined as 1995 BEAs. Recall that, because the regression includes origin-commodity specific time fixed effects, these ATTs are actually the effects on price differences between the destination and origin market. Columns (1) and (2) show the effects over the full history of MBR policy (1986 to 2019) using a continuous or discrete treatment variable.[37] The results complement those found in Chicago. We see small or negative price effects, but the marginal ATT from higher-valued services (i.e., the coefficient on the interaction of MBR and $value$) are significantly negative.

To get a sense of the heterogeneity of these effects across time, I split the data into pre- and post-2000. Though still negative, the post-2000 are much more noisy despite the majority of market-based rates approvals occurring in or after 2000 (see Figure 3.2). Overall MBR effects are slightly larger in the post period for both treatment effect variables, while the MBR effects for higher-valued services are differ considerably between the continuous treatment estimates while they are nearly identical for the discrete measurement. One could conclude that the effect of a

[37]The continuous treatment effect regressions omit markets that do not have any carriers at the time, as they are missing the denominator for calculating the treatment variable. The discrete treatment is 1 when the first carrier on a route receives MBRs.

Table 1.3: Commodity Price Effects

	(1) Continuous (All Years)	(2) Discrete (All Years)	(3) Continuous (Pre-2000)	(4) Discrete (Pre-2000)	(5) Continuous (Post-2000)	(6) Discrete (Post-2000)
MBR	0.004	-0.033**	0.001	-0.001	-0.006	-0.027
	(0.013)	(0.012)	(0.003)	(0.003)	(0.023)	(0.015)
MBR × Value	-0.722***	-0.483**	-0.239***	-0.175**	-0.655	-0.174
	(0.211)	(0.159)	(0.069)	(0.057)	(0.414)	(0.262)
Carriers	-0.014	-0.014	-0.011*	-0.007	-0.004	-0.002
	(0.010)	(0.009)	(0.006)	(0.005)	(0.012)	(0.010)
Observations	481509	648190	204109	275950	277400	372240

Notes: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. Standard errors in parentheses are clustered by commodity × origin markets × destination market. "Continuous" refers to the treatment variable, MBR, being the percentage of active carriers that have market-based rates at that time whereas "Discrete" means MBR=1 after any carrier receives market-based rates for that commodity-origin-destination route and 0 otherwise. All years cover 1986 to 2019. The Post-2000 columns are inclusive of the year 2000. Carriers is the lagged number of carriers operating in the market at the time. All regressions include lagged commodity-specific refinery production, consumption, and waterborne measures for the destination market and commodity-origin market time trends.

route switching to MBR, even partially, for the first time would have similar effects across time but adding another MBR carrier to an already partially deregulated market might differ based on how deregulated that market already is. Since deregulation is generally increasing, the markets in the post-2000 analysis are likely already deregulated. These estimates suggest that deregulating an additional carrier in an already partially deregulated market has a greater impact on closing large price gaps than partially deregulating a mostly regulated market. Another possibility is that the larger proportional decrease reflects that later treated markets have smaller price gaps at the time of deregulation.

In Table 1.4 I present MBR effects on logged destination market commodity sales. The interacted MBR effects again support the findings from the Chicago analysis: deregulation leads to increased consumption of higher-valued services. This appears to be true for the full period analysis, and for pre-2000, but these effects noisily invert in the post-2000 period despite decreasing price effects. It is unclear why this would be apart from an indication that the highest-valued markets were deregulated first and that carriers who are deregulated later are doing so in markets that have already been corrected for the misinformation that produced the initially high price differentials.

Table 1.4: Commodity Sales Effects

	(1) Continuous (All Years)	(2) Discrete (All Years)	(3) Continuous (Pre-2000)	(4) Discrete (Pre-2000)	(5) Continuous (Post-2000)	(6) Discrete (Post-2000)
MBR	0.004	-0.033**	0.001	-0.001	-0.006	-0.027
	(0.048)	(0.047)	(0.039)	(0.036)	(0.071)	(0.051)
MBR × Value	4.071***	3.635***	2.000**	1.825**	-2.463	-1.594
	(0.689)	(0.595)	(0.766)	(0.685)	(1.313)	(0.869)
Carriers	-0.057	-0.005	-0.019	-0.022	-0.065	0.004
	(0.043)	(0.034)	(0.089)	(0.073)	(0.045)	(0.031)
Observations	482659	649869	205259	277629	277400	372240

Notes: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. Standard errors in parentheses are clustered by commodity × origin markets × destination market. "Continuous" refers to the treatment variable, MBR, being the percentage of active carriers that have market-based rates at that time whereas "Discrete" means MBR=1 after any carrier receives market-based rates for that commodity-origin-destination route and 0 otherwise. All years cover 1986 to 2019. The Post-2000 columns are inclusive of the year 2000. Carriers is the lagged number of carriers operating in the market at the time. All regressions include lagged commodity-specific refinery production, consumption, and waterborne measures for the destination market and commodity-origin market time trends.

1.6.4 Robustness

Appendix Figures A1.20, A1.21, and A1.22 present alternative specifications for Equation 1.1. I first want to demonstrate how crucial the carrier-time fixed effects are to satisfy the parallel trends assumption underlying identification. Panels (a) and (b) of all three Figures show estimates for the balanced and unbalanced samples when the carrier-time fixed effects are missing. Though post-treatment rate effects remain positive and increasing, the significant pre-trends suggest that the point estimates are less reliable. This same issue extends to the commodity price outcome, which shows a significant pre-treatment dip. However, sales data appears to benefit less from the inclusion of the carrier fixed effects, although they do reduce some volatility. Regardless the overall conclusions drawn from the main specification do not change when comparing across carriers.

To address some of the concerns about endogenous selection into market-based rates, I re-run the original regressions with some modifications. Though all carriers in my analysis have applied for market-based rates, *West Shore* is the only one to omit certain destination markets from its application. In fact, all *West Shore* services included in my study are to markets that have never been considered in a market-based rates case. To demonstrate that including these services does not exaggerate treatment effects, I run my regressions excluding all *West Shore* services. The event studies for the unbalanced and balanced MBR effects are presented in Panels (c) and (d), respectively. Overall, the event studies without *West Shore* appear identical to the main specifications, despite losing more than 10 percent of the sample.

One last modification may be to add carrier-specific linear trends rather than carrier-time indicators, which Borusyak et al. (2021) acknowledge is a popular but misguided attempt to solve endogeneity issues without sacrificing many degrees of freedom. I replace the carrier-time fixed effects with linear destination market time trends in Panel (e) of Figures A1.20 to A1.22. The flaws of this approach are blatant upon sight, as it is clear that time trends are not linear for any of these outcomes. Their inclusion is likely to obscure actual non-linear trends in the effects.

1.6.5 Heterogeneity

Because I expect results to differ based on market characteristics, I estimate heterogeneous treatment effects across outcomes for the different carriers and market types (i.e., having a refinery or waterborne access) as well as the marginal treatment effect for distance from Chicago. To estimate these effects, I include an interaction of the market characteristic and the time-from-treatment indicators in Equation 1.1.[38] Figure A1.23 presents the resultant event study graphs for each outcome.

Surprisingly, the overall rate effects appear to be driven primarily by aggressive increases by Wolverine. They increase rates by almost 20% on average after a year of deregulation while the other two carriers make modest and occasional increases. This dramatic difference between carriers reemphasizes the practicality of FERC's carrier-specific approach to deregulation. It is reasonable that some firms exploiting deregulation does not mean that all firms will. These graphs also show that Wolverine's deregulated markets are also responsible for the large dip and subsequent increase

[38]For the continuous distance variable, I report only the marginal ATT of an additional 100 miles. That is, the event study reports the coefficients on the interaction of distance and time-from-treatment indicators.

in year 5 from treatment. However, it is Magellan's destination markets that drive the post-treatment sales increase.

There does not appear to be any major difference between rates to destinations with and without refineries. And, despite the differences between the price effects between these types of markets, they do not appear to follow different trends. That is, the differences are largely due to the volatility and the need to make every effect relative to the base period. In terms of commodity sales, refinery destinations experience a larger post-treatment increase and overall more volatile trends. It is possible that these sales fluctuations are largely caused by refinery production.

Rates to waterborne destinations appear to increase more than non-waterborne destinations, though the difference is generally not significant. Higher rate increases in the seemingly more competitive market is a surprising outcome if carriers are setting rates competitively. Conversely, there do not appear to be any significant waterborne-dependent differences in price and sales trends. Though, if the relative decline in non-waterborne destination commodity prices is to be believed, it is likely due to landlocked markets having fewer alternatives and therefore have higher price differences from connected markets. The lower commodity price could reflect the discussed improvement in allocative efficiency.

Rates for longer distances appear to decrease more than those to shorter distances, suggesting that the price discrepancy between cost-based and market-based rates is greatest for shorter distances. This is an intuitive outcome since market-based rates should bear little relation to the distance of the journey, because prices are set at the termini of the pipeline rather than along its route. I exploit this phenomenon in Section 1.6.6.

This analysis bolsters the need for more exploration in this area. Given the heterogeneity that exists in just this small sample of Chicago services, a full historical analysis of how carriers set their market-based rates would elucidate many of the issues currently arising before FERC.

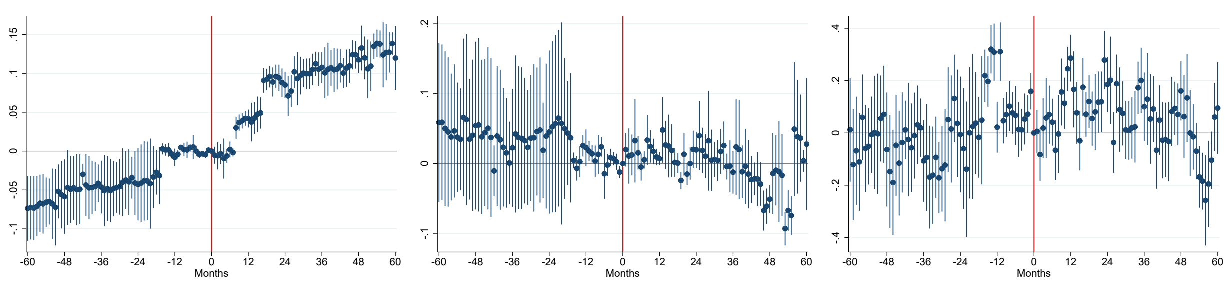
1.6.6 IV TWFE Event Study

Freyaldenhoven et al. (2019) proposes a simple instrumental variable (IV) TWFE estimator when pre-trends are present. The key is a identifying a covariate that is likely influenced by an unobservable confounder, but not the actual policy itself. The confounder is anything that might precipitate the policy. An example used in the paper is when measuring the effect of firm entry into a market on some outcome, one confounder may be the expected cash flow from entering the market. Once cash flow hits some level, the firm will decide to enter the market. The authors choose voting-eligible population, which would not be affected upon firm entry, as the proxy for profitability.

This same logic can be applied to firm entry into MBR deregulation. In this case firms are considering the expected *increase* in cash flow relative to cost-based regulation. A sufficiently high discrepancy between the cost-based rate and what a firm would charge may trigger an MBR application. Up to this point, I have used my cost proxy (distance × FERC oil pipeline index) as a control variable. Freyaldenhoven et al. (2019) suggests that it may be more valuable when treated as the "mismeasured regressor" and using leads on the treatment indicator as excluded instruments.[39] Therefore I run the recommended estimator, using a 2-year lagged treatment indicator as an instrument for the cost proxy, instead of the carrier-time indicators. I present the results in Figure 1.9.

Figure 1.9: Freyaldenhoven et al. (2019) Event Studies

(a) Rates (Unbalanced) (b) Commodity Sales (Unbalanced) (c) Commodity Sales (Unbalanced)



Robust standard errors clustered by service.

Given the large confidence intervals, it is clear that the cost proxy is not sufficiently relevant in relation to MBR application decisions. However, this tool may be useful when trying to get

[39] I also considered destination consumption and refinery production as possible alternatives, as these are likely related to profitability because they are measures of demand and supply, respectively. However, cost proxy variable proved to be much more relevant in practice.

cross-carrier estimates. One drawback of this approach, however, is that it is not clear whether it is suitable for unbalanced panels or for heterogeneous treatment effects.[40] It is likely that the issues identified in the recent DID literature exist in this context as well.

1.6.7 Alternate Specifications

The carrier-time fixed effects in my model save my estimation from the typical pitfalls of staggered TWFE DID approaches because comparisons are made within carrier, who typically have one treatment event or two close treatment events. In this section I explore methods that use variation across carriers to estimate ATTs.

The burgeoning research on DID with variation in treatment timing is already voluminous. Those that have risen to the top (e.g. Goodman-Bacon, 2021; Callaway and Sant'Anna, 2020; Sun and Abraham, 2020; de Chaisemartin and D'Haultfœuille, 2021; Borusyak et al., 2021) agree there are issues with TWFE estimation, primarily when treatment effects are heterogeneous. These issues stem from the fact that TWFE estimates are the weighted average of all possible DID combinations between units with different treatment times. Included in these micro-DIDs are the comparisons between already-treated units and newly treated units. When treatment effects are heterogeneous over time, the requisite parallel trends assumption is violated, as already-treated units are on the treated trend. As a result, the implicit weights for the micro-DIDs are often nonsensical, sometimes even negative. In static designs (i.e., non-event studies), Borusyak et al. (2021) shows that TWFE regressions assign more negative weights to later periods where large numbers of units are treated. Moving to the event study framework mitigates this issue somewhat, as it separately measures long-run effects. However, earlier treated units also often receive negative weights, which is not addressed by TWFE event study regressions. Several authors have proposed alternative estimators to address this issue.

Both Callaway and Sant'Anna (2020) and de Chaisemartin and D'Haultfœuille (2021) recom-

[40]The authors explicitly avoid contexts where treatment effects are heterogeneous, citing the recent literature on issues with TWFE in these setups.

mend semi-parametric estimators that explicitly calculate the difference in outcomes between a given period and the specified base period (typically 1 period before treatment time) and compare these differences for treatment groups against never-treated or not-yet-treated control groups. These estimators operationalize the purest form of the DID calculation by differencing within group across time, except they do so dynamically for each period before and after treatment. The key difference between these estimators is how they incorporate covariates for comparison across treatment and control, which I will discuss below.

There are also new regression-based solutions to the TWFE issues that attempt to remove the portion of the ATT that compares already-treated units to newly treated units. Sun and Abraham (2020) does this by estimating group-specific time-from-treatment effects and then averages across treatment groups where each treatment group is defined by the time of treatment. Cengiz et al. (2019) calculates a "stacked event study" by creating a dataset for each treatment period and estimating a pooled TWFE regression on the "stacked" datasets.

Below I explain these alternative estimates further and redo my analysis using their techniques. Due to the time required to compute these regressions at the monthly level, I instead present results using annualized data. For comparison, the annualized naive TWFE estimation results are presented in Figure A1.24.[41] It does not appear that any of the alternative estimators totally correct for the pretrends that are evident from only two pre-treatment placebos. As a result, the general conclusions drawn from these estimates would not differ from the naive TWFE approach.

1.6.7.1 de Chaisemartin and D'Haultfœuille (2021)

In a current working paper, de Chaisemartin and D'Haultfœuille extend their published static DID estimator (de Chaisemartin and D'Haultfœuille, 2020) to settings with varying treatment timing. Without any covariates, their estimator is identical to the Callaway and Sant'Anna (2020) estimator. But they differ in how they account for covariates, with Callaway and Sant'Anna incorporating them

[41] Because these are generated to compare against the alternative estimators, these estimates do not use carrier-time fixed effects.

semi-parametrically (with their doubly robust estimator) while de Chaisemartin and D'Haultfœuille do so linearly. Their estimator for each time after treatment k can be written as:

$$\begin{aligned}\hat{\delta}_k = \; & \frac{1}{N_k}\sum_{t=k+2}^{L} N_{tk}\Bigg[\sum_{g:E_{g,1}=t-k}\frac{N_{gt}}{N_{tk}}[Y_{g,t}-Y_{g,t-k-1}-(X_{gt}-X_{g,t-k-1})'\hat{\theta}_0] \\ & -\sum_{g:E_{g1}>t}\frac{N_{gt}}{N_t^{nt}}[Y_{g,t}-Y_{g,t-k-1}-(X_{gt}-X_{g,t-k-1})'\hat{\theta}_0]\Bigg]\end{aligned}$$

where N_k is the number of treated units lasting k periods after treatment, N_{tk} is the number of treated units lasting k periods after treatment in time t, L is the last period where there is still a group that is untreated, $E_{g,1}$ is the time when group g receives treatment, N_t^{nt} is the number of units not yet treated at time t, Y is the outcome of interest. Group g is typically defined by the time of treatment (i.e., all units treated the first treatment date are in group 1, on the second treatment date in group 2, and so on), but can also be the individual units. Note the last terms within the parentheses are a linear combination of covariates. $\hat{\theta}_0$ is derived by regressing covariates on outcomes for only the not-yet-treated observations so that the estimate reflects the untainted relationship between the variables. Conversely, Callaway and Sant'Anna (2020) use the covariates to calculate propensity scores for use in an inverse probability weighted comparison between $Y_{g_1,t} - Y_{g_1,t-k-1}$ and $Y_{g>g_1,t} - Y_{g>g_1,t-k-1}$ where g is the time of treatment. I do not estimate Callaway and Sant'Anna (2020) for this paper because of the computational costs of doing so.

1.6.7.2 Sun and Abraham (2020)

Sun and Abraham (2020) propose a regression-based alternative where each group indicator is interacted with the time from treatment indicators:

$$\ln r_{cdjt} = \alpha_{cdj} + \alpha_{ct} + \sum_{g}\sum_{k}\delta_{kg}\alpha_g \mathbf{1}[t - E_{cdj} = k] + \beta_X \mathbf{X}_{cdt} + \beta_C C_{dt} + \eta jt + \epsilon_{cdjt} \qquad (1.3)$$

where α_g is a set of indicators for groups defined by time of treatment. To obtain an the overall dynamic effects, the $\hat{\delta}_{kg}$'s are averaged across g.

1.6.7.3 Stacked Regression

The stacked regression requires specification of an event window. For each treatment date, I create a dataset that excludes already-treated units and any other units treated within the event window but not on the treatment date of interest. I am left with a "clean" dataset of treatment and control units that do not change treatment status within that period. Once I have a dataset for each treatment date, I "stack" them and estimate equation 1.1, except I interact all covariates except the time from treatment indicators with a stack ID. Because Cengiz et al. (2019) do not explicitly report their model, I rely on Baker et al. (2021) for the exact specification.

1.7 Conclusion and Further Work

While nearly every other industry has benefited from empirical studies of their deregulation, the oil pipeline industry has been a desert with respect to academic interest since its reform. Though academic work performed more than 30 years ago laid the foundation for current pipeline policy, my study represents the first attempt at a reflective analysis of any of these policies. My findings suggest that deregulation has been a success in the Chicago market. Though deregulated carriers increased their rates relative to regulated alternatives by about 5.7 percent on average for the first five years, doing so is not an apparent exercise of market power given that commodity prices remain constant in the long run. Additional evidence showing improvement in allocative efficiency in both Chicago and the entire U.S. pipeline market further demonstrates the welfare improvements from deregulation.

There is still much work to do in this area. Considering the heterogeneity found within the Chicago market, the external validity of my market power results beyond Chicago, and beyond the study period, remains unclear. FERC's implementation of its market-based rates policies is still changing, hinging on precedent set in specific cases using evidence gathered only from protested carriers. Due to several rate complaints, FERC has been reviewing market-based rates for the two largest U.S. carriers for several years now. State regulatory agencies such as the Railroad Commission of Texas (which regulates intrastate oil pipelines) have also recently sought guidance on how to implement market-based rate regulation. To aid regulators in developing precedent beyond the confines of a specific case's evidentiary record, there is demand for continued empirical research on oil pipeline markets.

Moving forward, there are a number of ways to expand the depth and breadth of available pipeline datasets. Tabulating the universe of historical rates would allow for a clearer picture of these markets over time.[42] Having not only which carriers are operating, but also the number of services they offer and their respective rates (and rate structures), is an obvious next step toward a historical analysis of these markets. Proprietary city-level commodity price data is also available via Oil Price Information Service (OPIS), which would allow for more precise commodity price effect estimates than those calculated from the state-level EIA data on which I currently rely.

Another expansion of the rate analysis would be to include contract and volume incentive rates. Other deregulation studies have examined the evolution of rate structures in deregulated markets. Because of the EPAct of 1992, all oil pipelines are allowed to alter their rate structures regardless of market-based rate status. Increased complexity allows for carriers to compete with one another with methods other than price levels. For both this and expansion into other markets, feasibility is simply a matter of extracting and tabulating as much information as possible from the published tariff sheets.

My efforts toward the expansion of available data for studying pipeline markets are described in Terkelsen (2021a). There, I document how I build a monthly panel of refined petroleum product supply and demand data for every U.S. geographic and commodity market from 1986 to 2019 using publicly available data and methods commonly used in FERC rate cases. I also document my construction of the historical pipeline network data that I rely on for my U.S. market analysis in this paper. I demonstrate the utility of these datasets in an extension to this paper through an examination of the consequences of partially deregulated markets.

[42]FERC houses the historical tariff sheets, accessible either via their online library or a FOIA request. At this point LawIQ has tabulated the universe of rates since 2007. They also have the PDF tariff sheets catalogued for nearly every carrier since the 1980s.

CHAPTER 2

SPILLOVERS OF MIXED REGULATION: EVIDENCE FROM U.S. PETROLEUM PIPELINE MARKETS

2.1 Introduction

The Federal Energy Regulatory Commission (FERC) regulates rates for common carrier oil pipeline services in the United States. In recent decades, regulators have opted for a more hands-off approach to price regulation. FERC's market-based rates program offers firms the opportunity to remove FERC price controls where they demonstrably lack market power. A peculiar consequence of deregulating firms on a case-by-case basis is that it results in markets in which both regulated and unregulated alternatives compete. I refer to these as "mixed regulation" markets.

This paper is an extension of Terkelsen (2021b), which explores welfare effects of pipeline deregulation in the U.S., but ignores potential spillover effects within and across the resulting mixed regulation markets. I investigate those spillovers in this paper. I consider two main types: those within firm and those across firms. Pipeline firms (or "carriers") that became partially deregulated potentially offer both regulated and deregulated services in the same markets. I point out that, under these conditions, capacity constrained firms would set their deregulated rates above what they would if the market was fully deregulated. Similarly, I argue deregulated carriers competing against regulated carriers in the same markets produce different outcomes than fully deregulated markets.

I empirically test the theoretical implications of these mixed regulation markets using data I construct for the purpose of studying petroleum pipeline markets. One of the biggest contributions of this paper is the 1985 to 2019 monthly pipeline route data, which I compile using various public data sources, and is available for public use.[1] This dataset records for each origin-destination-commodity route the active carriers, their regulatory status, and commodity-specific[2] consumption,

[1] If you would like to use this data, please email me at aterkels@gmail.com.

[2] The commodities are motor gasoline, aviation gasoline, jet fuel, kerosene, distillate No. 1 and

refinery production, and waterborne data for each end of the connection.

Using monthly variation in pipeline demand (i.e., refinery production) and regulatory status, I estimate the effect of mixed regulation markets on commodity price differences along these routes.[3] I find that deregulated carriers set lower rates in high demand times when all of their other services are also deregulated. Similarly, I provide evidence that partially deregulated firms increase their rates more in high demand times when competing against regulated firms.

Price regulation has been a historically favored topic for economists over the past few decades, with research spanning countless industries, regions, and market types (e.g. Joskow and Rose, 1989; Winston, 1993; Peltzman and Winston, 2000). Several studies exploit the disparities between state and federal regulation to measure these effects. But, I believe this paper is the first to explore the spillover effects of partial deregulation. There are various definitions of partial deregulation. For example, Winston (2012) reviews the history of "partial deregulation" in the U.S. airline industry and advocates that the lingering regulation enforcing barriers to entry be eliminated. His definition of "partially deregulated" differs from the one used in this paper. He refers to the relatively lower set of rules that apply to every firm in the industry, while I refer to markets where some rules apply to some firms and other rules apply to their competitors. Similarly, Nordhaus (2002) discusses the partial deregulation of electricity markets that have, like oil pipeline markets, undergone a shift toward market-based regulation following the Energy Policy Act of 1992. His definition of "partial deregulation" includes both the waning set of rules and inconsistently applied rules where some competitors are subject to state regulations while others are subject to federal regulations.

De Fraja and Delbono (1989) establish a theory of mixed oligopoly where public and private firms, with their distinctive objective functions, engage in Cournot competition in a homogeneous commodity market. They counterintuitively found that public firms aiming to maximize industry welfare in competition with private profit-maximizers achieve higher profits than their private competitors. De Fraja (2009) updates the mixed oligopoly theory, emphasizing the role of differing

distillate No. 2.

[3]Terkelsen (2021b) describes why commodity price differences between the destination and origin market indicate relative rate changes.

objective functions in the outcomes for such markets. Ngo et al. (2007) build off De Fraja and Delbono (1989) to theoretically investigate "coopetition" in markets where both semipublic and purely private firms compete and finds that semi-public firms behave less competitively (i.e., seeking to gain market share) than private firms in these markets.

There have been few empirical studies of partial deregulation. Mixed regulation markets are more common when state and federal policies are inconsistently applied within the same markets. Di Maggio et al. (2019) exploit quasi-experimental variation in state policy to estimate the effect of partial deregulation of national banks on loan origination. They use a difference-in-differences design for the 2004 preemption of national banks from state laws. However, I have not found any studies that examine how firms behave in partially deregulated markets relative to deregulated markets.

This paper proceeds as follows. Section 2.2 characterizes pipeline markets and presents the history of their regulation by FERC. Section 2.3 describes the data I constructed for this analysis. Section 2.4 explains the theory and presents my empirical approach for measuring mixed regulation spillovers within the firm and Section 2.5 does the same for spillovers across firms. The final section describes the implications of my findings.

2.2 Background

A pipeline service is defined by the commodities it serves, the origin market it receives those commodities from, and the destination market it delivers them into. Pipeline demand at the origin consists of refinery production and waterborne imports seeking to sell their commodities, while demand at the destination consists of end-use consumers or local marketers seeking to buy refined products. FERC's market-based rates (MBR) program allows rate deregulation for certain services if firms can demonstrate they lack market power in the relevant origin, destination, and commodity markets. If FERC grants MBRs for those services, that firm can set their prices without FERC supervision for only those services. Other services that the firm offers, even if they are from the same origin market or to the same destination market, are not necessarily deregulated. Nor are the rates of services by other firms in the same origin, destination, and commodity markets. These interesting circumstances are what I call “mixed regulation,” which is a consequence of the case-based nature of FERC’s deregulatory policy. See Terkelsen (2021b) for a more thorough description of how MBR deregulation works.

Note that markets are generally defined by both their geography and the commodit(ies) they serve. However, “markets” in this paper refers only to the geographic markets unless explicitly stated otherwise. Most MBR applications broadly apply for either “crude petroleum” or “pipelineable refined petroleum products.” This paper only examines the latter commodities, which include motor gasoline, aviation gasoline, jet fuel, kerosene, and distillate (diesel fuel or fuel oil).

Between 1990 and 2019, thirteen different carriers applied for MBRs for more than 200 origin and destination markets.[4] Markets vary in size and definition from case to case, but are generally defined by Bureau of Economic Analysis Economic Areas, commonly referred to as "BEAs". BEAs are large clusters of counties surrounding major cities. Other market definitions include 100 mile radii around a refinery or clusters of BEAs. Often carriers will expand their markets 75 to 100 miles beyond BEA boundaries to allow for trucking. However, FERC rulings focus on the more narrow market definition and rarely hinge on these expanded market definitions.

2.3 Data

I collect data from a number of sources to construct my overall pipeline route dataset. My aim was to compile the universe of market routes (defined by the origin market, destination market, and commodity) from 1986 to 2019 and identify which carriers offered service on that route, their regulation status, and market data for each market connected by the route.

The backbone of the dataset is a panel of pipeline services constructed from the LawIQ FERC Oil Tariff Database.[5] This included the origin point, destination point, and commodity served for

[4]See Figure A2.1 for a complete list of FERC market-based rates decisions.

[5]This is a proprietary compilation of FERC tariff sheets, which are publicly available either through FERC’s eLibrary or upon request for older sheets. Tariff sheets are only in PDF form and the inconsistent formatting across years and carriers requires manual tabulation.

each carrier's set of services. The tariff sheets are effective until cancelled by a subsequent tariff filing.

I use these data to identify which services are offered at a given time. To assign services to routes, I aggregated them to their commodity markets using tariff rates and to their origin and destination markets using BEAs.[6] Because the tariff database is only complete from 2007 to 2019, with only infrequent documentation of certain carriers before that period, I needed to impute a large amount of missing data. To supplement data prior to 2006, I capitalized on the fact that oil pipeline infrastructure does not change much over time. For example, PHMSA reported that 72% of oil pipeline infrastructure in use in 2012 was built before the 1980s.[7]

Therefore, from the starting point of services existing in 2007, I attempted to trace the history of each of the 56 carriers to 1986. My initial source was any pre-2007 tariff entry from the Tariff Database. I then turned to online sources for tariff information. I used FERC's eLibrary for declaratory orders for new or changing pipeline services and adoption notices for margers and acquisitions. Using online search engines, I searched for any press releases or news reports pertaining to pipeline construction, reversals and closures, as well as to mergers or acquisitions. For those carriers with little online documentation, I used PHMSA's oil spill database to check that operators and location of any spills matched my inferred pipeline system.

There are obvious limitations to this method of data generation. The most glaring issue is that there are likely network changes that do not leave a paper trail, such as carriers' decisions to not offer certain services in a given period. In this case, we can assume the carrier is offering the service at an infinite price. Other issues, though, imply more serious flaws in the data. For example, it is difficult for services that retired prior to 2007. Carriers rarely announce these closures unless there was an incident, likely an oil spill, that brought it about. Another issue is that I cannot account for changes in commodity service over time. A carrier's decision of whether to offer transportation for a given commodity would influence the relative price difference (i.e, the destination price minus the

[6]I use the 1995 definition of BEAs obtained from the Bureau of Economic Analysis via a FOIA request.

[7]See Figure 11 in their 2012 safety update: https://www.phmsa.dot.gov/sites/phmsa.dot.gov.

origin price) along that route. However, the post-2007 data shows very little variation in commodity service by connection. Therefore I assume pipelines did not change their commodity services prior to 2007.

Once I completed the market-connection panel, I merged in regulatory status using FERC orders on market-based rates (from Table A2.1) and commodity market data from my refined petroleum product (RPP) Market Database. This is a database I generated using methods borrowed from market-based rates cases, which rely on refined products data such as local consumption, refinery production, and waterborne movements. I explain how I created this data in Appendix A2.1.

Table 2.1: Full Data Summary Stats (1986-2019)

	Mean	St. Dev.	Min.	Max.
No. of Carriers	0.949	0.686	0	6
No. of Carriers w/ MBR	0.209	0.447	0	3
% of Carriers w/ MBR	0.221	0.400	0	1.000
Consumption_O	0.236	0.536	0	7.026
Consumption_D	0.186	0.526	0	7.026
$\text{Refinery Production}_O$	0.658	1.515	-0.036	11.274
$\text{Refinery Production}_D$	0.135	0.590	-0.036	11.274
$\text{Waterborne Receipts}_O$	0.018	0.161	0	5.480
$\text{Waterborne Receipts}_D$	0.023	0.214	0	5.480
$\text{Waterborne Shipments}_O$	0.055	0.253	0	3.002
$\text{Waterborne Shipments}_D$	0.005	0.078	0	3.002
Price Difference ($P_D - P_O$)	0.011	0.403	-3.390	3.351
No. of Origin Markets				65
No. of Destination Markets				109
No. of Orig. × Commodity Markets				370
No. of Dest. × Commodity Markets				637
No. of Orig. × Dest. Routes				670
No. of Orig. × Dest. × Comm. Routes				3721
N (Orig. × Dest. × Comm. × Month)				1,562,820

All volume data is reported in thousands of barrels per day and is commodity-specific. The subscript denotes which market the volume data refers to (O = Origin, D = Destination). Refinery Production is net production, which may result in negative values. Prices are in $ per gallon.

Origin markets are generally larger, with more consumption and refinery production. The average origin market connects to 16.34 destination markets, while the average destination market only connects to 2.97 origin markets. At most there are 6 carriers that offer the same service between markets, and on average 22% of these services are deregulated over the study period. In the following sections, I will present two theories of how partial deregulation may affect price setting and empirically test these theories using this dataset.

2.4 Spillovers Within Firms

2.4.1 Theory

Consider a capacity-constrained carrier that offers two heterogeneous services, service 1 and service 2. For example, let service 1 be the delivery of gasoline from Chicago to Toledo and service 2 be delivery of gasoline from Chicago to Detroit.[8] Assume the firm does not possess market power in the origin market, but can influence price in the destination market. Furthermore, allow service 1 to be deregulated. Note that when capacity does not interfere with demand, the firm engages in Cournot competition and will set its rates to reflect the lowest priced alternative above cost. I am interested where capacity constraints alter outcomes. Figure 2.1 below shows how the firm's optimal rate (t^{1*}) changes when its alternative service is deregulated (in Panel (a)) or not (in Panel (b)).

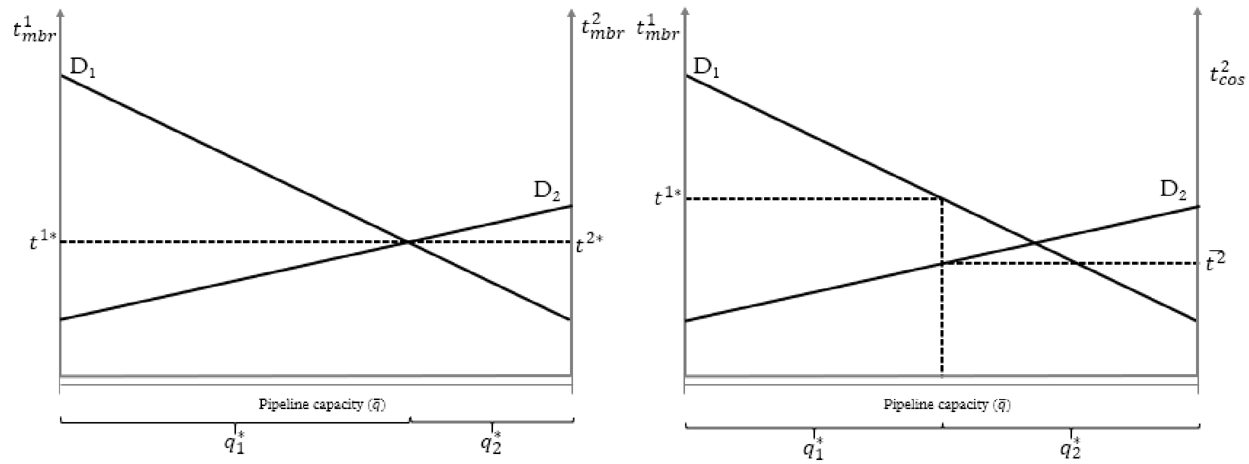
In Panel (a), the firm offers a fully deregulated menu in the origin market. Their optimal rate, t^{1*}, equates the values (i.e., demand) for each service Layson (1988). In Panel (b), when service 2 is regulated (i.e., the carrier offers a mixed menu), pipeline customers nominate q_2^* of the regulated service. This leaves q_1^* left for service 1. The carrier can set its price up to t^{1*} in Panel (b), which represents the intersection of demand and marginal cost (i.e., the residual capacity constraint, $\bar{q} - q_2^*$). If t^{1*} is on the inelastic portion of the D_1 curve, then the carrier will maximize its profits from service 1 at that price.[9] As a result the optimal price in the fully deregulated menu is lower than deregulated rate in the mixed menu.

[8]The key is that they share they same outbound line from the origin markets and, thus, must be allocated on set capacity.

[9]Note that I assume the carrier cannot price supracompetitively in the origin market.

Figure 2.1: Within-Carrier Theory: Baseline Demand

(a) Fully Deregulated Menu (b) Mixed Menu

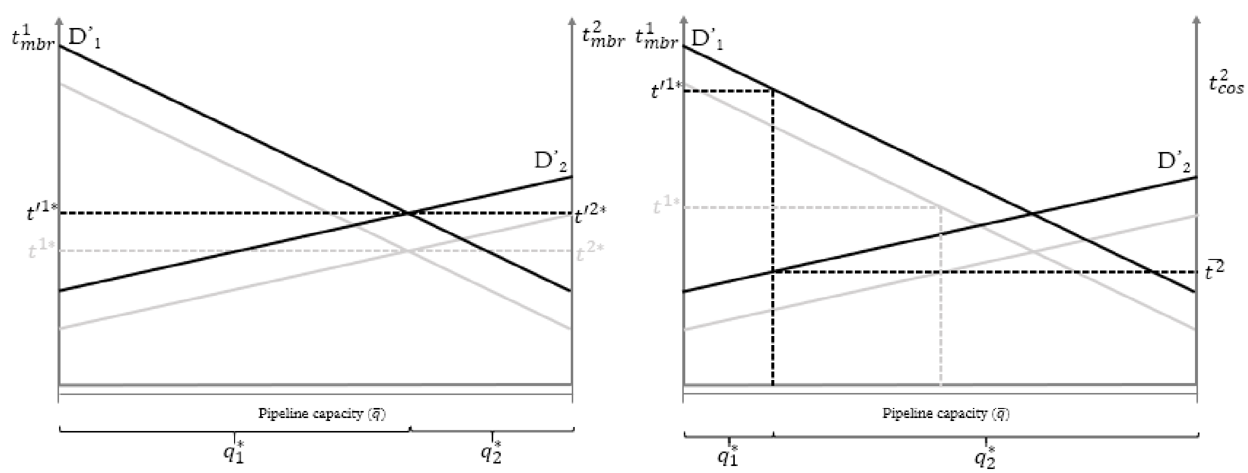


Deregulated rates are denoted by "mbr" for "market-based rate" and the regulated rate is denoted by "cos" for "cost-of-service" rate. The width of the x axis represents the total capacity available. Assume marginal cost of 0.

Now consider when origin market demand increases. Figure 2.2 below shows uniform increases across demand for both services.

Figure 2.2: Within-Carrier Theory: Demand Increase

(a) Fully Deregulated Menu (b) Mixed Menu



Refer to Figure 2.1 above. The gray lines represent outcomes prior to the demand increase.

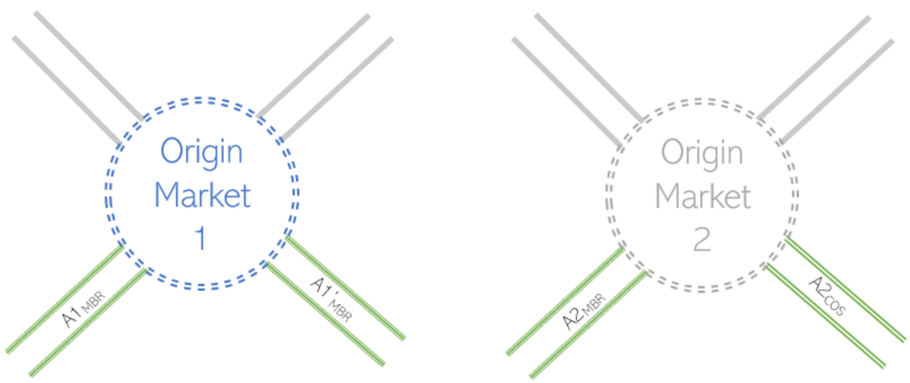
Following an increase in demand, the difference between the optimal rates increases when demand for service 2 is relatively elastic at $\bar{t}^2$. Note that the new t'^{1*} in Panel (b) represents the maximum price the carrier can charge for service 1 when service 2 is rate regulated at $\bar{t}^2$. The carrier can lower t'^1, but the line will be overnominated and the value of quantities transacted will not be reflected by either rendered price.

I conclude that mixed regulation menus result in higher deregulated rates when demand is sufficiently high to be constrained by capacity. Furthermore, increased demand will likely exacerbate this difference.

2.4.2 Empirical Analysis

To test the predictions from the previous section, I compare two types of origin markets. The first type of market contains an MBR carrier with at least two services, all of which are deregulated. In the second market, the carrier's services are mixed— i.e., at least one is deregulated and at least one is regulated. Figure 2.3 depicts these markets.

Figure 2.3: Within-Carrier Comparison



Each pair of parallel lines represents a service exporting refined products from the origin market. The gray services above represent any other services that exist in that market alongside carrier A's two services depicted in green. Note that Origin Market 1 and 2 can either be two different markets or the same market at two different points in time.

The parallel lines represents different pipeline services exporting product from the origin markets. The green services define treatment. My strategy is to compare the rates for $A1_{MBR}$ and $A1'_{MBR}$ to $A2_{MBR}$ using a pooled OLS regression with commodity×time and service fixed effects. The treatment in this case is $D = 1$ if a carrier has all deregulated rates in the origin market and $D = 0$ if a carrier has a mixed menu of rates in the origin market.

I run the following regression (note $i = ODC$):

$$\begin{aligned} n_i(p_{DCt} - p_{OCt}) = \; & \delta_D D_{it} + \delta_R Ref_{Ot-1} + \delta_M MBR_{Ot} + \delta_{DR} D_{it} \times Ref_{Ot-1} \\ & + \delta_{DM} D_{it} \times MBR_{Ot} + \delta_{RM} Ref_{Ot-1} \times MBR_{Ot} \\ & + \delta_{DRM} D_{it} \times Ref_{Ot-1} \times MBR_O + \beta_{OC} X_{OCt-1} + \beta_{DC} X_{DCt-1} \\ & + \alpha_i + \alpha_{Ct}, \end{aligned} \tag{2.1}$$

where $n_i(p_{DCt} - p_{OCt})$ is the commodity price difference normalized within route,[10] D is the treatment described above, Ref_{Ot-1} is lagged origin market demand (total RPP refinery production), and MBR_{Ot} is the percentage of routes (carrier and commodity-destination) in the origin market that are deregulated. I also control for time varying market characteristics using commodity-specific variables from my RPP Market Database and use route and commodity-time fixed effects to control for any unobservable time-invariant route characteristics and commodity-specific nationwide shocks. The series of interacted terms are intended to account for differences in market situations such as higher capacity demand, which is represented by origin market RPP production. The other multiplier, MBR_{Ot}, shows how these effects change with greater overall market deregulation.

My sample consists of any MBR-approved routes with origin markets where at least one MBR-approved carrier offers two or more services. Then I assign treatment according to the method above. Note that $D = 1$ if at least one carrier has a fully deregulated menu of services out of the origin market and $D = O$ otherwise. Also note that, because firms acquire MBRs over time and enter or exit markets, it is possible that D turns on and off for a given route over time.

We can see that commodity price differences are higher among fully deregulated carriers, as well as origin demand. This suggests that the high-demand origin markets are more likely to have fully deregulated carriers. The price differential is likely a consequence of the higher demand, as larger origin market refinery production floods the market and suppresses origin market commodity prices. However, we see consumption and waterborne receipts in these markets are lower than the mixed regulation markets. Such differences, as well as those among the other end

[10]This allows for easier interpretation of coefficients in the regression, where a one unit change in the left hand side is the standard deviation from the route average.

Table 2.2: Within-Carrier Spillover Sample

	$D = 0$	$D = 1$	Sample		$D = 0$	$D = 1$	Sample
Normalized $P_D - P_O$	0.021	0.049	0.031	WB Shipments$_O$	0.008	0.121	0.047
	(1.139)	(1.195)	(1.159)		(0.061)	(0.358)	(0.224)
Origin Demand	2.430	8.045	4.397	WB Shipments$_D$	0.002	0.009	0.004
(RPP Production$_O$)	(2.610)	(5.799)	(4.835)		(0.009)	(0.087)	(0.052)
MBR	0.483	0.512	0.493	Refinery Prod.$_O$	0.415	1.478	0.787
	(0.203)	(0.173)	(0.194)		(0.911)	(2.374)	(1.665)
Consumption$_O$	0.347	0.302	0.331	Refinery Prod.$_D$	0.208	0.327	0.250
	(0.802)	(0.560)	(0.726)		(0.652)	(0.835)	(0.724)
Consumption$_D$	0.275	0.298	0.283	Carriers$_{ODC}$	1.339	1.381	1.354
	(0.724)	(0.709)	(0.719)		(0.766)	(0.673)	(0.735)
WB Receipts$_O$	0.059	0.018	0.044	MBR Carriers$_{ODC}$	1.047	1.174	1.091
	(0.357)	(0.051)	(0.290)		(0.234)	(0.398)	(0.308)
WB Receipts$_D$	0.050	0.043	0.047				
	(0.308)	(0.277)	(0.298)	N	179483	96784	276267

All volume data are reported in thousands of barrels per day. The normalization of price differences occurs within route over time.

market characteristics appear insignificant. However, the more worrisome differences in the origin market demand and MBR may be largely attributable as variation across markets, and therefore do not warrant concern when route fixed effects are present.

I present the results of the OLS regression in Table 2.3. The columns vary based on the types of fixed effects that were included.

Overall effects appear robust to the specification. The first thing to note is the positive coefficient on D. As stated in the theory section, markets where carriers are partially deregulated and *not* capacity constrained will be forced to compete with their own lower regulated rates. This would result in relatively low deregulated rates and therefore relatively low commodity price differences compared to fully deregulated firms (i.e., $D = 1$). Therefore the effect of being partially deregulated increases price differences.

However, when looking at the interaction of D and origin demand, I find evidence that supports the theory. When demand increases, rates by fully deregulated carriers decrease relative to rates by partially regulated carriers. This allows relatively more product to flow to those destinations and lower destination commodity prices. However, when looking at the full interaction, this effect appears to diminish as the proportion of market-based rates services increase in the origin.

Table 2.3: Within-Carrier Spillovers Regression Output

	(1)	(2)	(3)	(4)
D	0.883^{***}	0.889^{***}	0.872^{***}	0.869^{***}
	(0.243)	(0.249)	(0.246)	(0.251)
Origin Demand_{t-1}	0.090^{***}	0.089^{***}	0.090^{***}	0.089^{***}
	(0.024)	(0.025)	(0.024)	(0.025)
D×Origin Demand_{t-1}	-0.059^{*}	-0.059^{*}	-0.059^{*}	-0.057^{*}
	(0.025)	(0.025)	(0.025)	(0.025)
MBR_O	-0.275	-0.288	-0.282	-0.282
	(0.236)	(0.260)	(0.238)	(0.260)
D×MBR_O	-0.843^{**}	-0.848^{**}	-0.832^{**}	-0.829^{**}
	(0.273)	(0.283)	(0.277)	(0.287)
Origin Demand_{t-1}×MBR_O	0.025	0.032	0.023	0.031
	(0.066)	(0.068)	(0.066)	(0.068)
D×Origin Demand_{t-1}×MBR_O	0.021	0.022	0.024	0.023
	(0.055)	(0.056)	(0.054)	(0.056)
Orig×Comm FE	Y	N	Y	N
Dest×Comm FE	Y	N	Y	N
Orig×Dest×Comm FE	N	Y	N	Y
Carrier FE	N	N	Y	Y
Observations	276267	276267	276267	276267

Standard errors clustered by origin market-destination market-commodity. Origin Demand refers to origin market total refined products refinery production, which represents total capacity demand. Lagged variables are denoted with a $t-1$ subscript. Carrier FE are not mutually exclusive and include only MBR-approved firms. See full table in Table A2.2.

It is comforting that the other significant effects in the table align with theory as well. As refinery production (origin demand) increases, we would expect the price difference to increase since volumes would flood the origin market and lower the origin commodity prices. Similarly, the effect of partially deregulated markets competing with low regulated rates diminishes as MBR alternatives emerge (i.e., the coefficient on $D \times MBR$ is proportionally negative). Finally, though insignificant, it is promising that price differences decrease as the proportion of MBRs increase. This suggests that deregulation is doing its job in allowing price signals to properly allocate goods and lower arbitrage opportunities on average.

2.5 Spillovers Across Firms

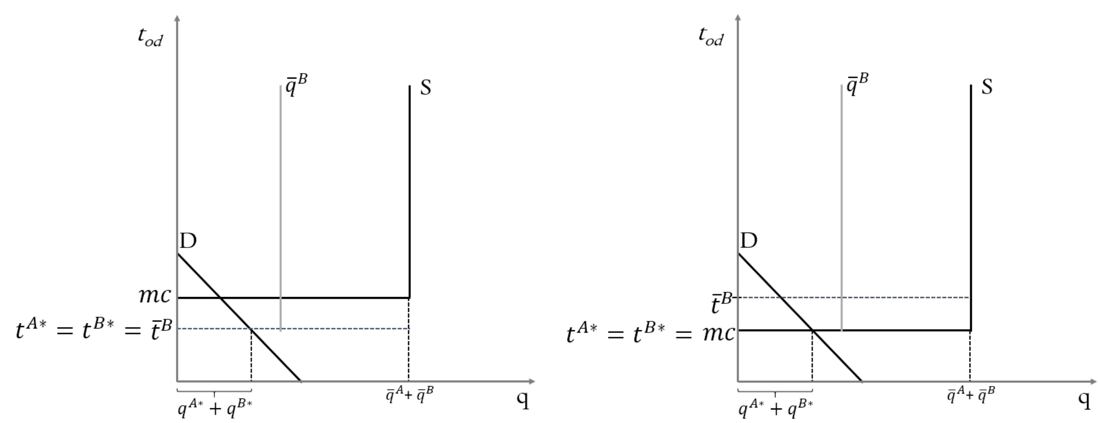
2.5.1 Theory

Suppose carriers A and B compete against one another in a homogeneous origin market. Let carrier A be deregulated and let both carriers share the same constant marginal cost, mc. We will explore how A's price-setting strategy changes with B's regulatory status and overall demand.

First, consider demand so low that it does not intersect with the joint capacity constraint. If B is regulated, then its rate is capped at $\bar{t}^B$. It could be that $\bar{t}^B$ is less than marginal cost, in which case carrier A would either exit the market or also charge below cost in the short run. See Figure 2.4a. However, I will focus on the case when $\bar{t}^B$ is greater than marginal cost. Figure 2.4b shows that when demand intersects the supply curve below the regulated firm's capacity, both carriers will charge mc regardless of carrier B's regulatory status. This is the Nash equilibrium since each carrier's best strategy would be to undercut the other if they charge above mc.

Figure 2.4: Across-Carrier Theory: Low Demand

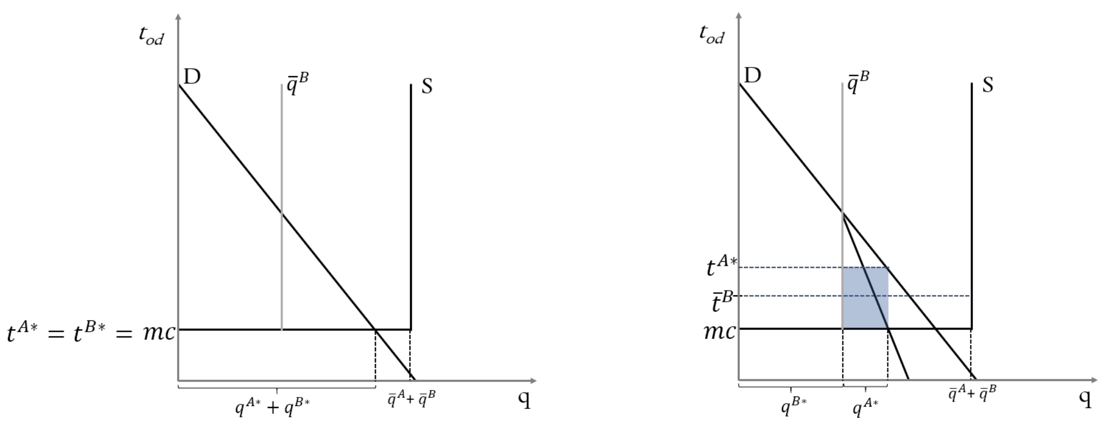
(a) Regulated rate less than mc (b) Regulated rate greater than mc



Now consider when demand rises such that it intersects the supply curve beyond carrier B's capacity ($\bar{q}^B$) but before total capacity ($\bar{q}^A + \bar{q}^B$), as in Figure 2.5. Then the optimal pricing strategy under full deregulation is to again set rates to mc. The rationale is the same as before where each firm will undercut the other if set above cost. Carriers will split zero profits. However, in the mixed regulation market, carrier A can charge above $\bar{t}^B$. If they do, pipeline customers will fully subscribe to carrier B's capacity at $\bar{q}^B$. Then, supposing a duopoly, carrier A is able to monopolize the residual demand (i.e., $D(t) - \bar{q}^B$). Here, we see A is making more profits (in blue rectangle) than they did in the fully deregulated market. This suggests that the relevant destination market is receiving fewer quantities under mixed regulation, likely inflating the commodity price difference between the connected markets.

Figure 2.5: Across-Carrier Theory: Medium Demand

(a) Fully Deregulated Market (b) Mixed Regulation Market

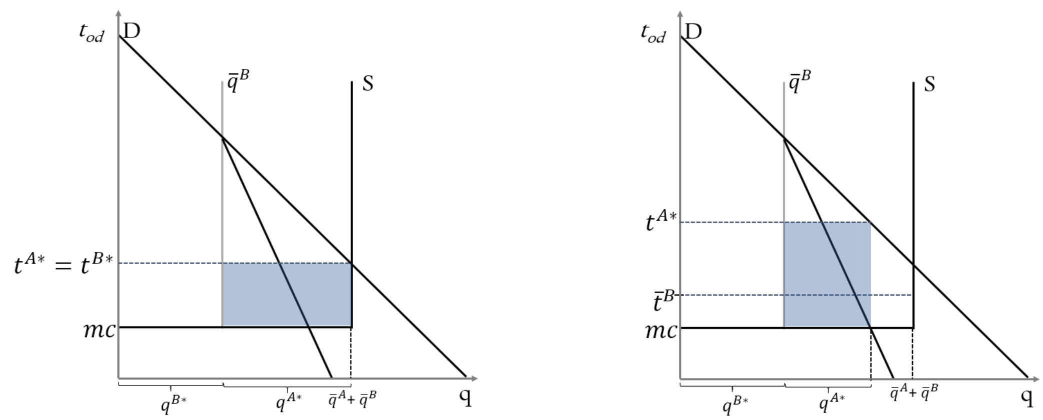


A similar strategy emerges when demand is so high that it intersects with total capacity, as it does in Figure 2.6. In the fully deregulated market, firms compete and set prices at the Bertrand-Edgeworth equilibrium such that t^{A*} and t^{B*} cannot increase above the intersection of supply and demand. In this case, capacity is fully subscribed and carrier A earns the profit in the blue rectangle. In the mixed regulation market, however, carrier A can again wait until carrier B fills up at their regulated rate and then monopolize the residual demand. Panel (b) shows that total quantity delivered is lower when the market has mixed regulation. Consequently, we would expect price differentials to be higher in the more mixed markets.

Note it is unclear whether increased demand exacerbates the difference between fully dereg-

Figure 2.6: Across-Carrier Theory: High Demand

(a) Fully Deregulated Market (b) Mixed Regulation Market



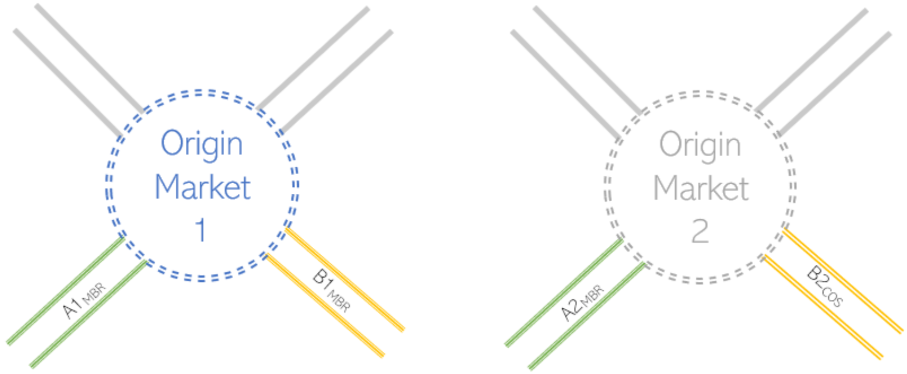
ulated and mixed regulation markets. Increases in demand between $\bar{q}^B$ and $\bar{q}^A + \bar{q}^B$ appear to produce the largest discrepancies. But, when demand exceeds total capacity, it seems the discrepancy between fully deregulated quantities and mixed regulation quantities dissipates since the fully deregulated quantities are capped.

2.5.2 Empirical Analysis

My ability to compare fully deregulated and mixed regulation markets is limited by the fact that very few markets become fully deregulated. Ideally, I could perform the same type of analysis as I did for the intra-firm spillovers. Figure 2.7 depicts the ideal comparison of service $A1_{mbr}$ in a fully deregulated market to service $A2_{mbr}$ in a partially regulated market.

It is unclear how deregulated a market must be for an MBR firm to behave as though it were in a fully deregulated market. I assume that firms with at least one other MBR competitor in an origin market behave more akin to a fully deregulated market since the presence of one other competitor could discipline prices. Therefore in my pipeline route data, I generate a treatment variable D such that $D = 1$ if there are at least two firms with MBR authorization for the origin market and $D = 0$ when only one firm has MBRs in an origin market. My sample is any route with approved MBRs

Figure 2.7: Across-Carrier Comparison



Each pair of parallel lines represents a service exporting refined products from the origin market. The gray services above represent any other services that exist in that market alongside carrier A's services depicted in green and carrier B's services in yellow. Note that Origin Market 1 and 2 can either be two different markets or the same market at two different points in time.

and more than one competing carriers in the origin market. To form a more balanced sample, I remove any routes from the observations where $D = 1$ to ensure each route has only one MBR carrier.

Table 2.4: Across-Carrier Spillover Sample

	$D = 0$	$D = 1$	Sample		$D = 0$	$D = 1$	Sample
Normalized $P_D - P_O$	0.032	0.008	0.022	WB Shipments$_O$	0.003	0.105	0.046
	(1.096)	(1.220)	(1.149)		(0.033)	(0.330)	(0.221)
Origin Demand	1.551	7.805	4.173	WB Shipments$_D$	0.003	0.006	0.004
RPP Production$_O$	(1.620)	(5.287)	(4.772)		(0.035)	(0.073)	(0.054)
MBR	0.525	0.449	0.493	Refinery Prod.$_O$	0.261	1.427	0.749
	(0.230)	(0.135)	(0.199)		(0.541)	(2.261)	(1.626)
Consumption$_O$	0.312	0.366	0.335	Refinery Prod.$_D$	0.236	0.238	0.237
	(0.798)	(0.651)	(0.740)		(0.700)	(0.718)	(0.707)
Consumption$_D$	0.280	0.266	0.274	Carriers$_{ODC}$	1.173	1.301	1.226
	(0.706)	(0.718)	(0.711)		(0.502)	(0.639)	(0.567)
WB Receipts$_O$	0.064	0.022	0.047	MBR Carriers$_{ODC}$	1.000	1.000	1.000
	(0.392)	(0.056)	(0.301)		(0.000)	(0.000)	(0.000)
WB Receipts$_D$	0.046	0.048	0.047				
	(0.290)	(0.304)	(0.296)	N	148414	107155	255569

All volume data are reported in thousands of barrels per day. The normalization of price differences occurs within route over time.

In Table 2.4 I present summary statistics for this sample. Similar to the previous analysis, routes in more deregulated markets have higher origin market demand on average. Unlike the previous sample where this aligned with higher price differences, the normalized price differences appear slightly higher in the mixed regulation markets. Note that I include the number of MBR carriers on the route to demonstrate the sample is limited to only those routes with one MBR carrier.

I run a regression identical to Equation 1, but for the newly defined treatment. The outcome is the normalized price difference between the connected markets. Table 2.5 below presents the results of this regression using various combinations of fixed effects.

Table 2.5: Across-Carrier Spillovers Regression Output

	(1)	(2)	(3)	(4)
D=1	0.081	0.016	0.070	-0.002
	(0.184)	(0.200)	(0.184)	(0.201)
Origin Demand$_{t-1}$	0.084**	0.083**	0.079**	0.086**
	(0.029)	(0.031)	(0.029)	(0.030)
D×Origin Demand$_{t-1}$	-0.016	-0.013	-0.013	-0.015
	(0.026)	(0.028)	(0.026)	(0.028)
MBR$_O$	-0.682*	-0.798*	-0.697*	-0.770*
	(0.270)	(0.314)	(0.271)	(0.312)
D×MBR$_O$	0.520	0.579	0.515	0.597
	(0.318)	(0.343)	(0.321)	(0.345)
Origin Demand$_{t-1}$×MBR$_O$	-0.010	-0.045	-0.002	-0.043
	(0.123)	(0.138)	(0.124)	(0.136)
D×Origin Demand$_{t-1}$×MBR$_O$	-0.008	0.032	-0.013	0.033
	(0.121)	(0.135)	(0.120)	(0.132)
Orig×Comm FE	Y	N	Y	N
Dest×Comm FE	Y	N	Y	N
Orig×Dest×Comm FE	N	Y	N	Y
Carrier FE	N	N	Y	Y
Observations	255569	255569	255569	255569

Standard errors clustered by origin market-destination market-commodity. Origin Demand refers to origin market total refined products refinery production, which represents total capacity demand. Lagged variables are denoted with a $t-1$ subscript. Carrier FE are not mutually exclusive and include only MBR-approved firms. See full table in Table A2.3.

As in the previous analysis, I find that origin demand is positively correlated with price differences while the continuous MBR variable measuring incremental deregulation is associated with lower price differences. Little else tells a compelling story, though the interaction of the treatment variable and origin demand aligns with my theoretical predictions and is consistent across specifications despite not being statistically significant. This is a good indication that markets with more deregulated firms lower arbitrage opportunities relative to markets where one deregulated firm competes against regulated alternatives.

2.6 Conclusion

In this paper, I identify two unintended consequences of mixed regulation markets. I demonstrate both theoretically and empirically that when only some firms are subject to price caps in otherwise competitive markets, unregulated firms do not behave as expected. Rather than price competitively, deregulated firms in capacity-constrained mixed regulation markets raise their prices above competitive levels when demand increases. Regulatory commissions should be aware of these trade-offs when deciding how deregulation should evolve in their respective industries. In the case of oil pipelines, regulators should prioritize whether partially deregulated markets may generate more social welfare if deregulated fully.

I also present novel data for studying refined products and petroleum pipeline markets in the United States. Though there are many directions to expand the information it contains,[11] these data offer more transparency to a historically opaque but major industry. My hope is that these data facilitate more research into oil pipelines in the future.

[11] Completing the tariff dataset through 1986 would produce a more accurate history of regulated oil pipeline carriers since FERC's revisions of its ratemaking methodologies. Furthermore, adding crude networks would allow for better understanding of the upstream market in the U.S.

CHAPTER 3

REGULATORY THREAT UNDER ADMINISTRATIVE LITIGATION

3.1 Introduction

Legislative regulation is generally thought of as a blanket action, affecting all firms in the industry concurrently and uniformly. Administrative litigation takes a more tailored approach, allowing regulatory matters to be adjudicated between stakeholding parties. As a result, firms whose actions fall under the purview of a regulatory agency must be strategic in their behavior to avoid unwanted legal fees and the risk of profit-reducing rulemakings. This paper examines how firms behave when the threat of regulation by administrative law agencies increases.

On March 30, 2012 the Federal Energy Regulatory Commission (FERC) appeared to revise its longstanding tone of regulatory lenience when it rejected a routine rate filing and ordered that *Buckeye Pipe Line* justify continuance of its flexible rates program (i.e., unregulated rates). After surprisingly reinstating rate regulation on several of *Buckeye*'s services, which had gone without regulation for nearly 22 years, FERC further solidified its pro-regulation stance when in 2017 it reestablished cost-based rates on additional *Buckeye* services following the first ever complaint against FERC market-based rates. Fears of other firms under FERC's purview were realized when customers immediately lodged a series of complaints against *Colonial Pipeline Company*, the largest pipeline network in the country, which had previously enjoyed rate deregulation under FERC for nearly two decades.

Existing literature has modeled regulatory review as either stochastic (Klevorick, 1973 and Bawa and Sibley, 1980) or an equilibrium outcome between a firm and regulator (Peltzman, 1976, Lyon and Maxwell, 2003 and Glazer and McMillan, 1992). I adopt Glazer and McMillan's framework, but modify it to reflect modern procedures in which reviews are initiated by a complainant *with standing* – i.e., someone whose welfare is of direct consequence to the review. I find that customers are more likely to file complaints against firms when they believe rulemakers (i.e., commissioners) will side with them. The model also implies that monopolistic firms will curb their prices, or self-regulate, when commissioners appear more sympathetic to complainants or seem more regulation-prone.

Previous papers have extended the conceptual framework from Glazer and McMillan (1992) to energy markets. For example, Brunekreeft (2004) extends the model to reflect vertical integration as a policy analysis tool for the German electricity supply industry. My paper also contributes to other literature that has empirically tested predictions from regulatory threat models. Erfle et al. (1990) show that oil price increases were limited despite the supply shocks resulting from the 1979 crisis due to media and therefore political attention. Driffield and Ioannidis (2000) demonstrate a long-term decline in profit margins in the UK petroleum industry following the 1979 Monopolies and Mergers Commission investigation. Most recently, Bonev et al. (2020) find evidence that firms reduce prices in Swedish heating markets when customer complaints increase.

Because regulation under administrative law can be narrowly applied to individual firms or even specific services, I empirically test the predictions of my regulatory model within the oil pipeline industry by comparing firms' pricing behavior for their more vulnerable services to that for their less vulnerable services. I construct a novel panel dataset of pipeline rates and other refined products market factors (i.e., consumption, refinery production, and waterborne transportation) and estimate an event study regression comparing dynamic price effects of the 2012 Order on services that either (a) serve markets with higher market concentration statistics and are therefore more likely to be regulated or (b) were previously contested when the firm applied for deregulation. I find that pipeline carriers do not appear to curb prices in highly concentrated or previously contested markets, and instead set prices as myopic profit-maximizers.

3.2 FERC's Threat of Regulation

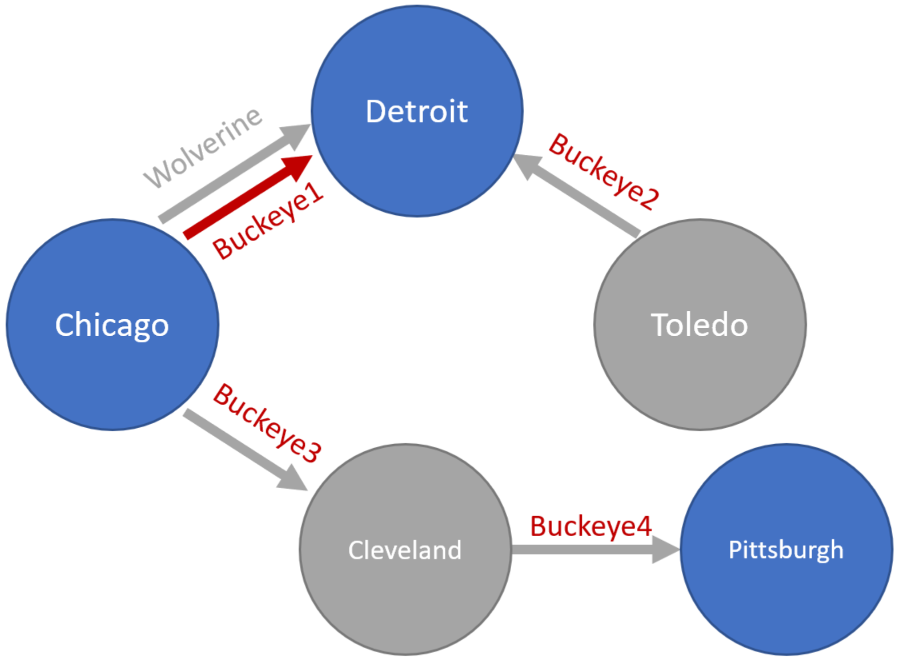
3.2.1 Market-Based Rates Program

Since the early 1990s FERC has offered oil pipeline carriers a variety of options to ease the administrative burden of regulation, even up to the point of removing price controls altogether. The market-based rates (MBR) program authorized applicant carriers to set flexible rates between markets in which the Commission determined they lacked market power. Though FERC retained jurisdiction over these rates, MBRs removed price controls from otherwise cost-regulated rates and were effectively rate deregulation. The policy was a virtual open door to those carriers who could incur the cost of the application, which required complex market analyses of all commodity and geographic markets in which the rates would apply. From 1990 to 2011, 88% of market applications were approved by FERC. In fact, only one applicant did not receive approval for any of its markets solely because it withdrew before the case went to hearing. In order to charge a MBR for a given service, a carrier must demonstrate that it lacks market power in both the origin market and the destination market of the service.

Consider the following example (refer to Figure 3.1). Say Buckeye, owner and operator of four pipelines shown below, was approved for market-based rates in the Chicago origin and the Detroit and Pittsburgh destination markets (in blue), but not for the Toledo origin market or Cleveland destination market (in grey). Then, the red pipeline connecting Chicago to Detroit would be approved for market-based rates and deregulated. However, Buckeye's line to Cleveland, even though it originates in an approved origin market, would not be deregulated because it is destined for an unapproved destination market. Likewise, Buckeye's line originating in Toledo is destined for an approved destination market, but would not be deregulated because it originates in an unapproved origin market. If Cleveland were en route to Pittsburgh, Buckeye3 would still remain regulated for service between Chicago and Cleveland even though it is a segment of a deregulated service. Finally, another pipeline linking Chicago and Detroit, which is owned by Wolverine, would not be deregulated even though it operates in the same approved markets as Buckeye1. To obtain market-based rates authority, it must submit its own application for these markets.

As with any litigated process, the requirements to obtain MBRs has transformed over the years, resulting in a fluctuating threshold of competitiveness for MBR approval. The current application process requires eight "statements" that define the geographic and commodity markets, identify those markets' immediate and potential alternatives, and calculate market concentration statistics. If an application or a set of specific markets within the application is not protested within a specified

Figure 3.1: MBR Diagram



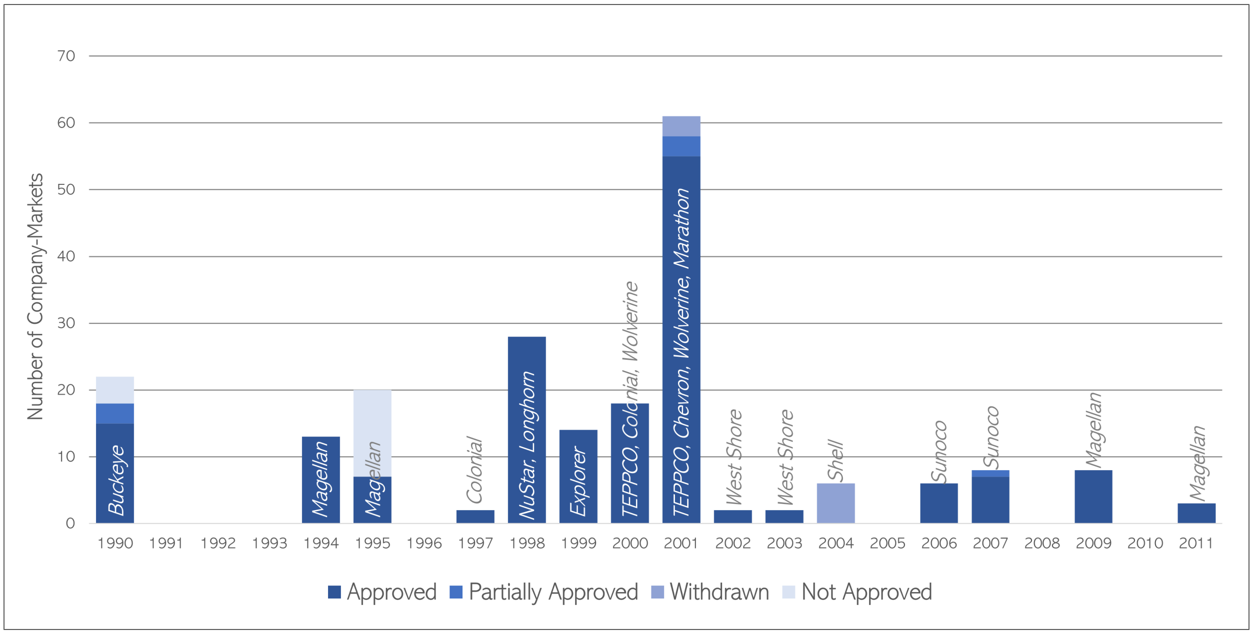
time frame, it is approved without contest. However, if an application is protested either in whole or in part, then the case is set for what is often a long and expensive administrative hearing on the protested markets. Some cases end in settlement, in which requests for certain markets or certain parts of markets are withdrawn, but many cases end with a FERC order that establishes new precedent, grants MBRs for at least some markets and rejects others. Figure 3.2 shows the history of MBR rulings for refined products carriers by determination.

Of the 213 markets that were evaluated, 180 were approved, 7 were partially approved,[1] 9 were withdrawn before a determination was made, and 17 were rejected. Note that the same geographic market may be represented more than once in these data since each carrier must apply separately for their own services in a market, and a geographic region may serve both as an origin market and a destination market. See Figure A3.1 in the Appendix for a map of markets.

By January 2012, more than half (54%) of all refined product pipeline services had MBRs

[1] Buckeye's partially approved markets are those that did not receive a market power determination, but were permitted flexible pricing. All other partial approvals refer to markets in which only a sub-region was approved.

Figure 3.2: Market-Based Rates Determinations from 1990 to 2011



Note: The approved carriers are listed inside the bar of their determination year. Buckeye's partially approved markets are those that did not receive a market power determination, but were permitted flexible pricing. All other partial approvals refer to markets in which only a sub-region was approved.

and one quarter of all regulated carriers participated in the program. The companies in the chart above (*Buckeye*, *Colonial*, *Magellan*, etc.) represent the largest oil movers in the country, hinting at the large fixed costs associated with market-based rates applications. These costs are drastically higher when an application is contested by an interested party, typically one of the customers on the pipeline. Since the experimental programs for Buckeye and Magellan, which did not go through the now established application process, about 45% of markets have been contested resulting in 60% of applications going to hearing or settlement negotiations.[2] Hearings are so expensive that *Shell Pipe Line* withdrew its application and sold off its assets in 2005 upon receiving complaints. Another indicator of the high application costs is that 15 carriers offered cost-regulated services in 2012 that were already authorized for market-based rates for other carriers. However, these 15 carriers have never applied for MBR authority in these or any of their other markets despite being

[2] A single application will contain all markets in which the carrier seeks approval at that time. If an application is not contested within some period, then all markets will be approved by FERC. If one of, say, five markets are contested after an application, then that market's determination is set for hearing by FERC while the other four are approved.

smaller alternatives (i.e., holding less market power) than their competitors.

It is reasonable why companies who can afford it are willing to pay such a great cost for deregulation. Though market power determinations are based on statistics at the time of the application, the authorization for MBRs is indefinite. Up until 2013 the authority, once given, had never been revoked. However, pipeline customers have always had the option to protest rates, which could lead to the removal of MBR authority. This is markedly different from a contested application since the burden of proof shifts to the protester of the rates rather than the carrier. Given FERC's seeming deference to applicant carriers in the past, it makes sense that pipeline customers would not think it a profitable strategy to incur the cost of protesting market-based rates.

3.2.2 The FERC Shift

FERC's tone appeared to shift in 2013 when it revoked *Buckeye Pipe Line*'s market-based ratemaking authority for several services after reviewing its 22-year-old experimental rates program. Buckeye's program was essentially a pilot for what would become the codified MBR program.[3] It was oddly never reviewed or officially grandfathered into the established program until March 2012 when FERC unexpectedly rejected *Buckeye*'s recently posted rates and requested that it "show cause" for continuing its experimental program.[4] Less than one year later in February 2013, FERC rejected *Buckeye*'s request that the program continue or, at least, have its services grandfathered into general MBRs. Instead, FERC only granted some services continued MBR flexibility and demoted others to cost-based ratemaking.

This marked an apparent shift in FERC's formerly lenient attitude toward MBRs. What followed was a cascade of events that would further solidify FERC's new stance in pipeline carrier eyes. Within a year of the order re-regulating *Buckeye*'s services, two pipeline customers filed a first-of-its-kind protest against two of *Buckeye*'s approved MBR markets, Pittsburgh and Harrisburg. Despite

[3]Unlike the MBR program established in 1994, the Buckeye experimental program imposed a cap on rate increases, though it was often non-binding. Otherwise, the program offered the same flexible pricing as the official version.

[4]See the press release here: https://www.globenewswire.com/en/news-release/2012/04/02.

the administrative law judge's recommendation in April 2016 that only Buckeye's Harrisburg authority be revoked, the Commission went even further in November 2017 when it revoked authority in both markets (Federal Energy Regulatory Commission, 2017). Less than one week later, three parties lodged a protest against *Colonial Pipeline Company*, which was the first company to obtain official market-based rates authority rather than be granted a pilot program. Since then, 11 other complainants have joined the case, which is ongoing at the time this paper is written.

Given these circumstances, carriers are reasonably concerned that their ratemaking flexibility might be next to be challenged and possibly revoked. As such, they are likely to modulate their behavior in order to avoid that.

3.3 Theory

To predict how firms behave under regulatory threat, I modify Glazer and McMillan's (1992) model of firm pricing under regulatory threat. Rather than fearing rate regulation by a legislator whose utility increases in expected profits and decreases in price (Peltzman, 1976), firms governed by administrative law fear lawsuits or "complaints" from parties with standing, *i.e.*, their own customers.

Following a complaint, the regulatory commission requests information from both parties to decide whether to rule with or against the complainant. This is my key divergence from Glazer and McMillan (1992) in that I do not assume that regulation will occur upon a complaint (or proposed legislation). I capture the expected probability of ruling with the complainant with ϕ. Assume there are N identical customers on a pipeline. Let the expected benefit of an individual customer i filing a complaint be

$$B_i = \phi(P - P^R)Q_i/\delta_i, \tag{3.1}$$

where P is the current price charged by the firm, P^R is the expected regulated price, $Q_i = Q_i(P)$ is the quantity demanded by the firm at price P, and δ_i is a customer's discount rate. For simplicity, I assume customer demand is identical across all customers and is substantially inelastic such that the difference between $Q_i(P)$ and $Q_i(P^R)$ is negligible. However aggregate Q is permitted to change with P on the extensive margin as customers enter and exit the market.

The costs of filing a complaint can be significant. A complainant should expect to hire outside lawyers and consult experts to argue its case throughout the legal proceeding, which can last several years. Because of the specific market studies stipulated to support or defend against a complaint, the costs would be independent of expected outcome unless more than one party joins the complaint and shares the burden.[5]

If a customer files a complaint, their payoff is $B_i - K$. Because regulated common carriers are prohibited from price discriminating, all customers receive the identical benefits if the complaint succeeds. If rate regulation is imposed, all customers will pay P^R. This presents a free-rider problem to all customers when aggregate B exceeds the cost of the complaint, K, but K is borne only by the complainant.

When individual B_i exceeds K and customers participate in a simultaneous move game, there is an obvious pure Nash Equilibrium where only one customer files a complaint. But, I will focus on the symmetric mixed strategy Nash equilibria. Let ν be the probability that any one of the $N > 1$ customers files a complaint (i.e., the mixed strategy probability). I will solve for the equilibrium ν as a function of other parameters.

There will be at least one complaint with probability $1 - (1 - \nu)^N$. Then the expected payoff for a customer who does not lodge a complaint is $B[1 - (1 - \nu)^{N-1}]$, or the expected benefit multiplied by the probability that at least one other customer will lodge a complaint. Thus, in equilibrium,

$$B[1 - (1 - \nu)^{N-1}] = B - K. \tag{3.2}$$

Solving for ν, the probability for each customer lodging a complaint is $\nu = 1 - (K/B)^{1/(N-1)}$ and for at least one customer lodging a complaint is

$$\mu = 1 - (K/B)^{N/(N-1)} = 1 - \frac{K\delta}{\phi(P - P^R)Q}^{N/(N-1)}. \tag{3.3}$$

It is apparent that $\mu_K < 0$ and $\mu_\phi > 0$, where the subscripts denote partial derivatives. Several factors can affect ϕ, such as recent commission orders or changes to market conditions that could

[5]This reflects the circumstances of the ongoing case against Colonial Pipeline Company in which 14 complainants have joined.

alter a determination of market power. P can enter the equation through several parameters. In principle, both the cost of filing the complaint and the probability of success could depend on the price, such that we have $K(P)$ and $\phi(P)$. Thus, the partial derivative of equation (3.3) with respect to price has a complicated form, given by the following:

$$\mu_P = -\frac{N}{N-1}\left[\frac{K\delta}{\phi(P-P^R)Q}\right]^{1/(N-1)}\left[\frac{\delta[(P-P^R)(\phi K_P - \phi_P K) - \phi K]}{\phi^2(P-P^R)^2 Q}\right] \tag{3.4}$$

Since $P > P^R$, $\phi K > 0$, and the denominator is positive, the direction of μ_P depends on $\phi K_P - \phi_P K$. It is likely that $K_P = 0$ because of the specific analyses required for any rate case. Although, it is possible that $K_P < 0$ since more creative and potentially expensive analysis would be necessary to demonstrate market power exists despite sub-monopolistic pricing. In the same vein, $\phi_P < 0$ since a commission is more likely to accept a complaint when the company of interest is exhibiting monopolistic characteristics like raising prices, all else equal. I can therefore conclude that the probability of any one customer complaint is increasing in P.

3.3.1 The Firm's Problem

The firm is not only cognizant of the probability a customer complains, but also shares its expectations about how the regulator will rule. Although the firm should expect to incur some cost, L, if a complaint is filed regardless of which way the commission rules. I am omitting this factor to facilitate calculations. The firm will solve a dynamic optimization problem where they balance current period profits against the risk of getting locked into regulation in later periods.

The firm's discounted profits if regulation is enacted are

$$V^R = [Q(P^R)P^R - C(Q(P^R))]/\delta_j = \pi^R/\delta_j, \tag{3.5}$$

where δ_j is the firm's discount rate, $Q(P)$ is its downward sloping demand, and $C(Q)$ is its convex cost function.

When setting its price, the firm considers both the possibility of experiencing a complaint and the possibility of it resulting in regulation. Its discounted profit function is

$$V = \quad QP - C + [\mu\phi V^R + (1-\mu\phi)V]/(1+\delta_j). \tag{3.6}$$

Solving for V gives me

$$\begin{aligned} V = & \ [(1+\delta_j)\pi + \mu\phi V^R]/(\mu\phi + \delta_j) \\ = & \ [(1+\delta_j)\pi + \mu\phi V^R + \delta_j V^R - \delta_j V^R]/(\mu\phi + \delta_j) \\ = & \ V^R + [(1+\delta_j)\pi - \pi^R]/(\mu\phi + \delta_j). \end{aligned} \tag{3.7}$$

3.3.2 Effect of Commission Bias on Prices

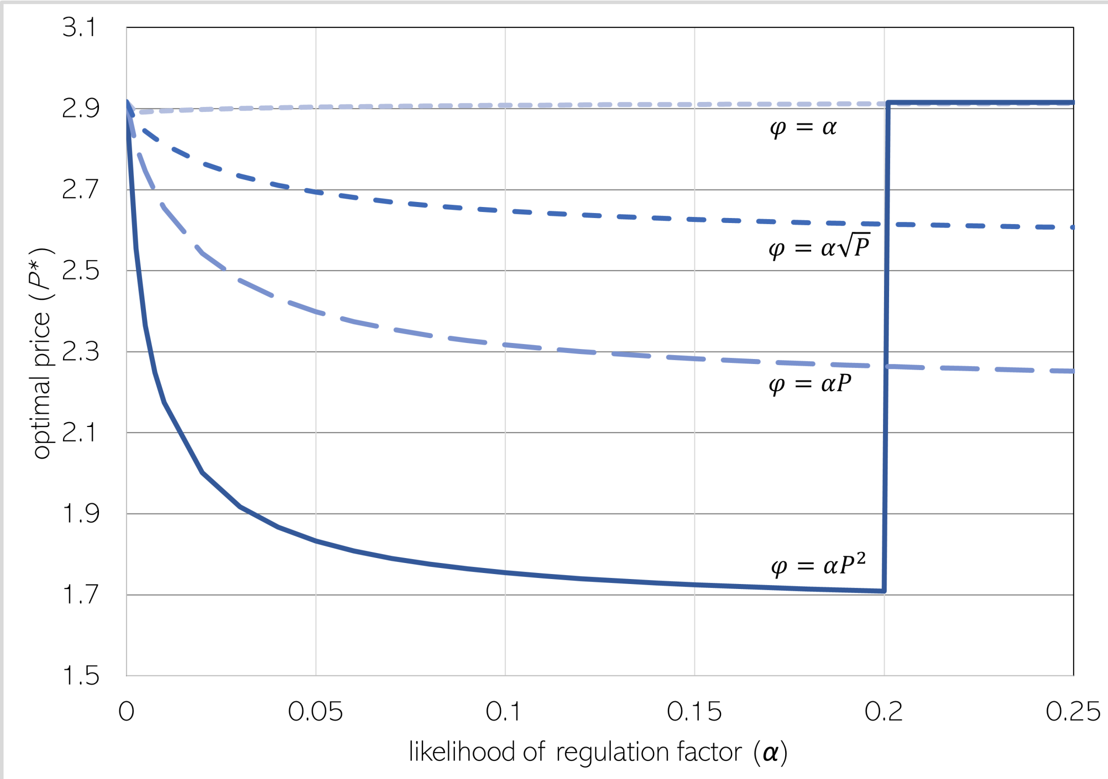
This paper is interested in the effect of regulatory threat on firm pricing. The threat in this case is a perceived bias detected in the regulatory commission based on, for example, the actions and words of its members or landmark rulings on relevant cases. Firms assess their standing with its regulators based on these observable factors and make decisions accordingly. Perceived commission bias on one side or the other can be measured with ϕ, the expected probability that the regulator will side with the complainant and enforce price regulation against the firm.

For example, let $\phi = \alpha f(P)$ where α is an exogenous factor affecting the likelihood of regulation. An increase in this factor can represent events such as the appointment of a regulation-favoring commissioner or a ruling that suggests the commission intends to tighten the reins on regulated firms. The graph below plots optimal price (P^*) against α for both exogenous ($\phi = \alpha$) and endogenous specifications of ϕ.

When ϕ is purely exogenous (i.e., $\phi_P = 0$), we see P^* is slightly increasing in α up to the monopolist price. But where ϕ is a function of P, be it linear, concave or convex, we see that P^* decreases in α except where the self-regulated price falls too low and the firm prefers short-run monopolistic profits and guaranteed future regulation over long-run self-regulated profits. Though this paper does not expressly test the relationship between P and ϕ, parties in MBR cases have invoked firm pricing in arguments before the FERC. MBR hearings have historically examined delivered price thresholds to identify "good" competing alternatives to regulated services,[6] though this methodology has never been explicitly endorsed. Most importantly, the two recent MBR

[6] *Delivered price* in this case refers to the amount paid for the commodity plus the transportation price.

Figure 3.3: Optimal Price by Likelihood of Regulation



I assume the following parameters: $P^R = 1$, $K = 0.1$, $Q_i = 2$, $\delta_i = \delta_j = 0.05$, $Q(P) = 100 - 20P$, and $C(Q) = 0.01Q^2$. Note that $N = Q(P)/Q_i$ and ϕ is truly $\phi = \min(\alpha f(P), 1)$.

complaint cases (i.e., *Buckeye* and *Colonial*) have examined deregulated pricing behavior to assess whether firms set prices supra-competitively. This suggests that prices do play a role in FERC decisions and, consequently, firms are likely to decrease their prices when they believe FERC will rule against them. Furthermore, if prices appear to play an increasingly important role in FERC decisions, my model suggests that self-regulated prices will decrease further even if FERC's perceived sentiment toward regulation does not change.

Ruling out the cases where regulation is preferred to curbing prices or where price plays no role in FERC's rulings, my model predicts that firms will reduce prices on their services to avoid regulation. Because price is not the sole consideration of FERC or the complainants when deciding whether to regulate, it is likely that firms will prioritize services in terms of their vulnerability to regulation. That is, α may be service specific. Consequently, firms may reduce prices even more on services that are relatively likely to be regulated due to non-price factors such as market share or concentration. Another possibility is that certain services are more likely to be subject to complaint either because there are more consumers of that service (N is higher) or because the consumers of that service have more cash to spend on a complaint case that they believe they are more likely to win (K is lower). Firms would combat the relative vulnerability of these services by lowering their prices for them.

Anecdotally, consumers have certainly increased the velocity of complaint cases against MBR firms since FERC's re-regulation of *Buckeye*'s MBRs in 2013, as I explained in the previous section. In the next section I describe my empirical approach for measuring firm self-regulation in the wake of FERC's pivot on MBRs.

3.4 Data and Empirical Approach

I adopt a dynamic difference-in-differences, or event study, design to measure whether pipeline carriers suppressed their MBRs as a result of FERC's shift on regulation. A dynamic specification is ideal for demonstrating how treatment effects vary over time, which is meaningful in this context because firms may differ on when they react to FERC's shift and the effect likely intensifies over time with every additional action by the FERC or complainants that threatens regulation. It is important to note that I cannot measure the average treatment effect on MBRs since changing perceptions about FERC's favorability toward regulation would have affected all MBRs. Such an event would have a widespread and heterogeneous impact on firm behavior. I exploit that heterogeneity and follow the theory that firms would be more self-regulatory with more vulnerable services to measure a *relative* treatment effect of FERC's shift on MBRs.

Because event studies rely upon an assumption of parallel trends, I must identify the point before which there would be no anticipatory effects. Though the back-to-back *Buckeye* and *Colonial* complaints would almost certainly signal to carriers that the threat of regulation had increased, it is not clear precisely which incident would trigger a change in firm behavior. It is likely, though, that the 2012 *Show Cause* Order presents the most exogenous shock to expectations, as it followed from what would have been a routine rate filing and was the first instance of FERC challenging market-based rates from a carrier.[7] Therefore, I measure differences between rates for the most vulnerable and least vulnerable services in 2012 and beyond.

I examine several measures of vulnerability. First, I hypothesize that firms will deem services in their most concentrated markets more vulnerable than those in their less concentrated markets, as they are more likely to fail the market power tests administered in the rate review process. I calculate the Herfindahl-Hirschman Index (HHI) based on FERC-approved methodologies for every period and market using the data described below. In my econometric analysis, I will use both the continuous measure and several discretized measures of HHI, both of which rely on pre-treatment period levels. Section 3.4.2.4 describes how I construct the discretized measures. Second, I utilize the fact that many markets have already undergone a rate review because interested parties contested them during the application process. It is reasonable that carriers will deem these markets more vulnerable since their customers have already indicated their willingness to litigate them. Thus, I identify markets based on whether they were ever contested in the MBR application process using FERC MBR order since 1990.

In addition to the data required for HHI calculations to identify my "treatment" and "control" groups, I also rely on these data to account for market changes that affect rates given the small sample size of markets. Without question, there are other market-specific confounding factors that could have concurrent effects on ratesetting, such as changes to competitors or demand shocks. To account for these market changes, I incorporate a novel dataset of my own construction including market-level refinery production, local refined products consumption, and waterborne transportation derived using methods relied upon in FERC MBR hearings. This section describes the data I both acquired and assembled to estimate these price effects of FERC's regulatory threat.

[7] While some other events may have precipitated the *Show Cause* order, the consultants from *Buckeye*'s legal team suggested they were surprised by the order.

3.4.1 FERC Tariff Rates

I obtained the universe of tariff rates for refined petroleum products from 2007 to 2019 from LawIQ LLC, a regulatory and legal data analytics firm based in DC, who electronically compile the PDF documents filed regularly with FERC and other state regulatory commissions. Because my market power statistics rely on estimates of specific commodity consumption and production, I restrict the data only to services for those products (i.e., motor gasoline, aviation gasoline, jet fuel, kerosene, and distillates). I also exclude all incentive and contract rates to ensure comparison across similar services.

The dataset fortunately includes unique origin and destination identifiers which allow me to construct a panel of services over time.[8] A service is defined by the company, origin station, destination station, and commodity. These data also provide the origin and destination counties, which I link to the 1995 Bureau of Economic Analysis Economic Areas (BEAs). I rely on the 1995 BEAs (over 2004 or 1977) because they were the most used market definitions in MBR applications. To identify which rates were market-based, I obtained the 20 relevant FERC market-based rates orders from FERC's eLibrary,[9] compiled the list of MBR-approved markets for each firm, and linked these to the tariff data.

Since FERC MBR decisions are based in large part on market concentration statistics and therefore firm entry and exit from markets, I use all FERC-regulated refined products services when calculating HHIs for each market. I remove services that do not span the entire study period. To avoid any rate fluctuations affected by a change in regulatory status, I also remove any service that changed market-based rates authority over this time period.[10] As a result I have a balanced panel of FERC rates, both MBR and cost-based, and a time-varying estimate of market concentration.

Because rates can vary significantly from service to service, particularly those regulated by

[8] For a given period of time, I interpolate the rate as the most recent rate filing.

[9] Found here: https://elibrary.ferc.gov/eLibrary/search.

[10] This includes Magellan's rates from West Gulf Coast and Wichita to Tulsa, Denver, and Colorado Springs and Buckeye's services to Pittsburgh, Harrisburg, New York City, Cleveland, Rochester, Buffalo, and Syracuse

cost-of-service, I rely on the natural log of rates in my analysis. These rates can be examined over time and by HHI quartile[11] or contested status in Figure A3.2. Market-based rates appear to have increased in all markets over time. The graphs on the left show rates by origin market vulnerability and the graphs on the right show rates by destination market vulnerability. There is reason to believe that MBR origin markets may be more valuable to carriers because there are fewer of them and they contain more rates than destination markets. Origin markets are typically larger markets that contain refineries and are connected to multiple destination markets. Destination markets, conversely, are smaller and are connected to fewer markets. The HHI quartile graphs (A3.2a to A3.2d) show the 4th (highest) quartile apparently diverging from the others' trends in 2013. Rates in more concentrated origin markets appear to decrease relative to those in less concentrated origin markets in 2012, which is consistent with the theory. But the opposite is true for concentrated destination markets, which increase rates relative to other markets. Similarly, rates in contested (i.e., more vulnerable) origin markets increase at a slower rate than uncontested markets and appear to diverge beginning in 2012, which is again consistent with theory. However, rates in contested versus uncontested destination markets appear quite parallel.

I also present the number of carriers in each market by year and vulnerability measure in Figure A3.3. The number of competitors in origin markets surprisingly bears no clear correlation with market concentration, suggesting refinery production and consumption are larger indicators of HHI. However, the number of carriers appears to correlate with market concentration in destination markets. Looking at the trends, there appears to be significant and heterogeneous volatility in market participation over the study period. Interestingly, the most competitive origin and destination markets prior to the *Show Cause* Order (1st quartile) lose carriers in the years approaching 2012,[12] suggesting that these markets become more concentrated following the order. The most concentrated markets do not appear to notably fluctuate except for those in the intra-carrier 4th quartile, which sees an increase beginning in 2017. Contested and uncontested origin markets follow similar trends

[11]Quartiles are constructed using only pre-2012 HHIs and do not fluctuate over time.
[12]This is also true for contested destination markets.

into 2012, after which the uncontested markets appear to steadily lose carriers. The destination markets appear to diverge by contested status beginning in 2011, followed by contested markets losing carriers on average before an uptick beginning 2016. Whether any of the volatility following 2012 is caused by the *Show Cause* Order is not tested in this paper. Rather, I treat these market changes as exogenous and solely test whether firms adjust their prices.

3.4.2 Market Power Statistics

Carriers and complainants typically hire teams of consultants to gather the data underlying their HHI and market share calculations for a small batch of markets in a given year. The inputs of such analyses are market-specific: (1) refined products consumption, (2) refinery production, (3) waterborne shipments and receipts of refined products, (4) all alternative pipeline capacity into and out of the market, and (5) rack prices to determine "good alternatives" from outside the market. I have constructed my own dataset of (1)-(3) for every county and month since 1985. I provide an overview of how I collected this data below, but for a more detailed description please see Terkelsen (2021a). I rely on the Law IQ tariff database, which identifies what carriers operate in each market at a each point in time, described in Section 3.4.1 to estimate (4) from 2007 to 2019. One shortcoming of these data are that they do not contain the pipeline capacities, only the number of services and competitors.[13] I describe in Section 3.4.2.4 how I get around this limitation to obtain reasonable HHIs. My analysis assumes all identifiable alternatives in a market are good alternatives and therefore do not consider market participants beyond the bounds of the BEA definitions.

[13]One could assume that the number of services offered by each carrier into or out of a market would correspond to its capacity. But, because some carriers list consolidated rates in their tariffs rather than specific origin-destination stations, it would be inappropriate to infer these correspond to lower capacity.

3.4.2.1 Consumption

To estimate consumption, I followed the methodology described in the most recent *Colonial* rate case in January 2020,[14] which I depict in Figure A3.4. The goal is to calculate an estimate of refined products for every county in the U.S. and then aggregate these to the market level.

I start with Energy Information Agency's (EIA) End-Use Consumption Data[15], which provides annual state-level consumption data by end-use sector (i.e., residential, transportation, commercial, and industrial) and commodity (i.e., motor gasoline, aviation gasoline, jet fuel, kerosene, and distillate). I allocate these data to the county level in proportion to key indicators of economic activity for each sector using data from Census, BTS, and BEA. For example, I allocate state residential consumption of kerosene and distillate to each county in proportion to annual population estimates from U.S. Census and state transportation consumption of aviation fuels in proportion to departing air freight by airport from BTS. See Figure A3.4 for the economic indicators used to apportion commodity usage by county for each sector. For the purposes of this analysis, I maintain or aggregate the data annually. I do, however, use the EIA Prime Supplier data to split distillates into either Distillate No. 1 or Distillate No. 2 based on the ratio of sales volumes for a given state-month. Once I have sector-specific commodity consumption estimates at the county-level, I sum across sectors to get total commodity consumption, and across commodity to get total consumption.

I then aggregate the counties within each market to get total market consumption, which I present by year and market vulnerability in Figure A3.5. There appears to be a negative correlation between market size and concentration for both origin and destination markets. This makes sense given that larger areas tend to contain not only people who consume, but also refineries that produce and pipelines that transport. Though there is little volatility over time, average consumption in both concentrated origin and destination markets decreases over time compared to other markets. Notably, there appears to be a sharp decline in 2012. A decline in consumption in origin markets would increase market concentration since refineries will depend more on exporting pipelines to

[14] *Colonial Pipeline*'s Exhibit No. CPC-00141 from its January 24th, 2020 filing can be found using FERC's eLibrary in Docket No. OR18-7-002 (consolidated).

[15] Obtained from https://www.eia.gov/state/seds.

sell their products. Conversely, the effect of decreased consumption in destination markets on concentration is negative. When comparing contested and uncontested origin markets, we can see that consumption in uncontested markets is declining prior to 2012, and then appears parallel to contested markets. In destination markets, contested consumption slightly falls relative to uncontested in the years approaching 2012, after which trends appear parallel. These changes are important to account for when measuring price effects, as these will influence market-based rates.

3.4.2.2 Refinery Production

The EIA compiles an annual list of operating refineries in the U.S., along with its crude distillation capacity.[16] I aggregate these lists and compile an annual dataset of refinery production by county. I then multiply EIA monthly refinery utilization rates[17] and EIA monthly refinery yields[18] for the relevant commodities reported by PADD subregion. This multiplier can be used with the crude capacity to obtain monthly refinery production estimates for each county. Note that my calculation assumes uniform utilization rates and yields across all refineries within the same PADD subregion.

These estimates are reported annually and by HHI quartile in Figure A3.6. Like consumption, there is an inverse relationship between market concentration and refinery production. Refinery production appears to increase over time regardless of market concentration or whether the markets were contested. Overall trends appear parallel across groups with little variation over time.

3.4.2.3 Waterborne Shipments/Receipts

Though my previous estimates roughly follow methods borrowed from FERC rate cases, I could not do the same for waterborne data. Typically, parties rely on the U.S. Army Corps of Engineers (USACE) shipment and receipt data reported annually by port. However these are only available in PDF format and offer insufficient coverage of the time frame of interest. Instead, I rely on USACE's

[16]Obtained from https://www.eia.gov/petroleum/refinerycapacity/.
[17]Obtained from https://www.eia.gov/dnav/pet/.
[18]Obtained from https://www.eia.gov/dnav/pet/.

Port Facility Workbook[19] to identify which facilities accommodate the commodities of interest and scrape textual data on oil storage capacity at these facilities. I then aggregate to the county level to get total county storage capacity. Under the assumption that this capacity has not changed significantly since the beginning of the study period, I allocate EIA's monthly PADD-to-PADD plus foreign imports commodity-specific refined products movements by tanker and barge to each county weighted by its waterborne storage capacity.[20]

These estimates are presented by year and market vulnerability in Figures A3.7 and A3.8. The trends presented in these graphs are less informative than previous data since it draws from more aggregated PADD-level, rather than state-level, data. However when comparing trends between contested and uncontested origin markets, both waterborne receipts and shipments appear to deviate substantially over the study period. Once again, this demonstrates the need to control for these variables when measuring changes to pipeline rates.

3.4.2.4 HHI Calculation

Market concentration statistics are a key input to FERC MBR decisions. My measurement of HHI statistics, therefore, is not aimed at identifying "true" market concentration. Rather, I am interested in obtaining a measure that accurately indicates to a carrier whether that market is more or less likely to be deemed as unworthy of MBRs by FERC. Therefore, I calculate market concentration statistics using the methods relied upon in FERC market power determinations, though I make certain adjustments to accommodate my data. It is important to note that these calculations are based on available capacity rather than actual delivery-based market shares, as pipeline delivery data is highly confidential. Conceptually, the HHI captures the extent to which residual refinery production (after being consumed or exported via water) in the origin market is served by a small number of pipelines and, conversely, how residual end-use consumption (after being served by waterborne receipts) in the destination market is served by both pipelines and refineries. If there

[19] Obtained from https://publibrary.planusace.us/.

[20] Obtained from https://www.eia.gov. Note that this data cannot account for intra-PADD movements.

were just a single pipeline and no other players, then the HHI would be 1. However, if there are more pipelines, such that none dominates, then HHI declines.

There are two main HHI measures relied upon in MBR proceedings. Both measures partition alternative into default suppliers, which are deducted from total demand to form a “residual demand”, and competing alternatives across whom demand is divided into capacity-based market shares which are then squared and summed into HHIs. The preferred method is called the "FERC Effective Capacity Method," which bases market share on the minimum of competing capacity and residual demand. Specifically, these are calculated as follows:

$$HHI_{EC,o} = \sum_{j \in m} \left[\frac{\min(ref_m - wbs_m - cons_m, K_{jm})}{ref_m} \right]^2 \tag{3.8}$$

and

$$HHI_{EC,d} = \sum_{j \in m} \left[\frac{\min(cons_m - wbr_m, K_{jm})}{cons_m} \right]^2, \tag{3.9}$$

where o and d indicate whether the market, m, is an origin or destination, ref_m is local refinery production, $cons_m$ is local refined products consumption, wbs_m and wbr_m are waterborne shipments and receipts, and K_{jm} is the sum of firm j's pipelines capacity and refinery production in market m. Note that if the numerator is negative, the HHI is zero. The minimum function in the numerator puts an upper limit on the amount of capacity that a carrier (or producer) can supply at residual demand. Since the denominator is total demand, which is strictly greater than origin residual demand and weakly greater than destination residual demand, these HHIs rarely equal 1. Consequently, carriers with exceedingly large capacities are unlikely to inflate the HHI.

The other measure, called the "DOJ Adjusted Capacity Method," is a similar calculation except that residual demand is evenly distributed across the carriers. Thus, competing alternatives are assumed to be able to serve only a proportion of residual demand. The precise formulas are:

$$HHI_{DOJ,o} = \sum_{j \in m} \left[\frac{\min(\frac{ref_m - wbs_m - cons_m}{J_m}, K_{jm})}{ref_m} \right]^2 \tag{3.10}$$

and

$$HHI_{DOJ,d} = \sum_{j \in m} \left[\frac{\min(\frac{cons_m - wbr_m}{J_m}, K_{jm})}{cons_m} \right]^2, \tag{3.11}$$

where J_m is the number of firms, carriers or refinery operators, in market m. These measures are typically smaller than their Effective Capacity counterparts because the evenly divided residual demand is often far lower than any carrier's market capacity. This formula, as a result, reduces the importance of actual pipeline capacity.

Note that these measures are positively correlated with one another and cannot be inversely related. While it is crucial that I stick as close as possible to these HHIs, as these are the figures in the minds of ratesetters for various carriers, I make several necessary adjustments to accommodate my data. First, several origin markets do not possess refineries (i.e., origin demand is zero resulting in an HHI of zero) but do experience fluctuations in carrier entry/exit. To allow my HHIs to account for these changes in conditions and to incorporate relevant but otherwise omitted waterborne data, I utilize net waterborne transportation by adding waterborne receipts to origin market demand and, symmetrically, waterborne shipments to destination demand. Second, I also lose meaningful variation when deducting consumption from origin market refinery production (i.e., demand). This results in several markets with HHIs of zero, and the measure cannot capture carrier entry and exit. To resolve this issue, I mimic the destination market calculation by treating local consumption like a competitor rather than an automatic deduction in demand. Third, I do not have data on pipeline capacity or refinery ownership. Given this limitation, I model my calculation more on the DOJ HHI measure because of capacity's smaller role relative to the EC method. This is particularly important in larger markets where single carriers are unlikely to possess sufficient capacity to serve all demand.

Selection of this methodology, along with my decision to treat origin market consumption as a competitor, presents an additional problem in that it is unclear how to weight pipeline carriers with consumption and refinery production. I resolve this by assuming the median refinery production (in markets with refineries) is equal to a single carrier's pipeline capacity into the market and median local consumption is equal to carriers' pipeline capacity out of a market.[21] This way the HHIs will fluctuate with changes in consumption and refinery production.

[21] Another assumption embedded in this approach is that carrier capacity always exceeds their proportion of residual demand.

My HHI calculations are as follows:

$$HHI_{DOJ^*,ot} = J_{mt}\left[\frac{ref_{mt} + wbr_{mt} - wbs_{mt}}{(ref_{mt} + wbr_{mt})(J_{mt} + (cons_{mt}/\widetilde{cons}))}\right]^2 \tag{3.12}$$

and

$$HHI_{DOJ^*,dt} = J_{mt}\left[\frac{cons_{mt} + wbs_{mt} - wbr_{mt}}{(cons_{mt} + wbs_{mt})(J_{mt} + (ref_{mt}/\widetilde{ref}))}\right]^2, \tag{3.13}$$

where $\widetilde{cons}$ and $\widetilde{ref}$ are the median local consumption and median local refinery production over every market and time period. Also note that J_{mt} now only counts pipeline carriers.

After calculating the $HHI_{DOJ^*,ot}$ and $HHI_{DOJ^*,dt}$ for each market and time, I construct four sets of HHI quartiles based on market type (origin or destination) and inter- versus intra- carrier. The inter-carrier quartiles bin markets based on their HHIs relative to all other MBR markets[22] in the dataset while the intra-carrier quartiles bin markets within each carrier. This distinction is to examine whether carriers are concerned about how vulnerable their markets are relative to other carriers' markets or about the markets most vulnerable within their own services.

My analysis separately examines the effect of conditions in origin and destination markets. To ensure I am not simply examining the same markets from a different perspective—which may happen, for example, if all high-concentration destination markets were served only by low-concentration origin markets—I present a cross-tabulation of origin and destination HHI quartiles for market-to-market routes and services in Figure 3.4.

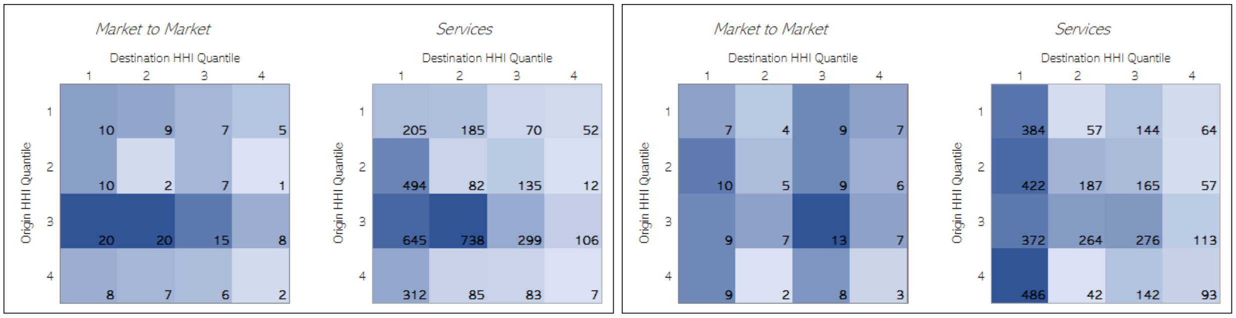
Note that not all data is represented in this cross-tab, as origins with MBRs might deliver to non-MBR destinations, and vice versa.

Graphs showing HHIs over time by market vulnerability are provided in Figure A3.9. There is some, though very little, variation throughout the study period, though more concentrated markets experience a sudden increase in 2012. This is primarily due to the concurrent decrease in consumption or carrier changes. Differences between contested and uncontested markets appear more

[22] Restricting the quartiles to only the MBR markets ensures that there are market-based rates in each quadrant. When binning across all markets irrespective of MBR status, there do not exist any MBR markets in the highest quartile.

Figure 3.4: Route Distribution by Quartile

(a) Inter-Carrier Quartile (b) Intra-Carrier Quartile



Note: Market-to-Market counts only the unique market routes (e.g., Chicago to Minneapolis) in that cross-section. Services counts the individual services for which there is a unique rate between those markets. The quartiles were constructed using Stata's xtile command, which employs a clustering algorithm and therefore may not equalize group frequencies.

stark for origins, where uncontested markets experience an average increase in market concentration beginning in 2012 and continuing until uncontested market concentration exceeds contested markets.

3.4.3 Other Data

I use additional data for controls in my model, such as a cost measure, local commodity prices, and local commodity sales. For costs, I calculate the distance of each service using HERE API.[23] Pipeline cost indexing is based on the Producer Price Index for Finished Goods (PPI-FG) on the basis that pipeline costs tend to closely follow prices for finished goods.[24] I multiply distance by PPI-FG (indexed to 1985) to obtain a time-varying proxy for costs.

3.4.4 Summary Statistics

The full balanced panel from 2007 to 2019 contains 7,919 carrier services, 39.7% of which are MBRs, from 22 carriers delivering goods from 28 origin markets to 78 destination markets where markets are defined using 1995 BEAs. While my primary analysis examines an event's effects

[23]I assume driving distances are comparable to pipeline distances. Access to the API can be found at https://developer.here.com/.

[24]This data is available since 1947 from FRED at https://fred.stlouisfed.org.

on MBRs, I also examine cost-of-service (COS) rates. Though COS rates must remain below a regulated service-specific cap, carriers may adjust their rates below this cap or request a cap increase. That is, just because they are cost-regulated does not mean they are fixed.

My estimation of the regulatory threat effect relies on comparing services that are more vulnerable to re-regulation to services that are less vulnerable. I approach this in 3 different ways. The first way is by using the continuous HHI measures as an intensity of treatment variable. The second way separates markets into quartiles, both inter- or intra-, based on their pre-treatment HHIs.[25] The final way is by identifying markets that underwent particular scrutiny during their initial MBR hearing. As I explained before, applicants typically request approval for multiple markets in a single application. Those that are contested by interested parties are typically set for hearing by the FERC and only ruled on after litigation. I flagged markets that went through this additional examination under the assumption that carriers will be more protective of markets that have already been revealed to be targets of their customers.[26]

A list of MBR-approved origin markets can be found in Table A3.4, along with their vulnerability statuses. There is a clear and expected correlation between the inter- and intra-market quartile binnings. However, there does not seem to be a correlation between a market's contested status and its concentration.

Table 3.1 reports descriptive statistics by HHI quartile and contested status for origin markets from 2008 to 2019.[27] The top row shows tariff rates by quartile. The second row shows origin market HHI by quartile (i.e., the variable I use to construct quartiles). The third row shows destination HHI by quartile. Finally, the fourth row shows the fraction of services that have MBR authorization. Though there are minimal differences between the inter- and intra- carrier quartiles, we can see the average origin HHI increases from about 0.02 to 0.30 across the inter-carrier quartiles

[25]I use their average HHIs prior to year 2012.

[26]A market is flagged if it was contested in at least one proceeding. Other carriers authorized for the same market would be aware if it was contested in another carrier's MBR proceeding. It is therefore reasonable to believe that all carriers would view the market as vulnerable whether the dispute occurred during their proceeding or not.

[27]This table omits any services from non-MBR origins destined for MBR destinations.

Table 3.1: Origin Market Services by Vulnerability Measure (2008-2019)

	Inter-Carrier Quartile					Intra-Carrier Quartile							
	1	2	3	4	Total	1	2	3	4	Total	Uncontested	Contested	Total
Rate (cents per bbl)	166.699	137.975	204.869	127.828	168.685	158.332	173.721	200.575	125.274	167.894	219.402	153.237	168.685
	(122.856)	(56.863)	(99.532)	(52.888)	(92.464)	(113.322)	(77.128)	(101.177)	(50.306)	(91.087)	(126.966)	(72.261)	(92.464)
HHI_O	0.022	0.075	0.165	0.296	0.153	0.029	0.089	0.186	0.274	0.152	0.155	0.152	0.153
	(0.012)	(0.028)	(0.072)	(0.109)	(0.111)	(0.015)	(0.026)	(0.086)	(0.117)	(0.115)	(0.153)	(0.095)	(0.111)
HHI_D	0.361	0.375	0.376	0.408	0.380	0.297	0.423	0.374	0.371	0.376	0.328	0.396	0.380
	(0.292)	(0.294)	(0.295)	(0.294)	(0.294)	(0.268)	(0.314)	(0.281)	(0.301)	(0.297)	(0.279)	(0.297)	(0.294)
MBR	0.521	0.335	0.473	0.244	0.399	0.545	0.376	0.472	0.456	0.451	0.631	0.328	0.399
	(0.500)	(0.472)	(0.499)	(0.430)	(0.490)	(0.498)	(0.484)	(0.499)	(0.498)	(0.498)	(0.483)	(0.470)	(0.490)
N (Service × Year)	10452	23616	41796	18756	94620	13296	25536	25128	19776	83736	22092	72528	94620
No. of Services	871	1968	3483	1563	7885	1108	2128	2094	1648	6978	1841	6044	7885

Standard deviations in parentheses. HHI_O and HHI_D are calculated in accordance with Equations (3.12) and (3.13), respectively. See Table A3.5 in Appendix for additional variables.

and have slightly less variation across the intra-carrier quartiles. For reference, FERC has loosely considered HHIs of more than 0.18 as indicative of high market concentration.[28] The difference between uncontested and contested markets' HHI_O's confirm that these are similar on balance.

Surprisingly, there does not appear to be a correlation between HHI_O's and rate levels. Nor is there a clear relationship between HHI_O quartile and HHI levels in the corresponding destination markets, which are much higher on average than the HHI_O's in this sample. This can be expected since the origin markets in this sample must have had sufficiently low market concentration to warrant MBR authorization in the past. Looking at the proportion of MBRs, we can see that less than half (39.9%) of the services from these origins terminate in MBR-approved destination markets. If we compare the proportion of inter-carrier Q1 services with MBRs to Q4 services, we can see that the proportion of MBRs in the highest concentration markets (24.4%) is half of what it is in the lowest concentration markets (52.1%). So it appears that MBRs are more likely to be sought and granted in markets with lower market concentration. A similar pattern emerges when comparing uncontested market MBRs (63.1%) to contested markets (32.8%). Note that the intra-carrier quartiles offer greater overlap of these variables, which is useful in estimation strategies involving propensity scores.

[28]Though not treated as a cut-off point, markets with HHIs less than 0.18 are typically approved without further examination while those with higher HHIs undergo additional scrutiny of market shares and other factors to form a conclusion about a specific carrier's market power. Historically, a threshold of 0.25 has also been considered.

I provide a list of MBR destination markets in Table A3.6. Once again, this table highlights the overlap of inter- and intra-carrier quartiles, but does not appear to be correlated with whether a market was contested. In fact, Table 3.2 suggests, surprisingly, that uncontested destination markets are more concentrated (with HHI_D of 0.24) than their contested counterparts (with HHI_D of 0.16).

Table 3.2: Destination Market Services by Vulnerability Measure (2008-2019)

	Inter-Carrier Quartile					Intra-Carrier Quartile							
	1	2	3	4	Total	1	2	3	4	Total	Uncontested	Contested	Total
Rate (cents per bbl)	195.781	155.573	178.829	206.028	181.071	186.739	185.588	178.067	191.885	185.158	162.467	189.444	181.071
	(111.532)	(72.642)	(113.736)	(96.863)	(102.476)	(114.135)	(64.659)	(105.401)	(86.753)	(102.764)	(73.109)	(112.234)	(102.476)
HHI_O	0.160	0.128	0.139	0.110	0.144	0.151	0.115	0.134	0.136	0.140	0.134	0.148	0.144
	(0.139)	(0.073)	(0.120)	(0.080)	(0.118)	(0.129)	(0.062)	(0.113)	(0.095)	(0.114)	(0.106)	(0.122)	(0.118)
HHI_D	0.059	0.205	0.333	0.769	0.186	0.074	0.200	0.254	0.582	0.186	0.240	0.161	0.186
	(0.026)	(0.045)	(0.152)	(0.213)	(0.188)	(0.051)	(0.061)	(0.111)	(0.303)	(0.193)	(0.253)	(0.144)	(0.188)
MBR	0.904	0.863	0.851	1.000	0.887	0.940	0.929	0.967	0.982	0.948	0.894	0.885	0.887
	(0.294)	(0.344)	(0.356)	(0.000)	(0.316)	(0.237)	(0.256)	(0.179)	(0.133)	(0.221)	(0.308)	(0.319)	(0.316)
N (Service × Year)	20160	13080	7164	2124	42528	20280	6792	8724	3996	39792	13200	29328	42528
No. of Services	1680	1090	597	177	3544	1690	566	727	333	3316	1100	2444	3544

Standard deviations in parentheses. HHI_O and HHI_D are calculated in accordance with Equations (3.12) and (3.13), respectively. See Table A3.7 in Appendix for additional variables.

As expected, we see the average HHI_D is much lower when looking only at MBR destination markets. Unfortunately, the dataset is also more sparse despite there being 30% more destination markets (34) than origin markets (26). This may suggest that origin markets are more valuable to carriers as a single origin market contains more MBR services on average than a single destination market despite destination markets possessing a greater *proportion* of MBR services. The data again shows no correlation between destination concentration and origin concentration or rates.

Though these tables allow U.S. to compare overall averages across the vulnerability measures, the more relevant perspective for a difference-in-differences estimation are of the time trends of these variables to support the parallel trends assumption, i.e., $E[Y_{1,t}(0) - Y_{0,t}(0)] = E[Y_{1,s}(0) - Y_{0,s}(0)]\ \forall s \neq t$. In this setting it is crucial to emphasize that I rely on a *conditional* parallel trends assumption ($E[Y_{1,t}(0) - Y_{0,t}(0)|\mathbf{X}] = E[Y_{1,s}(0) - Y_{0,s}(0)|\mathbf{X}]\ \forall s \neq t$), as specific market conditions that affect rates will change over time. Though the graphs presented in Figures A3.2 through A3.9 provide some view of the pre-trends for vulnerable markets, they do not account for sample weights or any control variables added to the econometric model. Regardless of these caveats, pre-treatment trends of the more vulnerable services (Q4 or contested rates) appear mostly parallel to one or more less vulnerable groups, with some exceptions. One glaring exception is in Figure A3.9e. Though their HHIs appeared balanced on average for the entire period, we see that uncontested markets' HHIs were on the rise relative to contested markets prior to 2011 and increase to above contested HHI levels beginning in 2014. By examining the uncontested market trends in Figures A3.5e and A3.3e, we can see that the denominator for HHI_O is shrinking (via lower origin consumption and fewer carriers).

3.4.5 Empirical Strategy

To address concerns about changing market conditions, my difference-in-differences estimation controls for lagged demand-side and supply-side variables presented in Table A3.5. The variables are lagged to avoid simultaneity with rate setting, as the level of rates might affect, for example, equilibrium consumption. However, it is unclear whether these market changes, particularly the number of carriers or services, are a result of the *Show Cause* order. For instance, it is possible that carriers removed more expensive services from vulnerable markets, rather than lower their prices, to avoid a rate case. Such considerations are ignored in my analysis as I assume major changes to market conditions are overwhelmingly caused by factors other than a shift in FERC bias. Moreover, because my empirical strategy relies on identifying heterogeneous effects of the same event on different groups, ignoring measurable and concurrent factors that differentially affect these groups could misattribute confounding effects. With that said, this paper specifically tests the hypothesis that firms will adjust their rates under the threat of regulation rather than identify an overall treatment effect of FERC's shift.

I use a dynamic two-way fixed effects (TWFE) model including leads and lags from the 2011 base year (i.e., the year before the 2012 *Show Cause* order) to identify the average treatment effect of regulatory threat on vulnerable carrier rates. Though recent literature has called into question whether TWFE models estimate difference-in-differences in staggered designs (see Goodman-Bacon 2021, Borusyak et al. 2021, Athey and Imbens 2021, Callaway and Sant'Anna 2020, Sun and Abraham 2020), two-way fixed effects models in uniform treatment time designs offer intuitive, unbiased difference-in-differences estimates when the conditional parallel trends assumption holds (Baker et al., 2021). The dynamic version of this estimator permits the treatment effect to vary over time, which is valuable in this set-up because the initial event precipitates a series of events that may have their own effects on firm pricing behavior.

Specifically, I estimate the following:

$$\ln rate_{icjmt} = \alpha_{icjm} + \alpha_{ct} + \alpha_{jt} + \sum_{k \neq 2011} \delta_k \mathbf{1}[t = k] VM_{cjm} + \mathbf{X}_{cmt}\beta_X + \epsilon_{icjmt}, \tag{3.14}$$

where α_{icjm} is carrier-service fixed effects, α_{ct} and α_{jt} are commodity-specific and carrier-specific time trends, VM_{cjm} is the vulnerability measure for carrier j's commodity c services in market m, and X_{cmt} is a set of time-varying controls including lagged demand-side observables (e.g., refinery production), lagged supply-side observables (e.g., number of carriers in the market), and a proxy for cost.[29] I explain above why the lagged time-varying market characteristics are important.[30] The specific characteristics chosen (i.e., origin refinery production, destination consumption, origin waterborne shipments, destination waterborne receipts, and carrier/service counts) were minimal to ensure both non-pipeline supply/demand forces in each market are represented. Including the other omitted market factors do not significantly impact results. The commodity-specific time trends account for any nationwide commodity market shocks. Finally, the carrier time trends enforce that I only make comparisons between pricing strategies for a given carrier's most and least vulnerable services. These trends are crucial for isolating the effect, as I am trying to identify changes between more vulnerable and less vulnerable services, all else equal.

The vulnerability measures are constructed based on the continuous HHIs, the HHI quartiles, or whether the market was contested. I also estimate a model that substitutes origin market fixed effects and pre-event market concentration in the linked market (e.g., origin HHI if measuring effects on vulnerable destination markets) for carrier-service fixed effects. After estimating $\hat{\delta_k}$ for

[29]Distance × PPI-FG.

[30]It is important to note that, though correlated with the non-lagged values, these controls assume carriers have a delayed reaction to market changes and do not account for instant shocks to the markets. Other transformations of these variables, e.g. exponential, did not alter my findings.

all $k > 2011$, I average these post-treatment effects to obtain an overall average treatment effect of the *Show Cause* order.

Because I seek to measure average firm response, I ensure carriers are equally represented in the average treatment effect estimates using sampling weights.[31] This adds robustness to my results as it prevents a single firm from driving the estimates.

3.5 Results

3.5.1 Average Rate Effects

I separately analyze rates by origin market and by destination market because FERC's MBR decisions are made at the market-level rather than the service-level. To ensure that I compare rates for similar services, I omit the lowest origin HHI quartile, which experiences a drastic decline in number of carriers in the years preceding 2012 (see Figure A3.3).[32] Table 3.3 shows the average treatment effect on the treated (ATT) of FERC's shift on MBRs. The ATT reflects the average of post-treatment effects (i.e., 2012 to 2019) estimated from the dynamic model. I also present the average of pre-treatment effects, which I call "Placebo" (borrowed from de Chaisemartin and D'Haultfœuille, 2020). Columns (1) through (4) show the continuous, or *penetrative effect*, of FERC's 2012 shift by HHI, while the remaining columns all employ binary treatment measures. Each of the first two columns report results from a single regression, which also include the interaction of origin and destination HHIs with the treatment time, while the remaining columns show estimated effects in origin and destination markets from separate regressions. I present estimates from both the carrier-service fixed effects model and the market fixed effects model. This section discusses these overall average effects while Section 3.5.2 discusses the dynamic effects.

Nearly all regressions testing the theory that firms curbed rates in their most concentrated

[31] For example, if there were 10 carriers and one carrier made up 1/2 of the services (i.e., was over-represented by 5 times), then that carrier's services would receive a weight of $\frac{1}{5}$ $(= \frac{1}{10}/\frac{1}{2})$.

[32] Results are not sensitive to including the first quartile or omitting the 2nd quartile. However, the efficiency of these estimates are optimized by only including the second and third quartiles in the control group.

Table 3.3: Summary of FERC Shift Effect on Log MBR Rates in Vulnerable Markets

	Continuous HHI				Top vs Lower HHI Quartile				Contested vs Uncontested Markets	
	with Interaction		w/o Interaction		Inter-Carrier		Intra-Carrier			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
					Origin Markets					
ATT	-0.008	-0.008	0.028***	0.027**	0.006	0.005	0.011***	0.011***	-0.013***	-0.014***
	(0.013)	(0.012)	(0.011)	(0.011)	(0.003)	(0.003)	(0.003)	(0.003)	(0.004)	(0.004)
Placebo	-0.022	-0.024	-0.007	-0.003	0.001	0.001	-0.004	-0.003	0.004	0.001
	(0.013)	(0.014)	(0.010)	(0.011)	(0.003)	(0.004)	(0.003)	(0.003)	(0.005)	(0.005)
Carrier-Service FE			Y	N	Y	N	Y	N	Y	N
Market FE	N	Y	N	Y	N	Y	N	Y	N	Y
N			32292	32292	32292	32292	32292	32292	32292	32292
					Destination Markets					
ATT	0.058***	0.055***	0.091***	0.086***	0.090***	0.084***	0.050***	0.048***	-0.001	-0.003
	(0.013)	(0.013)	(0.008)	(0.008)	(0.007)	(0.008)	(0.004)	(0.005)	(0.003)	(0.003)
Placebo	-0.038***	-0.027**	-0.016	-0.002	0.027***	0.035***	-0.006	0.000	0.005	0.006*
	(0.011)	(0.012)	(0.009)	(0.008)	(0.007)	(0.007)	(0.005)	(0.005)	(0.003)	(0.003)
Carrier-Service FE	Y	N	Y	N	Y	N	Y	N	Y	N
Market FE	N	Y	N	Y	N	Y	N	Y	N	Y
N	32292	32292	32292	32292	32292	32292	32292	32292	32292	32292

All standard errors are clustered at the service level. All regressions include commodity-specific time trends and carrier-specific time trends. *p < 0.05, **p < 0.01, and ***p < 0.001. "Interaction" refers to the interaction of the origin and destination market continuous HHIs. *ATT* is the average of post-treatment effects (i.e., 2012-2019). *Placebo* is the average of pre-treatment effects (i.e., 2008-2011). See full tables in Table A3.8 and A3.9.

markets show this is not the case. Instead, firms appear to have increased their rates in their most concentrated markets, even when controlling for changes in market conditions. Only the interacted model (columns (1)-(2)) produces negative, though insignificant, results for the origin market. The other continuous HHI estimates suggest that carriers increased rates more in their more concentrated markets. For example, on average a 0.1 higher origin market HHI is associated with 0.28% higher rates following 2012 and a 0.1 higher destination market HHI is associated with 0.91% higher rates. Note that the statistically significant placebos for the continuous HHI destination model including the interaction suggest the presence of pre-trends in this model. I will discuss these further in the next section.

Columns (5) through (8), which present effects from the binary measures of HHI where $D = 1$ if the market is in the 4th quartile and $D = 0$ if it is in the second or third HHI quartile, confirm the positive rate effects for the more concentrated markets. Though the inter-carrier origin market estimates are small (0.5% to 0.6%) and insignificant, we see that rates *to* the most concentrated destination markets increased by 8.4% to 9.0% more than less concentrated markets though the placebos are once again suspicious. The intra-carrier origin market estimates are substantially higher than the inter-carrier estimates and show that carriers increased rates from their most concentrated markets 1.1% higher than their less concentrated markets following FERC's MBR challenges. The intra-carrier estimates for destination markets are, however, smaller than the inter-carrier estimates at 4.8-5.0%, though are much more convincing with small insignificant placebo estimates.

There is some evidence that firms reduced their rates in vulnerable contested markets, which pipeline customers have historically revealed they are willing to litigate. Columns (9)-(10) reports that rates to contested origin markets fell by 1.3-1.4% relative to other, uncontested, origins. The estimates for contested destination markets are also negative, but less reliable, considering the significant Placebo effects and insignificant ATTs.

The full regression output is presented in Table A3.8 and Table A3.9. Note that the even-columned results, which do not have carrier-service fixed effects, attempt to capture fixed characteristics of the connected markets in addition to time-varying market conditions. Interestingly, I find that origin market concentration has a large positive effect on rates, whereas destination HHI has a significant negative effect. In the interacted model, the effect of route HHI, which is the interaction of both origin and destination HHIs, is also significant and negative. Market-based rates appear to positively correlate with the cost index given the positive within carrier-service effects, but the relationship disappears or inverts in the regressions without carrier-service fixed effects. Regardless of specification, MBRs are positively correlated with increases in origin market demand (refinery production), though changes in origin supply alternatives (waterborne shipments) have a much smaller negative relationship with rates. These estimates concur with theoretical impacts of demand and supply shocks. Conversely, I find a significant negative relationship with destination market demand (consumption) and a positive relationship with supply alternatives (waterborne deliveries). MBRs also surprisingly increase with the number of carriers in the origin market, though appear to have no relation to the number of services. These estimates run counter to traditional supply and demand theory.

3.5.2 MBR Dynamic Effects

To better assess the pre- and post-2011 rate effects of the *Show Cause* order, I plot the dynamic effects from all regressions from Table 3.3 in Figures A3.10 to A3.13.

3.5.2.1 Origin Market Event Studies

The continuous HHI effects in origin markets from both the interacted models (Figures A3.10a and A3.11a) and non-interacted models (Figures A3.10b and A3.11b) show similar immediate rate effects that diverge over time. There is an instant increase in 2012 that declines and ultimately becomes negative in the interacted models, but persists in the alternative non-interacted models. The pre-treatment dynamic effects across these estimates potentially reveal some pre-trending in 2008. However, the jump in 2012 is evidence of carriers differentially adjusting rates based on market concentration in 2012.

In Figures A3.10c and A3.11c, we see the rate effect from the discrete inter-carrier HHI quartile comparison follows a similar stark jump from 2011 to 2012. Though the ATT is statistically insignficant, the plot demonstrates a persistently positive rate effect over the study period. These estimates are particularly persuasive, as they follow level pre-trends from 2008 to 2011. Figures A3.10d and A3.11d present a larger increase in 2012, which escalates further in 2013 to 2015 before declining to lower but still-positive levels from 2017 to 2019. The difference between the inter-carrier and intra-carrier results indicate that firms were more reactive with the services they felt were *their* most vulnerable rather than those that were most vulnerable when compared to other carriers.

My theory supports a positive rate effect if (a) firms do not believe prices affect the likelihood of FERC imposing regulation or (b) the cost of reducing rates to avoid regulation is so high that firms prefer short run profits with guaranteed re-regulation. However, I find negative effects when comparing contested to uncontested markets.

Figures A3.10e and A3.11e, show rates in the more vulnerable contested markets declining after 2013. Though there appear to be drastic pre-trends from 2008 to 2011, there is a punctuated drop in 2014, which may relate to the unprecedented October 15, 2013 complaint against several of *Buckeye*'s market-based rates.[33]

3.5.2.2 Destination Market Event Studies

I present dynamic effects for vulnerable destination markets in Figures A3.12 and A3.13. Again, all approaches testing the theory that firms would curb rates in more concentrated markets, in fact, reveal the opposite. Firms increased their rates in more concentrated destination markets following the 2012 order. When using the continuous measures of HHI, there appear to be increasing pre-trends approaching the 2011 base year, but then a punctuated increase in 2012 which either persists then declines (in the interacted models) or increases then flattens (in the non-interacted models).

In the regressions using the binary measures of market concentration (Figures A3.12c, A3.13c, A3.12d, and A3.13d), the rate effect jumps from 2011 to 2012, diverging from either flat or decreasing pre-trends, then continue to rise until remaining high and flat after 2016. Contrary to the origin market analysis, the inter-market effect is much larger than the intra-market effect. Also unlike the origin market analysis, the contested destination markets do not appear to differ at all from the uncontested markets in terms of rates following 2012.

3.5.2.3 Route Event Studies

Though FERC does not examine competitive conditions along routes for its market power determinations, it is possible that consumers are sensitive to changes along certain routes and therefore may make a complaint on those grounds. I define vulnerable routes as having both a vulnerable origin and a vulnerable destination.

Figure A3.14 shows dynamic effects for vulnerable "routes" rather than origin or destination points.[34] The continuous HHI effects in Figure A3.14a are from the same regression as column (1)

[33] Carrier reaction to this event would have appeared in 2014, as the complaint occurred in late 2013.

[34] For brevity, only the carrier-service fixed effect estimates are included.

in tables A3.8 and A3.9 and Figures A3.10a and A3.12a. Note that the plotted effects in A3.14a are from the interaction term and not the sum of time-from-treatment effects from origin HHI, destination HHI, and the interaction. The ATT is substantially larger than when looking only at vulnerable origin or destination markets. The profile of dynamic effects are almost reverse of those from the origin analysis, which showed increasing pre-trends and an immediate positive rate effect that declines over time. The post-event rate effects on more competitive routes declines from 2011 to 2012 and then increases steadily and substantially.

The subsequent graphs are slightly different in that they do represent the total rate effects on more vulnerable routes versus less vulnerable or only partially vulnerable routes. The inter-carrier HHI results in Figure A3.14b follow the same trend as the destination market analysis, except with smaller rate effects. Conversely, the intra-carrier estimates suggest that firms actually decreased rates for their most concentrated routes, once in 2012 and again in 2016.

I also perform a similar analysis comparing contested routes, where both termini are contested, to totally or partially uncontested routes. Rate effects appear null until 2016, after which there are minuscule but significantly positive rate effects.

3.5.2.4 An Alternative Specification

The TWFE estimator relies on the strong assumption that comparison groups (more vulnerable and less vulnerable services) would have followed parallel trends had FERC not challenged *Buckeye* in 2012. Several papers have proposed semi-parametric estimators which relax this assumption. Abadie (2005) proposes an estimator that allows for situations where differences in observables result in non-parallel paths between groups. The two-step estimator first takes the difference in outcomes between the year of interest and the base year and then takes a simple weighted average based on the propensity score to obtain an average treatment effect on the treated (ATT).

Focusing only on the binary treatment variables, I estimate a semi-parametric estimator:

$$\hat{\delta}_t = \mathbb{E}\left[\frac{Y_t - Y_{2011}}{Pr(VM = 1)} \times \frac{VM - Pr(VM = 1|X)}{1 - Pr(VM = 1|X)}\right],$$

where VM is 1 if the market is vulnerable, and 0 otherwise.[35] Inspired by Sant'Anna and Zhao (2020), I estimate individual time-from-treatment effects to plot an event study. The results can be found in Figure A3.15 in the Appendix.

The market concentration results directionally match the previous estimates, though origin market rate effects appear significantly larger that the linear regression estimates and follow a more dynamic profile. The destination market results, which could only be estimated for the intra-carrier analysis due to overlap restrictions, begin with suspiciously high pre-trends that are followed by positive rate effects that are slightly larger in magnitude relative to the TWFE estimates.

The contested market analyses diverge from the TWFE estimates in that MBRs to contested origins appear to rise sharply in 2013 rather than the sharp 2014 drop seen previously. Similarly, the destination market analysis now shows steady pre-trends approaching the 2011 base year, after which rates dip and then gradually increase over time. These results suggest that, rather than suppressing rates on what would seem to be their most vulnerable services to regulation, carriers actually increased these rates despite the escalating threat of regulation.

3.5.2.5 MBR Discussion

Whether I use the individual service fixed effects specification or the market fixed effects specification, my findings suggest that firms did not curb rates to more concentrated origin or destination markets in the aftermath of FERC's review of Buckeye's unregulated rates. Instead, it appears that following the 2012 *Show Cause* order, firms increased rates substantially to their more concentrated destination markets and, less so, to their concentrated origin markets. As stated, the theory supports this outcome if firms either believe that the FERC does not consider rates when making a market determination or if firms believe the opposite: that FERC is especially sensitive to rate increases such that curbing rates to the point of avoiding re-regulation would produce lower expected profits than pricing monopolistically and guaranteeing future regulated prices.

[35] I use the `stdipw` option in the user-written drdid Stata command available from https://friosavila.github.io/playingwithstata/main_drdid.html with iweights to equally weight the carriers.

However, it is interesting to note where firms do appear to curb rates for their vulnerable services. For example, it is curious that the rates for services from concentrated origin markets to competitive destination markets declined following 2012 when all other measurements increased (see Figure A3.10a). It is possible that firms believed their concentrated origin markets, particularly those to more competitive destination markets, were not immediately threatened by re-regulation, but became increasingly precious over time as the April 2016 Initial Decision introduced the threat of a losing rate protest and the November 2017 FERC Opinion solidified it. This explanation also suits the intra-carrier rate effects found in Figure A3.10d. Just as in Erfle et al. (1990), the increasingly concentrated markets may not see the expected rate increases, as they are suppressed by strategic pricing in the face of regulatory threat. It is reasonable that the origin markets require more protection from regulation, as they contain far more rates than a given destination market.

The declining contested origin market rates are a similarly peculiar finding. However, the drastic market changes seen in A3.9e might suggest that the rising rates out of uncontested origin markets are likely related to increasingly concentrated uncontested markets despite inclusion of the lagged covariates. To check for this, I estimated the same TWFE model but tested whether adding various pre-event continuous HHI and HHI quartile time trends would impact the estimates. None of these affected origin market outcomes, though the contested destination markets did see increases in rates relative to uncontested markets following 2012.

In the following sections, I explore the same time trends for non-MBR rates and estimate a triple difference (DDD) model testing the difference in these trends.

3.5.3 COS Dynamic Effects

My main analysis focuses on the effect of FERC's evolving regulatory stringency on market-based rates, which are liable to become regulated upon complaint. It is likely that the lagged controls for those markets were insufficient to capture rate changes made in immediate response to shifting market conditions. Though COS rates may not exceed their regulated caps, which are set either by an annual index on the previous year's cap or through an arduous rate-setting process before the FERC, carriers may adjust rates below the cap in response to market conditions. Because COS rate cases are rare for existing services, which this sample is restricted to, and indexed rates are a percentage increase or decrease on previous rates, I can estimate the same TWFE regression on COS rates by the same carriers to determine whether the MBR results may be affected by market conditions.

I provide the event study graphs in Figures A3.16 and Figures A3.17.[36] For the continuous HHI measure in origin markets, I find significant pre-trends preceding 2012, after which rates decline from 2012 to 2014, then bounce back and rise beginning in 2015. There are similar pre-trends in the destination market analysis, though rates do not change following 2011 and experience a substantial fall in 2016.

Given that COS rates cannot rise as drastically as MBR rates, it is interesting that COS rate effects (4.5%) are larger overall than the MBR ATTs (2.8%). Similarly, it is curious to see the COS rates to more concentrated destination markets relatively dropping when MBRs rise over the same period. A similar trend exists for the binary treatment effects for origin markets (Figures A3.16b and A3.16c). However, the intra-carrier destination market analysis follows a unique trend with rates in the more concentrated markets descending relative to competitive markets until 2013, at which point rates increase.

When comparing COS rates in contested and uncontested origin markets, rates spike in 2012 and steadily decline for the remainder of the study period. Similarly, COS rates to contested destination markets increase from 2012 to 2014 and then begin to decline through 2019. Though pre-trends are irrelevant in this context, as I am evaluating the extent to which market changes would affect the MBR event studies, both contested market analyses appear to have steady pre-trends approaching 2012. It is important to note that though it is not expected that firms would adjust their COS rates in response to FERC's stance on MBRs, it is possible that MBRs affect COS through competitive or intra-firm strategic forces. Thus, if a policy affects MBRs and MBRs affect COS rates, then the

[36]I include only the carrier-service FE results for the sake of space. Also note that there were not enough COS rates in the most-concentrated MBR markets to run the inter-carrier destination market regression.

policy may appear to affect COS rates. Despite this possibility, I assume it is not the case in the following analysis.

3.5.4 Triple Differences

Under the assumption that COS rates would not be affected by FERC MBR policy but would be able to at least somewhat reflect market conditions, I estimate a triple difference (DDD) model comparing MBR and COS rates across more and less vulnerable markets.

To do this, I interact an MBR indicator with the time from treatment and vulnerable market indicators:

$$\ln rate_{iot} = \alpha_i + \alpha_t + \sum_{k \neq 2011} \delta_k \mathbf{1}[t = k] VM_{io} MBR_{io} + \mathbf{X}_{iot}\beta_X + \epsilon_{iot}, \tag{3.15}$$

where $MBR_{io} = 1$ when a rate is market-based and 0 when it is COS.

The results can be found in Figures A3.18 and A3.19. When looking at the continuous HHI measures, neither the origin nor destination market event studies suggest that there was a substantial change in 2012. However, increased MBR differences between more and less concentrated markets emerge in 2014 for origin markets and in 2015 for destination markets. In 2017, these differences invert such that the rate effects are negative for MBRs out of competitive origin markets. Similarly, in destination markets, MBR difference decline relative to COS differences beginning in 2017. In all of the competition-oriented analyses, there is a negative impact on MBR rates in concentrated markets beginning 2017, the landmark year in which FERC ruled with complainants against Buckeye's MBRs.

Conversely, the contested market analysis shows that MBRs to contested origin markets decreased more relative to uncontested markets than COS rates. In 2017, these differences suddenly revert to zero. For destination markets, there appears to be no difference between COS and MBR pricing behavior until 2017, at which point MBRs in contested markets jump dramatically higher than COS rates to the same markets. Again, these results do not change significantly when

HHI-based time trends are added to the regression.[37]

Because COS rates cannot perfectly respond to market changes, it would be misleading to focus on the point estimates from these regressions. For example, MBR rates may be able to rise in response to demand shocks while COS rates are held at their caps. This would give the appearance of MBRs responding more to the event than COS rates. However, the significant effects in the cost-of-service analysis show firms do heterogeneously adjust rates with respect to market conditions. There are instances where the COS rates appear to be decreasing on average whereas the MBR rates in the same markets increase.

Another issue to consider are the spillover effects from MBRs to COS rates, which I explore in Terkelsen (2021a). Firms may adjust COS rates to benefit their MBR services.

3.6 Conclusion

In the face of increasing scrutiny by both FERC and litigious consumers, pipeline carriers should theoretically self-regulate in an attempt to avoid actual regulation. In my examination of how U.S. carriers set rates in relation to landmark FERC decisions reversing decades of momentum toward economic freedom, it appears carriers are not responding as expected. Rather than curb rates in markets most vulnerable to regulation, carriers appear to set rates myopically—increasing them in their most concentrated markets. This result holds across both origin markets and destination markets. In my analysis of previously contested markets, where pipeline consumers have historically been revealed to be litigious, I find the same result. Overall, carriers prioritize short-run market response over strategic pricing to avoid future regulation.

[37] These results are not provided for the sake of space, but are available upon request.

APPENDIX

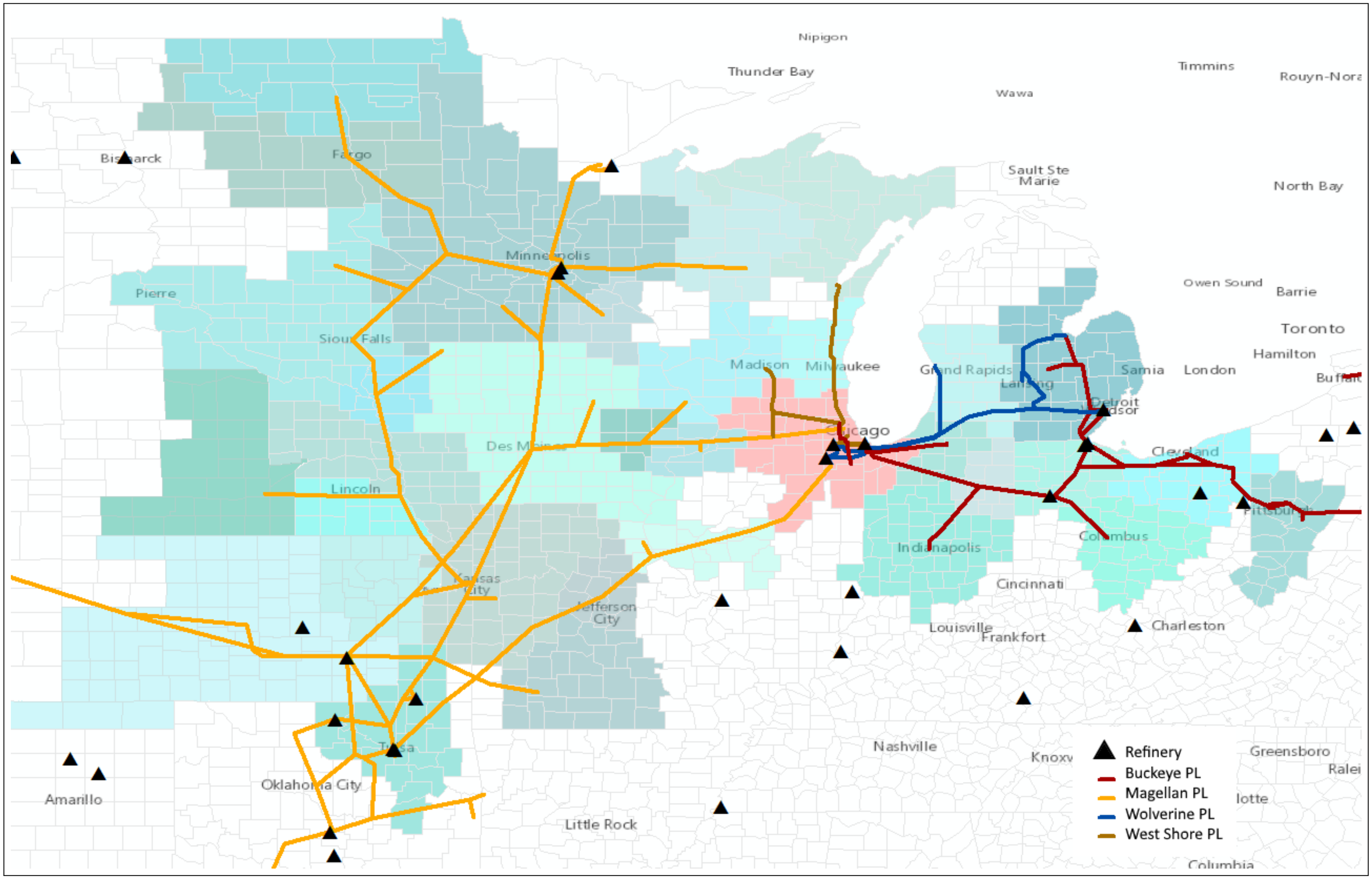
Figure A1.1: Chicago Origin MBR Cases (1990-2002)

Carrier	Date	Approved Destination Market(s)	
Buckeye	12/31/1990	Scranton	Saginaw-Bay City
		Pittsburgh	Fort Wayne
		Harrisburg	Kokomo-Marion
		Philadelphia	Indianapolis
		Columbus	Hartford
		Lima	Seattle
		Toledo	Terre Haute
		Detroit	
Magellan	7/28/1994	Chicago	Rockford
		St. Louis	Wausau
		Oklahoma City	Dubuque
		Tulsa	Davenport
		Wichita	Columbia
		Springfield/Decatur	Minneapolis/St. Paul
		Peoria	
Magellan	6/6/1995	Springfield (MO)	Omaha
		Kansas City	Eau Claire
		Lincoln	Fargo
		Quincy	Columbia
TEPPCO**	7/31/2000	Houston	Evansville
		Beaumont	Indianapolis
		St. Louis	Toledo
Wolverine	9/29/2000	Chicago	Toledo
		Elkhart	
TEPPCO**	4/25/2001	Shreveport*	Memphis
		Cincinnati/Dayton	
Wolverine	6/18/2001	Detroit*	
Marathon Ashland**	9/21/2001	Houston	Elkhart
		Baton Rouge	Louisville
West Shore	7/1/2002	Chicago	

*Partially deregulated markets

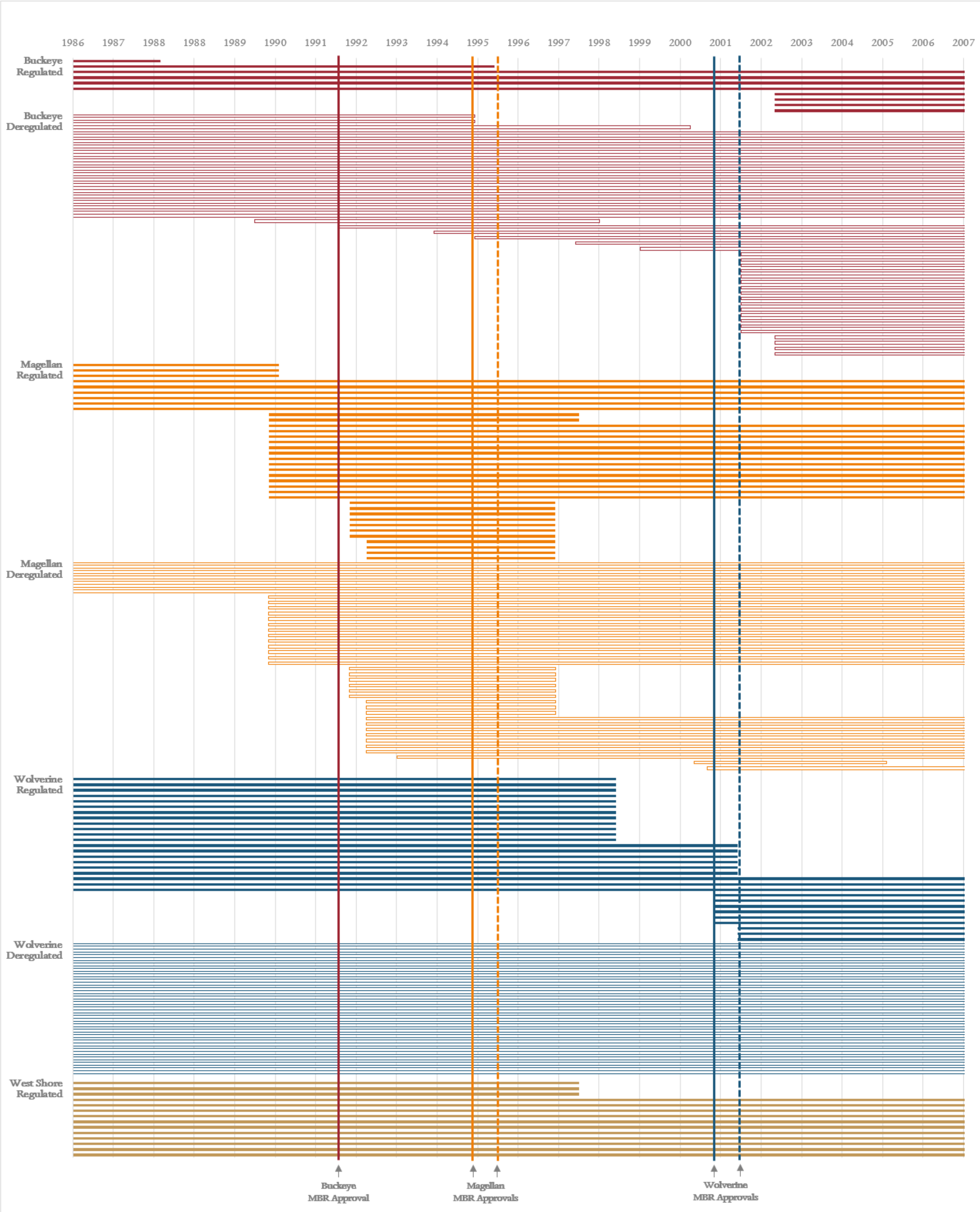
**Carriers excluded from analysis

Figure A1.2: Map of Chicago Refined Products Origin Market



Note: Markets (in shades of blue/green) are defined by 1995 BEA Economic Areas. Only the pipeline systems exporting product from the Chicago BEA market are depicted. Pipeline system shapefiles supplied by EIA.

Figure A1.3: Duration of Refined Products Services from Chicago



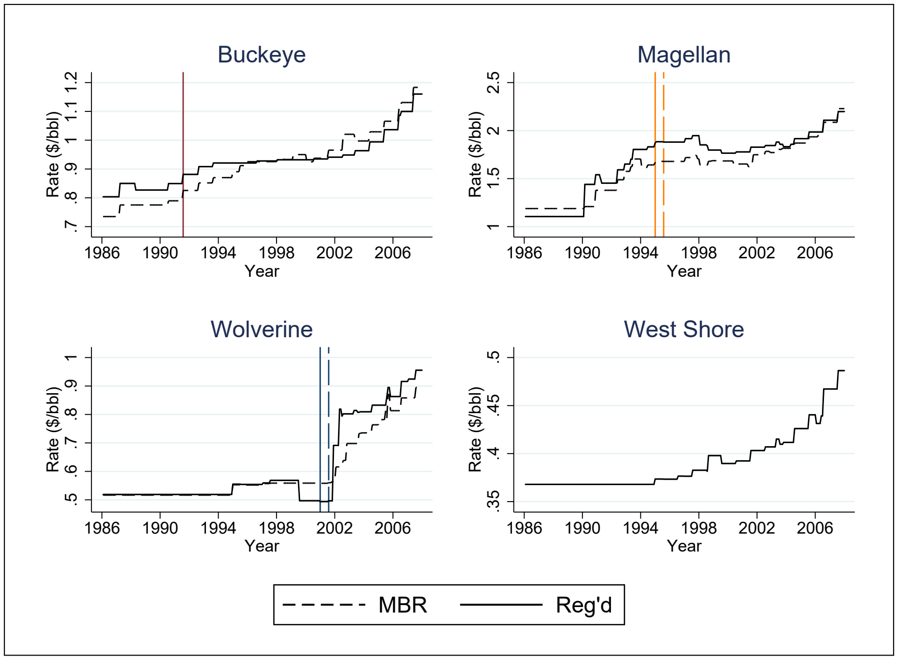
This graphic ignores the commodity specification of the service. Each horizontal bar represents the life of any refined products service connecting a unique origin-destination pair. The horizontal lines show the approximate dates of deregulation.

Table A1.1: Summary Statistics by Carrier

		Buckeye	Magellan	Wolverine	West Shore	All Carriers
Rates ($/bbl)	MBR	0.767	1.210	0.517		0.727
	Regulated	0.829	1.190	0.519	0.368	0.695
	All	0.786	1.198	0.518	0.368	0.711
Rate/Mile ($/bbl-mi)	MBR	0.294	0.357	0.214		0.267
	Regulated	0.271	0.291	0.248	0.258	0.264
	All	0.288	0.318	0.229	0.258	0.266
Destination Commodity Price ($/gal)	MBR	0.628	0.681	0.632		0.639
	Regulated	0.660	0.670	0.625	0.606	0.636
	All	0.638	0.675	0.629	0.606	0.637
Destination Commodity Sales (mgpd)	MBR	3.668	1.253	3.430		3.111
	Regulated	3.417	0.880	4.162	2.158	2.752
	All	3.593	1.031	3.760	2.158	2.926
Waterborne Destination (%)	MBR	0.831	0.311	0.882		0.626
	Regulated	1.000	0.023	0.568	1.000	0.447
	All	0.873	0.177	0.755	1.000	0.546
Destination Waterborne Receipts (mbpd)	MBR	2.444	0.068	1.785		1.240
	Regulated	0.352	0.001	0.488	0.134	0.187
	All	1.922	0.037	1.261	0.134	0.770
Destination Waterborne Shipments (mbpd)	MBR	0.465	0.032	0.858		0.398
	Regulated	0.162	0.000	0.220	0.065	0.086
	All	0.389	0.017	0.600	0.065	0.259
Refinery Destination (%)	MBR	0.723	0.430	0.882		0.646
	Regulated	1.000	0.000	1.000	0.000	0.366
	All	0.792	0.231	0.930	0.000	0.521
Destination Refinery Production (mbpd)	MBR	16.843	18.269	15.000		16.899
	Regulated	9.015	0.000	32.412	0.000	9.167
	All	14.891	9.794	22.041	0.000	13.448
Destination Consumption (mbpd)	MBR	41.101	18.315	56.301		35.967
	Regulated	33.443	7.806	22.296	17.844	16.179
	All	39.191	13.440	42.550	17.844	27.135
Distance (100 miles)	MBR	2.766	3.913	2.492		3.171
	Regulated	3.116	4.779	2.141	1.492	3.337
	All	2.853	4.315	2.350	1.492	3.245
No. of Markets	MBR	5	12	2	0	19
	Regulated	1	9	1	3	14
	All	6	21	3	3	33
No. of Services	MBR	168	228	102		498
	Regulated	56	216	120	53	445
	All	224	444	222	53	943
No. of Obs	MBR	20288	27762	7866		55916
	Regulated	12960	43260	37052	12975	106247
	All	33248	71022	44918	12975	162163

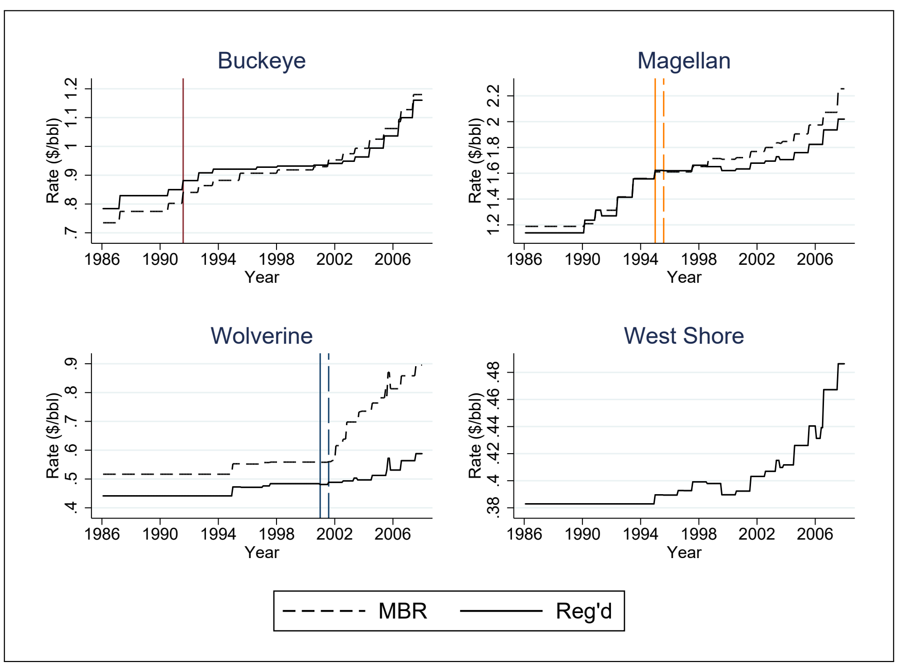
Notes: mbbl = Thousands of barrels. mbbd = Thousands of barrels per day. mgpd = Thousands of gallons per day. For comparison, rates, rates/mile, destination commodity price, and destination sales are the pre-1991 (i.e., pre-deregulation) averages. *West Shore* is the only carrier to offer only regulated rates for the full period. The outcome variables (rates, prices, and sales) are the pre-treatment averages for ease of comparison, while other variables are averaged or counted over the full period from 1986 to 2007.

Figure A1.4: Average Rates by Carrier and MBR Status (All Services)



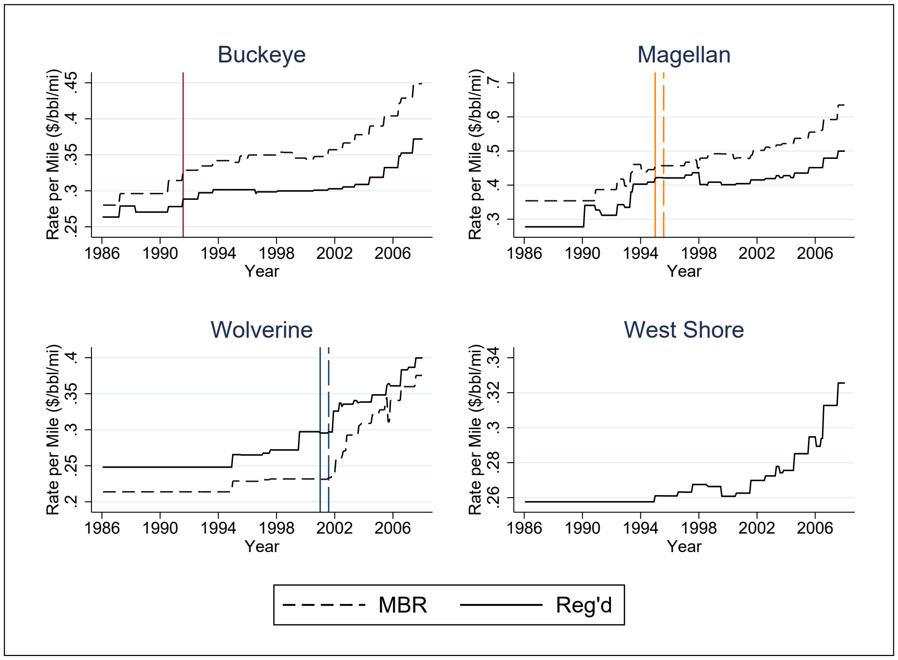
Vertical lines denote treatment dates. Carrier rates collected from FERC Tariff filings compiled by LawIQ. MBR status and treatment dates are from historical FERC MBR Orders.

Figure A1.5: Average Rates by Carrier and MBR Status (Balanced Panel)



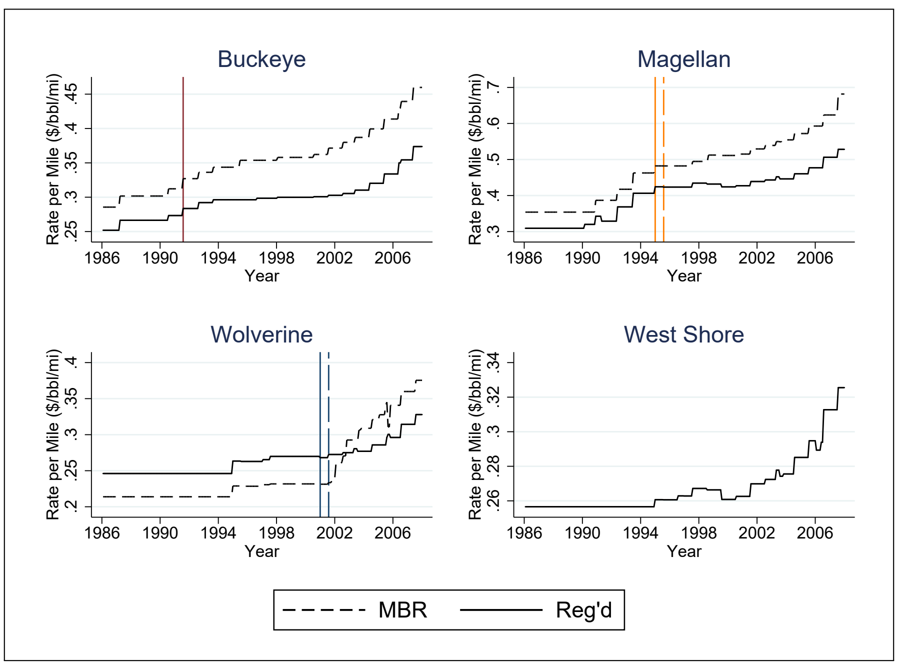
Vertical lines denote treatment dates. Carrier rates collected from FERC Tariff filings compiled by LawIQ. MBR status and treatment dates are from historical FERC MBR Orders. The balanced panel omits all rates that do not span the entire study period.

Figure A1.6: Per-Mile Rates by Carrier and MBR Status (All Services)



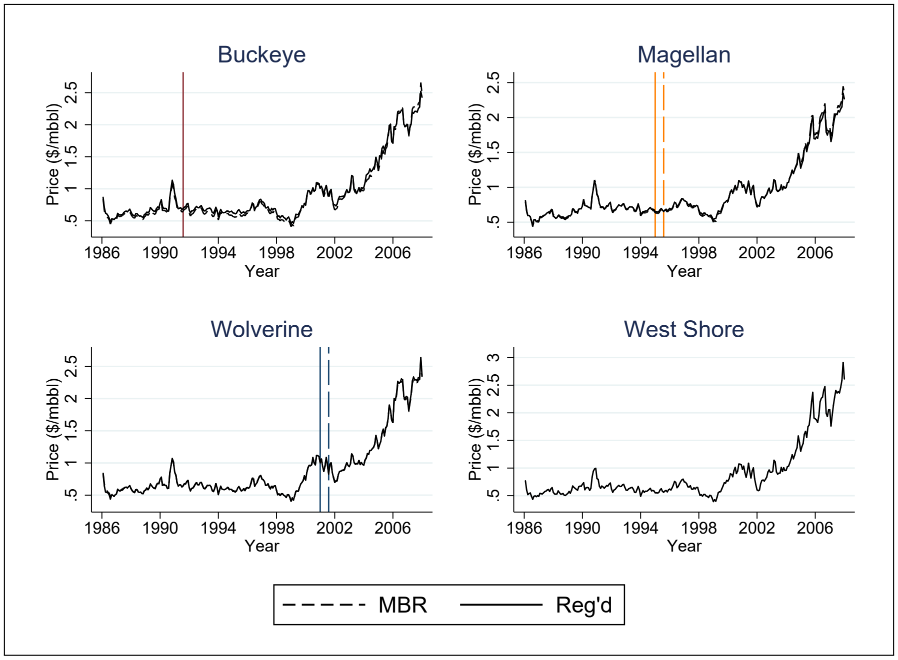
Vertical lines denote treatment dates. Carrier rates collected from FERC Tariff filings compiled by LawIQ. MBR status and treatment dates are from historical FERC MBR Orders. Mileage from Google API driving distances.

Figure A1.7: Per-Mile Rates by Carrier and MBR Status (Balanced Panel)



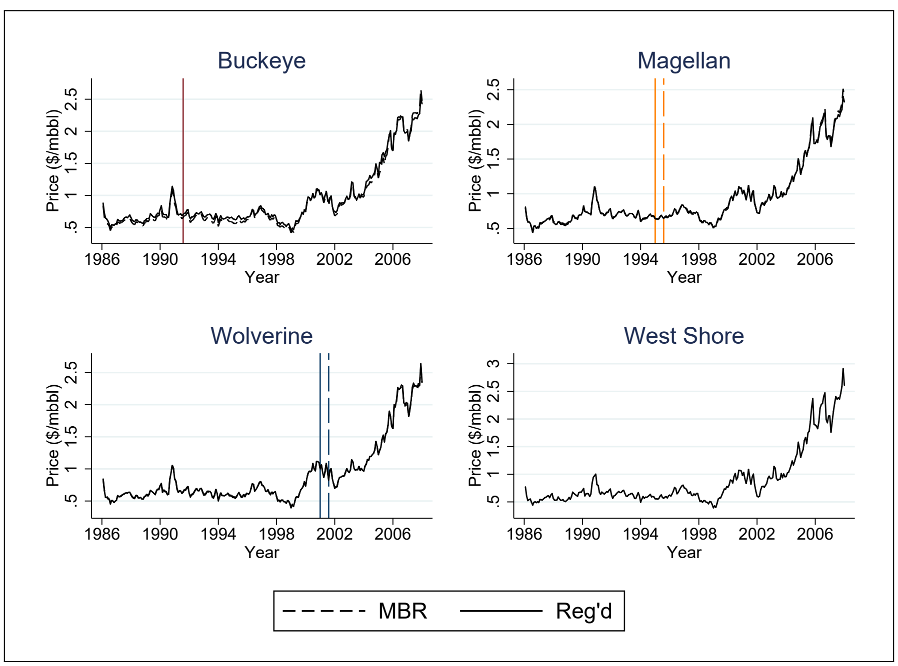
Vertical lines denote treatment dates. Carrier rates collected from FERC Tariff filings compiled by LawIQ. MBR status and treatment dates are from historical FERC MBR Orders. Mileage from Google API driving distances. The balanced panel omits all rates that do not span the entire study period.

Figure A1.8: Commodity Prices by Carrier and MBR Status (All Services)



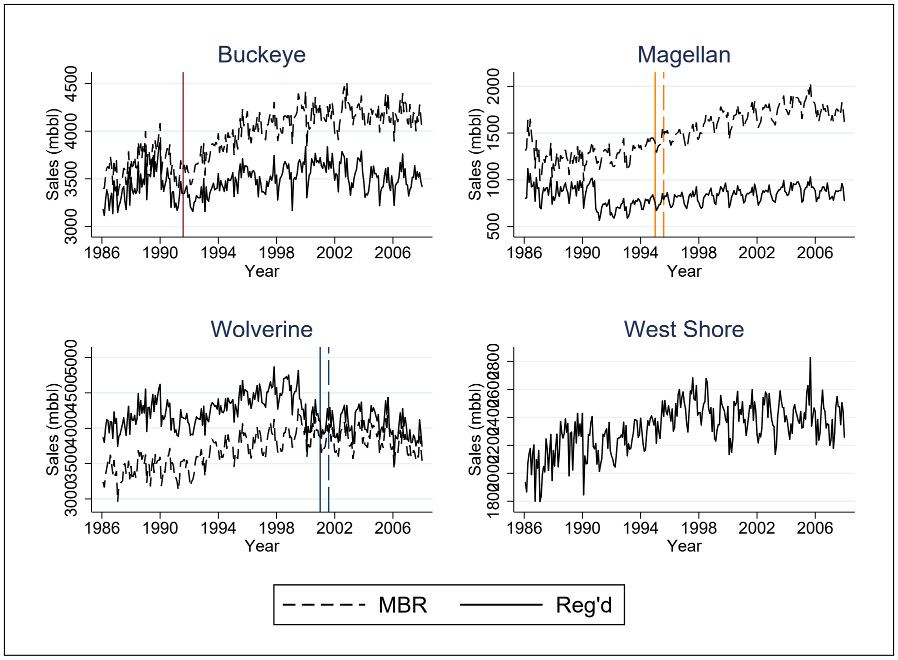
Vertical lines denote treatment dates. Commodity price data from EIA's Prime Supplier (Form EIA-782C). MBR status and treatment dates are from historical FERC MBR Orders.

Figure A1.9: Commodity Prices by Carrier and MBR Status (Balanced Panel)



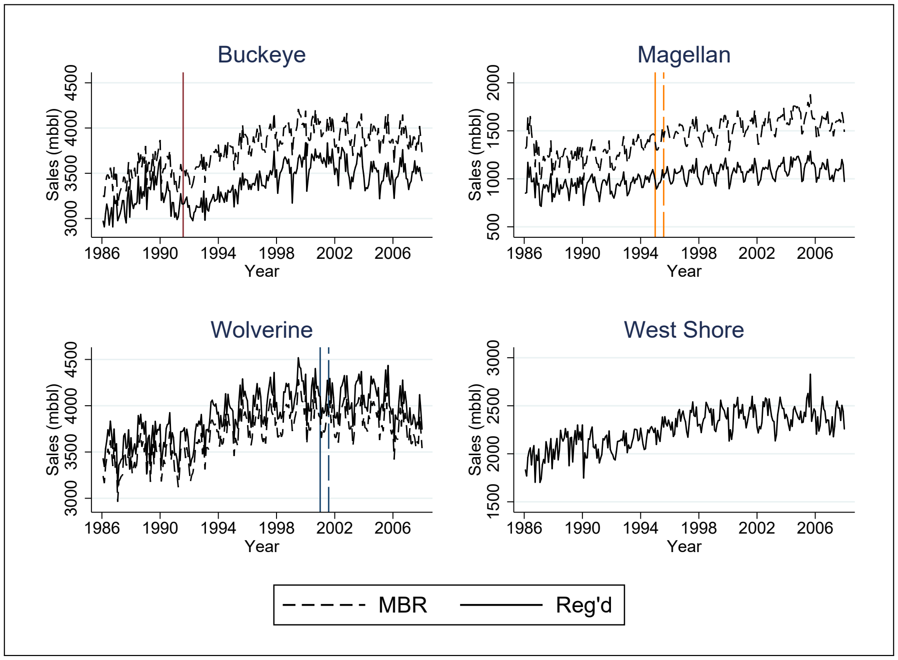
Vertical lines denote treatment dates. Commodity price data from EIA's Prime Supplier (Form EIA-782C). MBR status and treatment dates are from historical FERC MBR Orders. The balanced panel omits all rates that do not span the entire study period.

Figure A1.10: Commodity Sales by Carrier and MBR Status (All Services)



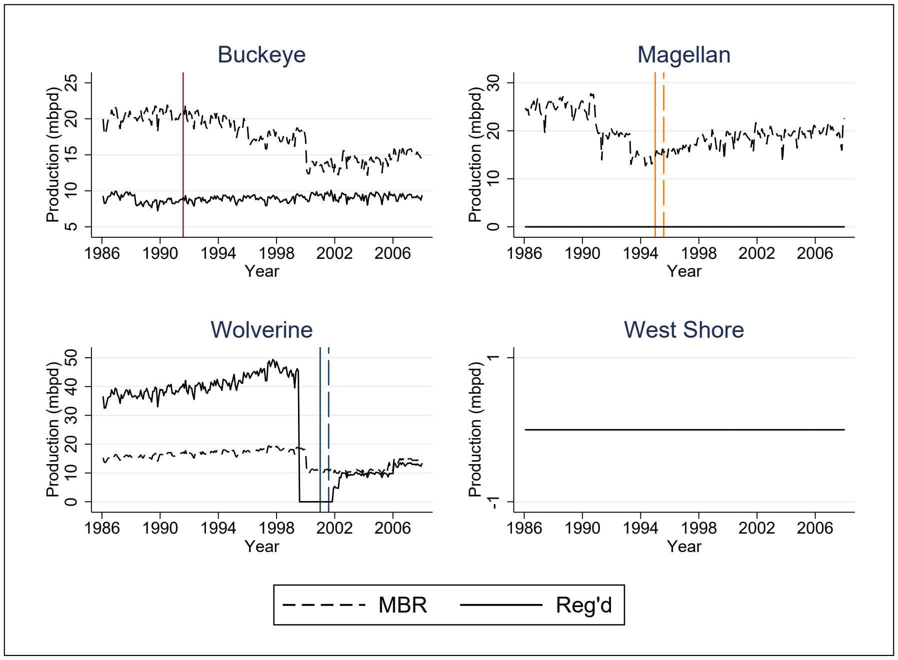
Vertical lines denote treatment dates. Commodity sales data from EIA's Prime Supplier (Form EIA-782C). MBR status and treatment dates are from historical FERC MBR Orders.

Figure A1.11: Commodity Sales by Carrier and MBR Status (Balanced Panel)



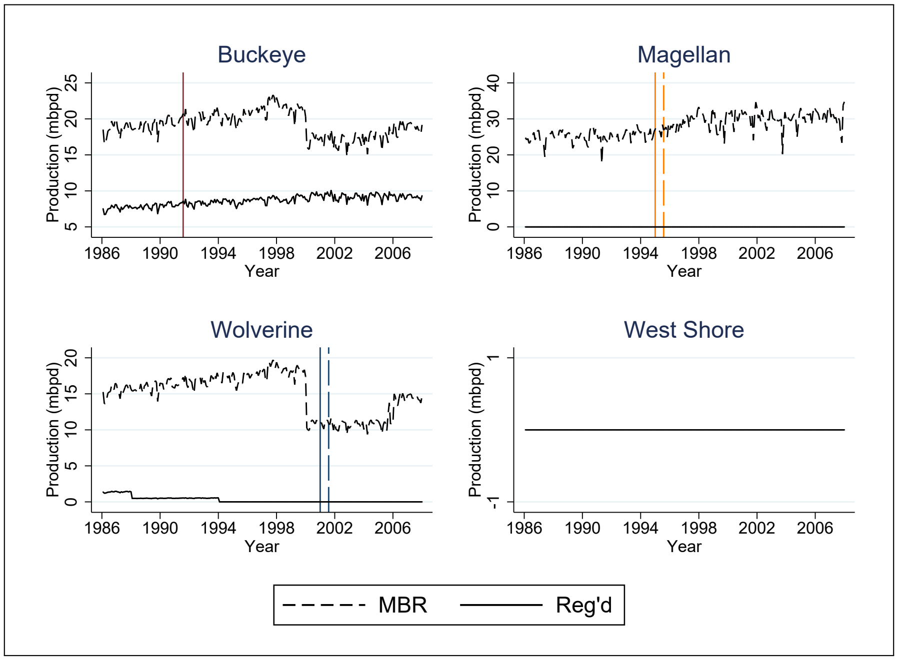
Vertical lines denote treatment dates. Commodity sales data from EIA's Prime Supplier (Form EIA-782C). MBR status and treatment dates are from historical FERC MBR Orders. The balanced panel omits all rates that do not span the entire study period.

Figure A1.12: Refinery Production by Carrier and MBR Status (All Services)



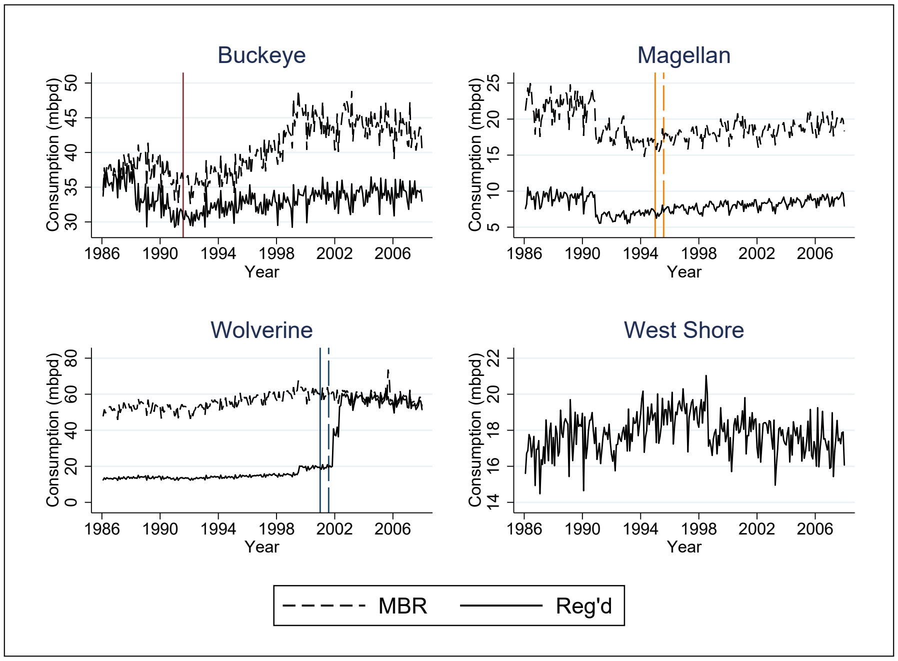
Vertical lines denote treatment dates. Refinery production estimated using EIA refinery-level crude capacity and PADD subregion level utilization rates and yields. MBR status and treatment dates are from historical FERC MBR Orders.

Figure A1.13: Refinery Production by Carrier and MBR Status (Balanced Panel)



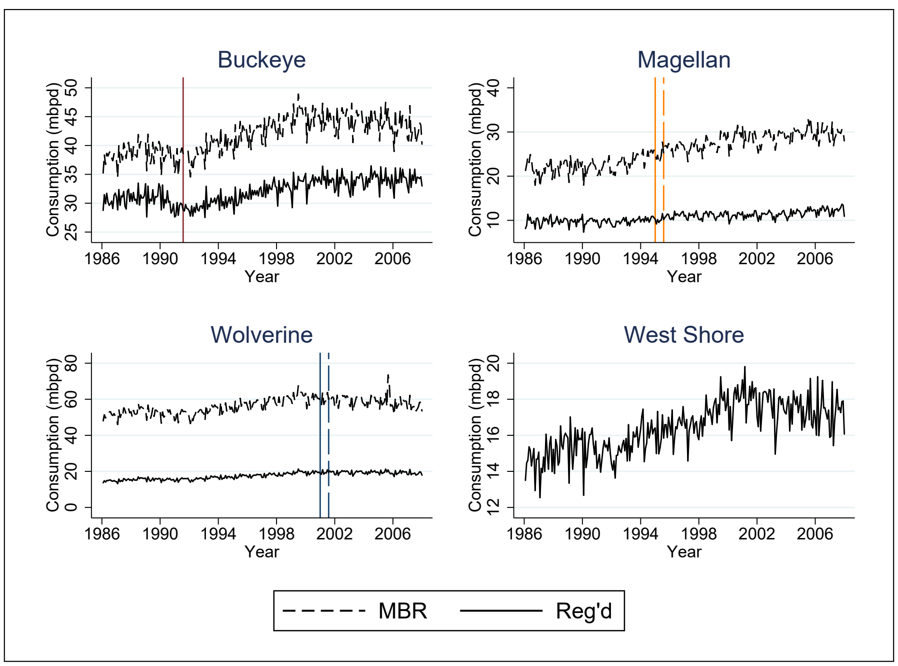
Vertical lines denote treatment dates. Refinery production estimated using EIA refinery-level crude capacity and PADD subregion level utilization rates and yields. MBR status and treatment dates are from historical FERC MBR Orders. The balanced panel omits all rates that do not span the entire study period.

Figure A1.14: Local Consumption by Carrier and MBR Status (All Services)



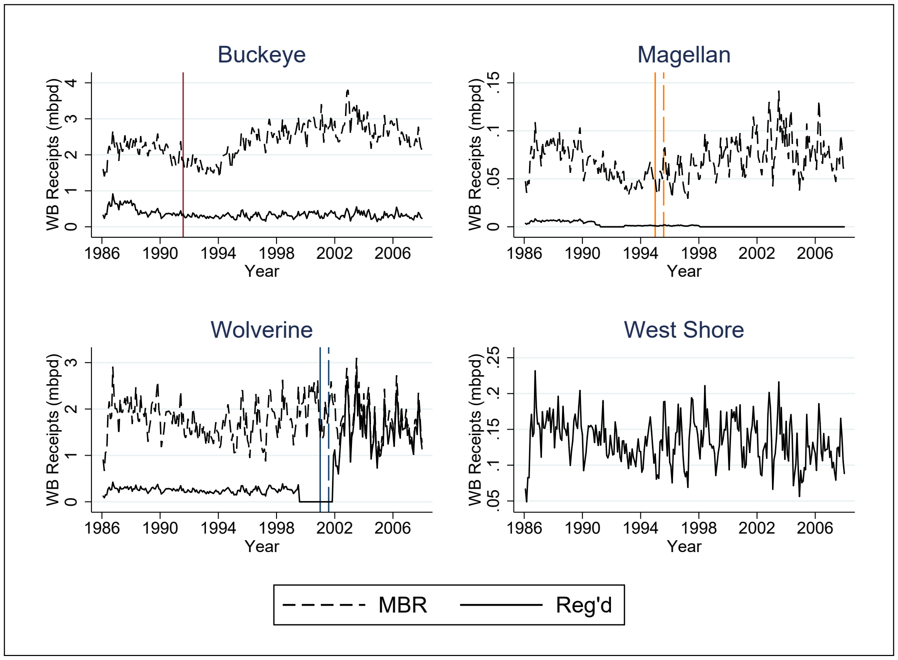
Vertical lines denote treatment dates. Consumption estimated using EIA SEDS and power plant fuel consumption data allocated to markets using U.S. Census county-level population data, BEA county-level employment data, and BTS air freight records. MBR status and treatment dates are from historical FERC MBR Orders.

Figure A1.15: Local Consumption by Carrier and MBR Status (Balanced Panel)



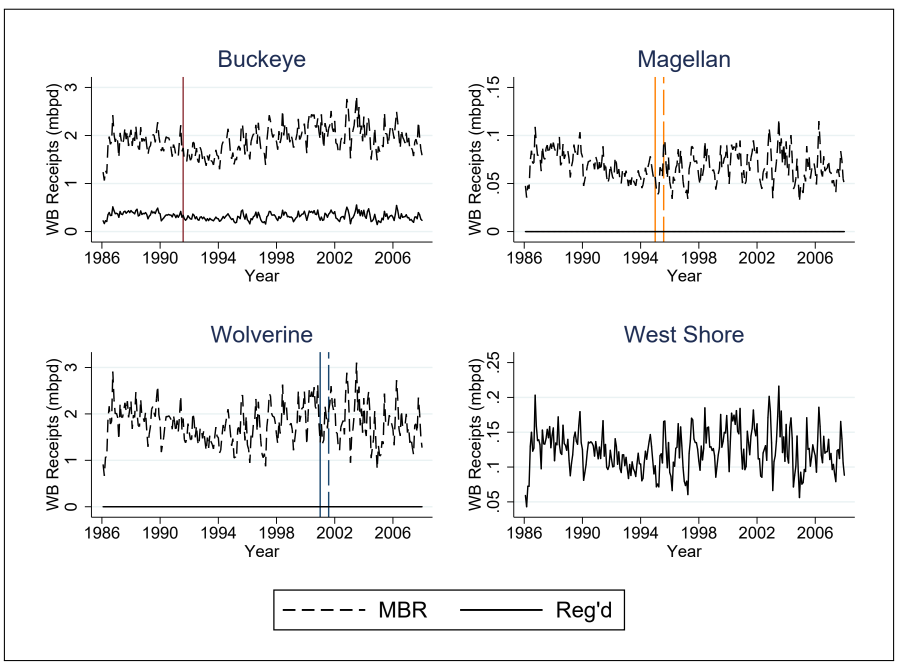
Vertical lines denote treatment dates. Consumption estimated using EIA SEDS and power plant fuel consumption data allocated to markets using U.S. Census county-level population data, BEA county-level employment data, and BTS air freight records. MBR status and treatment dates are from historical FERC MBR Orders. The balanced panel omits all rates that do not span the entire study period.

Figure A1.16: Waterborne Receipts by Carrier and MBR Status (All Services)



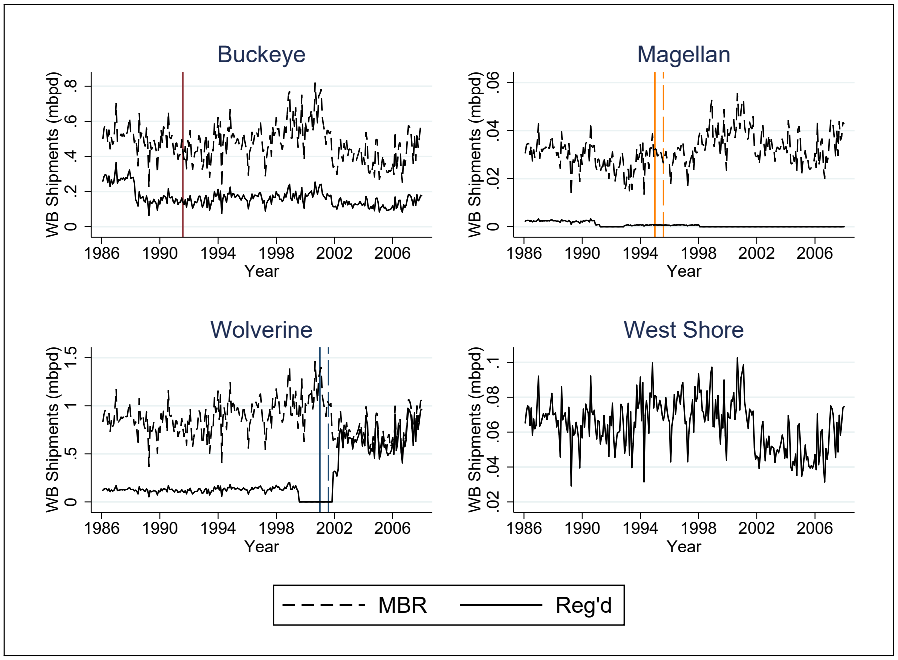
Vertical lines denote treatment dates. Waterborne data calculated using EIA intra-PADD movements and USACE port facility refined products capacity records. MBR status and treatment dates are from historical FERC MBR Orders.

Figure A1.17: Waterborne Receipts by Carrier and MBR Status (Balanced Panel)



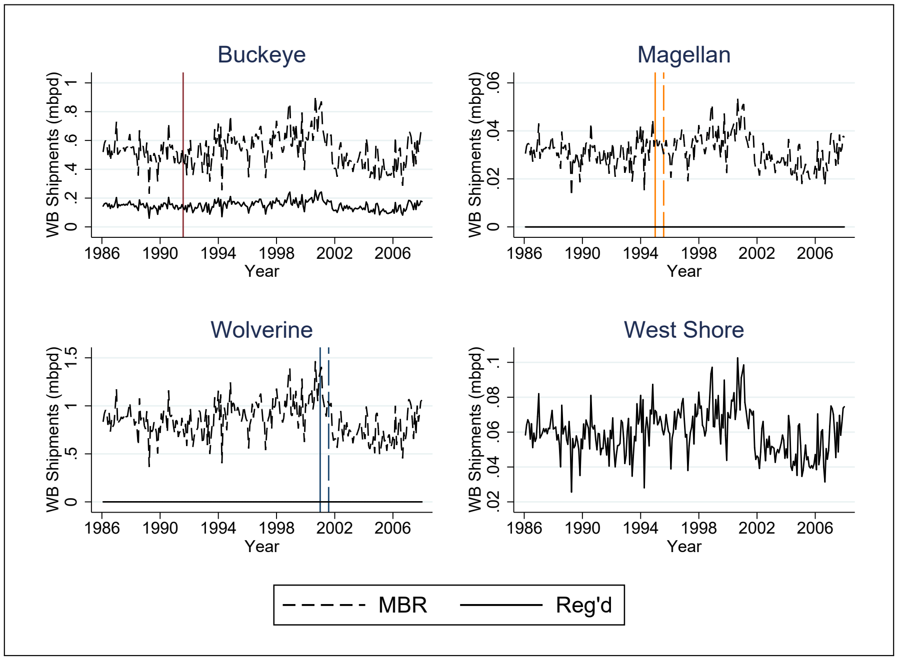
Vertical lines denote treatment dates. Waterborne data calculated using EIA intra-PADD movements and USACE port facility refined products capacity records. MBR status and treatment dates are from historical FERC MBR Orders. The balanced panel omits all rates that do not span the entire study period.

Figure A1.18: Waterborne Shipments by Carrier and MBR Status (All Services)



Vertical lines denote treatment dates. Waterborne data calculated using EIA intra-PADD movements and USACE port facility refined products capacity records. MBR status and treatment dates are from historical FERC MBR Orders.

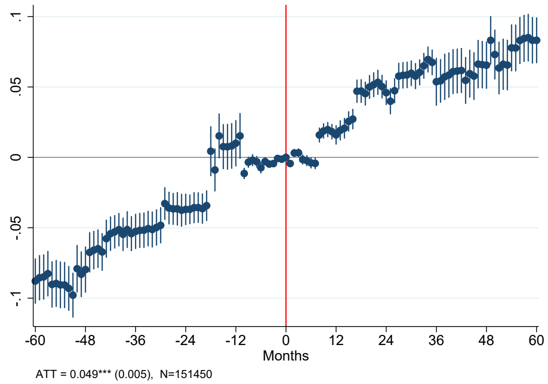
Figure A1.19: Waterborne Shipments by Carrier and MBR Status (Balanced Panel)



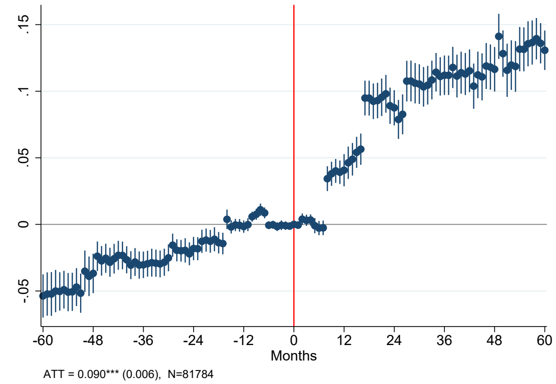
Vertical lines denote treatment dates. Waterborne data calculated using EIA intra-PADD movements and USACE port facility refined products capacity records. MBR status and treatment dates are from historical FERC MBR Orders. The balanced panel omits all rates that do not span the entire study period.

Figure A1.20: Rate Effect Estimates

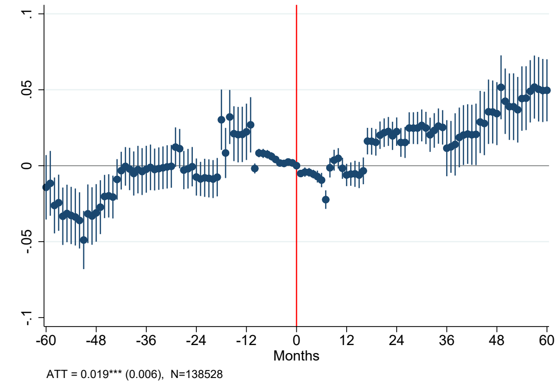
(a) Unbalanced Panel w/o Carrier-Time FE



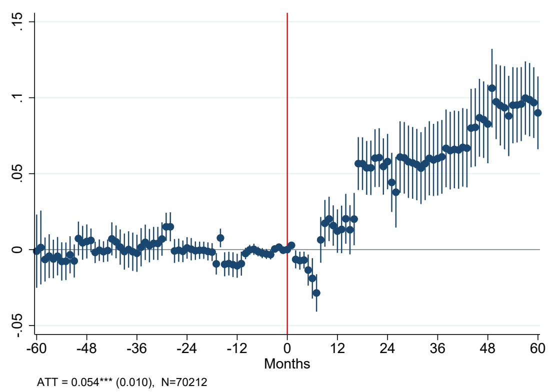
(b) Balanced Panel w/o Carrier-Time FE



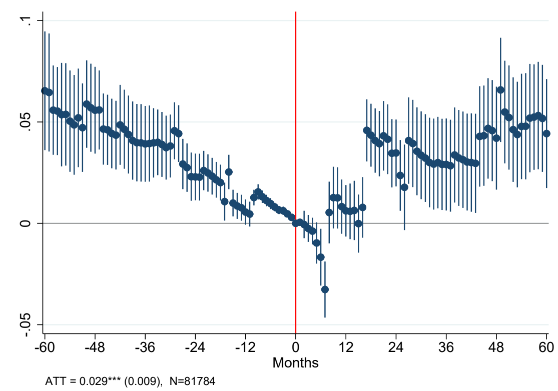
(c) Unbalanced Panel w/o West Shore



(d) Balanced Panel w/o West Shore



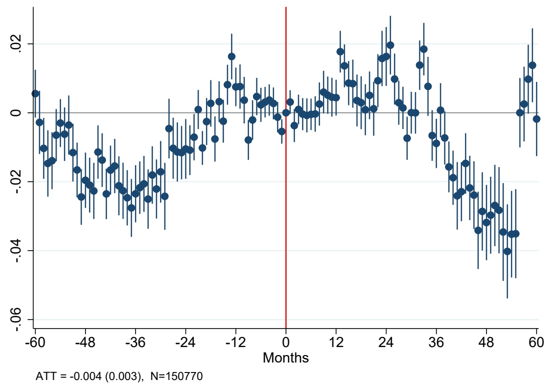
(e) Balanced Panel w/ Linear Market Time Trends and no Carrier Trends



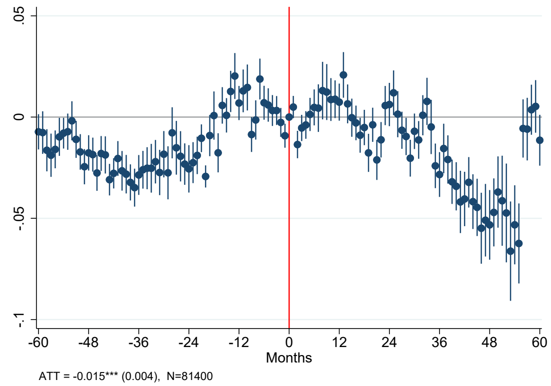
Note: All standard errors are clustered at the service (carrier-commodity-origin-destination) level. Vertical lines show 95% confidence intervals.

Figure A1.21: Commodity Price Effect Estimates

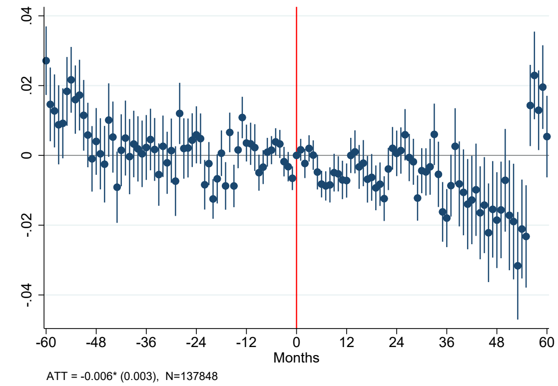
(a) Unbalanced Panel w/o Carrier-Time FE



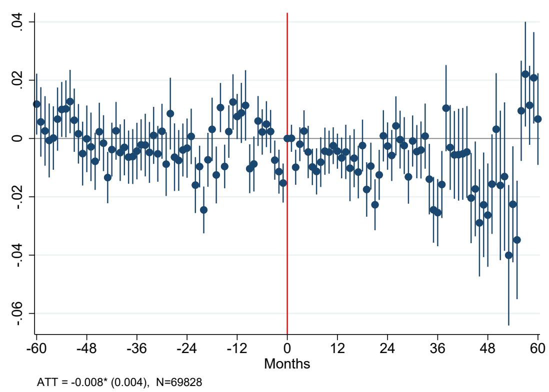
(b) Balanced Panel w/o Carrier-Time FE



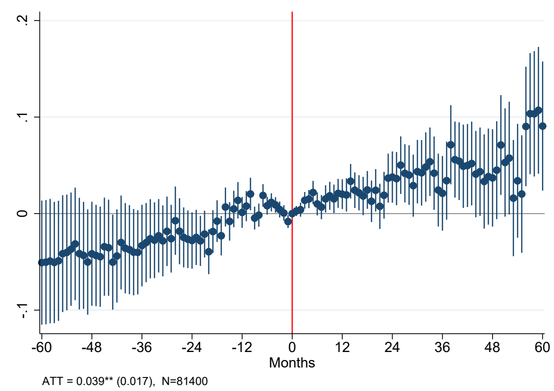
(c) Unbalanced Panel w/o West Shore



(d) Balanced Panel w/o West Shore



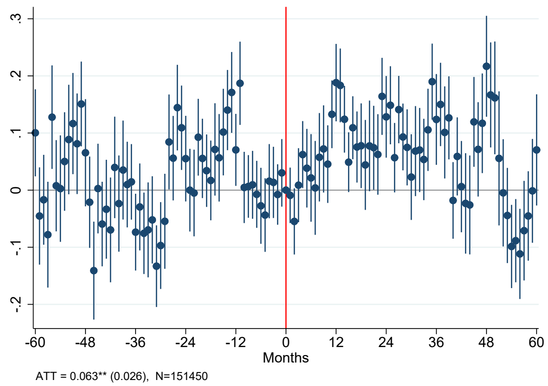
(e) Balanced Panel w/ Linear Market Time Trends and w/o Carrier-Time FE



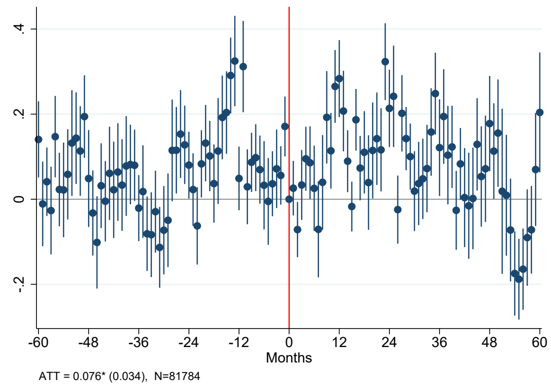
Note: All standard errors are clustered at the service (carrier-commodity-origin-destination) level. Vertical lines show 95% confidence intervals.

Figure A1.22: Commodity Sales Effect Estimates

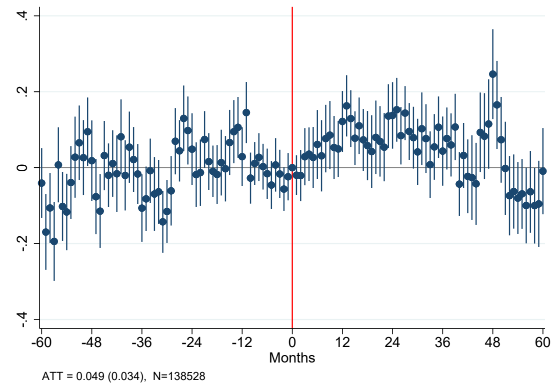
(a) Unbalanced Panel w/o Carrier-Time FE



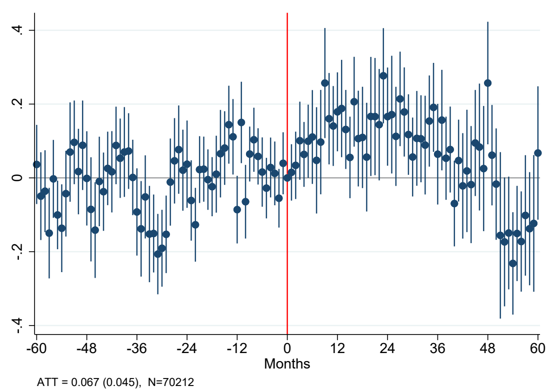
(b) Balanced Panel w/o Carrier-Time FE



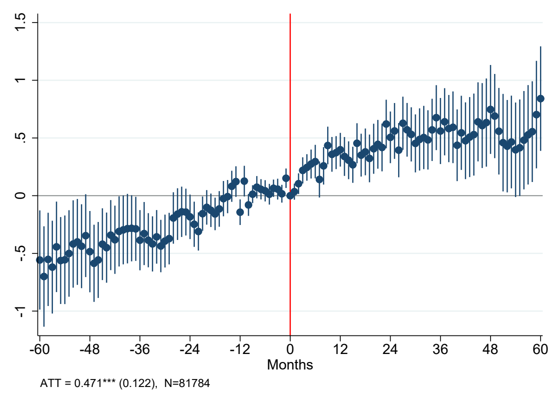
(c) Unbalanced Panel w/o West Shore



(d) Balanced Panel w/o West Shore



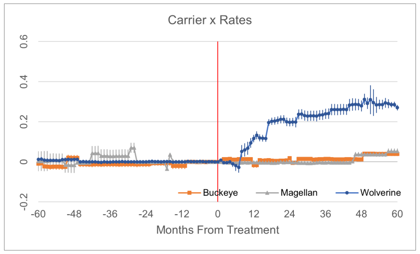
(e) Balanced Panel w/ Linear Market Time Trends and w/o Carrier-Time FE



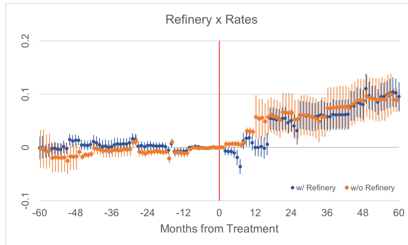
Note: All standard errors are clustered at the service (carrier-commodity-origin-destination) level. Vertical lines show 95% confidence intervals.

Figure A1.23: Heterogeneity ATTs

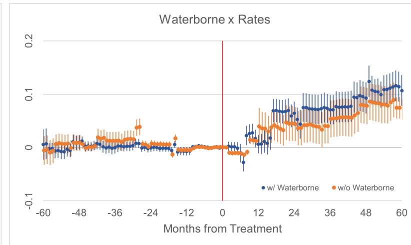
(a) Carrier × Rates



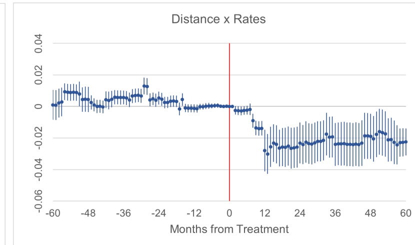
(b) Refinery × Rates



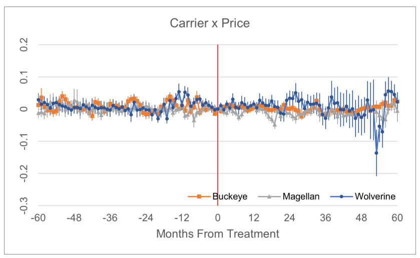
(c) Waterborne × Rates



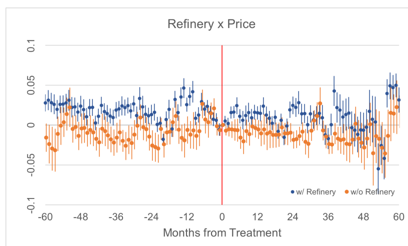
(d) Distance × Rates



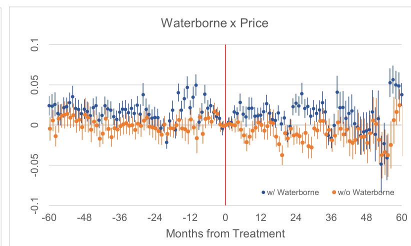
(e) Carrier × Commodity Price



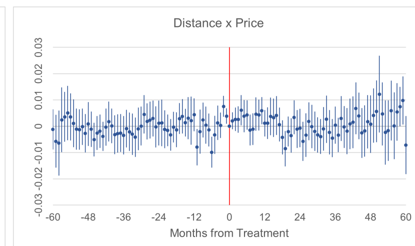
(f) Refinery × Commodity Price



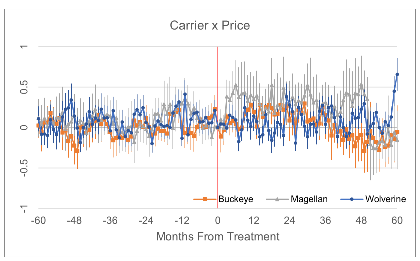
(g) Waterborne × Commodity Price



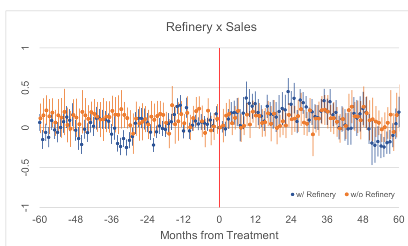
(h) Distance × Commodity Price



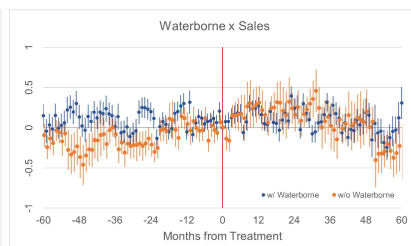
(i) Carrier × Commodity Sales



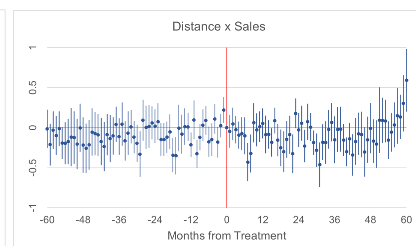
(j) Refinery × Commodity Sales



(k) Waterborne × Commodity Sales



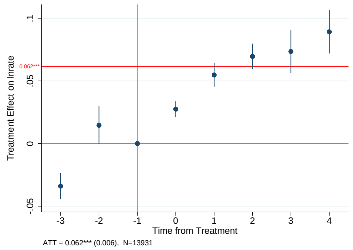
(l) Distance × Commodity Sales



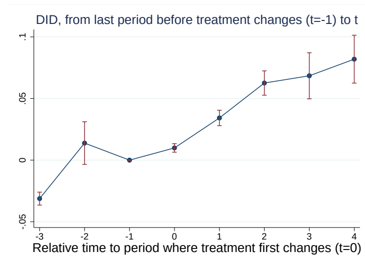
Note: All standard errors are clustered at the service (carrier-commodity-origin-destination) level. Vertical lines show 95% confidence intervals. The vertical red line denotes the time of treatment. The distance effects are the heterogeneous effects of an additional 100 miles between origin and destination on top of the base treatment effects. For example, a coefficient of 0.1 would mean that services that are 100 miles longer have 10% higher rates.

Figure A1.24: Alternative Specification: Annualized Event Study

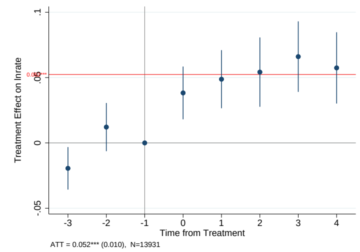
(a) TWFE Rate Effects



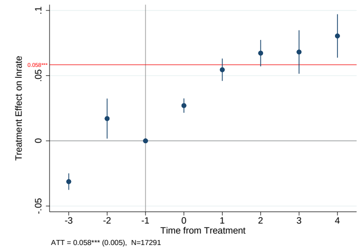
(b) de Chaisemartin and D'Haultfœuille (2021) Rate Effects



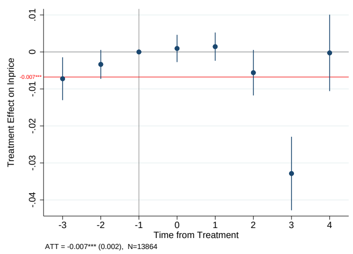
(c) Sun and Abraham (2020) Rate Effects



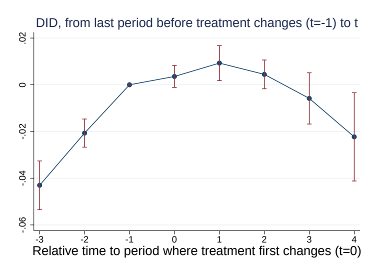
(d) Stacked Rate Effects



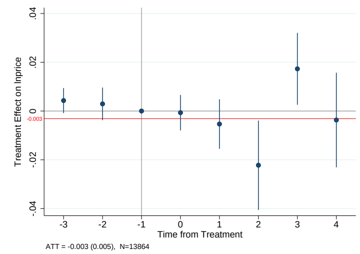
(e) TWFE Commodity Price Effects



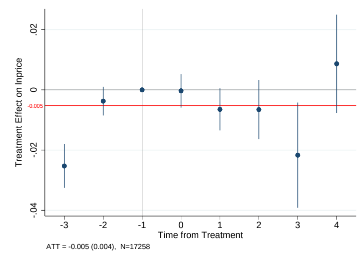
(f) de Chaisemartin and D'Haultfœuille (2021) Commodity Price Effects



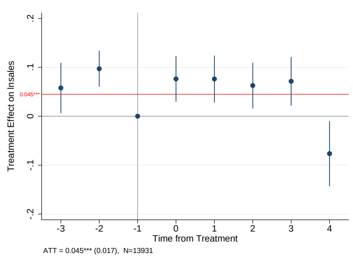
(g) Sun and Abraham (2020) Commodity Price Effects



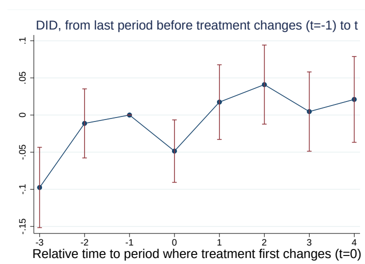
(h) Stacked Commodity Price Effects



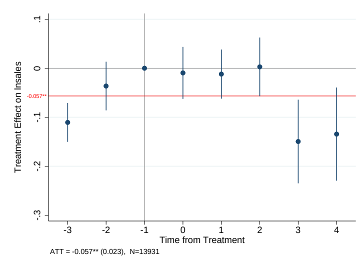
(i) TWFE Commodity Sales Effects



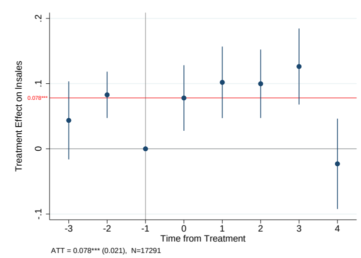
(j) de Chaisemartin and D'Haultfœuille (2021) Commodity Sales Effects



(k) Sun and Abraham (2020) Commodity Sales Effects



(l) Stacked Commodity Sales Effects



Note: All standard errors are clustered at the service (carrier-commodity-origin-destination) level. Vertical lines show 95% confidence intervals. The horizontal red line marks the 5-year average post-treatment effect. de Chaisemartin and D'Haultfœuille (2020) graphs generated using authors' DID_MULTIPLEGT command. Sun and Abraham (2020) estimates generated using authors' EVENTSTUDYINTERACT command.

Table A2.1: List of FERC orders on Market-Based Rates

Pipeline	Application Date	Order Date	FERC Citation	Docket No.	Origin Markets	Destination Markets	Notes
Buckeye	10/15/2014[1]	11/16/2017	161 FERC ¶ 61,180	OR14-4		Harrisburg** and Pittsburgh**	k.a. Opinion No. 558. Buckeye loses MBR Authority
Buckeye Linden	8/1/2016	8/24/2017	160 FERC ¶ 61,021	OR16-21	New York City	New York City	Approved without contest.
Buckeye	10/15/2012	2/28/2013	142 FERC ¶ 61,162	OR13-3	New York City	New York City	Approved after removing jet fuel commodity
Magellan	1/15/2010	12/14/2011	137 FERC ¶ 61,222	OR10-6	McPherson, KS and El Dorado, KS		Origins approved via settlement
Magellan	1/15/2010	7/7/2010	132 FERC ¶ 61,016	OR10-6	McPherson, KS* and El Dorado, KS*	Denver	Destination approved without hearing, Origins set for hearing following shipper protest
Magellan	6/2/2009	9/25/2009	128 FERC ¶ 61,278	OR09-9	Houston ("West Gulf Coast")	Tulsa	Approved without contest.
Sunoco	4/12/2005	3/30/2007	118 FERC ¶ 61,266	OR05-7	Philadelphia	Cleveland, Harrisburg[2], Pittsburgh, Scranton, and Toledo	Approved after market revision and settlement
Sunoco	4/12/2005	1/19/2006	114 FERC ¶ 61,036	OR05-7	Detroit, Philadelphia*, Pittsburgh, Rochester, and Toledo	Cleveland*, Detroit, Harrisburg*, New York, Philadelphia, Pittsburgh*, Scranton*, and Toledo*	Contested application, MBR approved in uncontested origin markets and some contested destination markets. Others set for hearing
Shell	7/9/2002	5/23/2003	103 FERC ¶ 61,236	OR02-10	St. Louis* and Chicago	Champaign, Chicago*, Evansville*, Indianapolis*, St. Louis*, and Toledo	Contested application. Approved in part, application withdrawn on 4/27/2004
West Shore	3/20/2001	7/1/2002	100 FERC ¶ 61, 001	OR01-6	Chicago	Chicago	Approved without contest.
Marathon Ashland	2/22/2000	9/12/2001	96 FERC ¶ 61, 263	OR00-1	Houston, New Orleans, St. Louis, Evansville, Chicago	Houston, Baton Rouge, Champaign, Chicago, Elkhart, Grand Rapids[3], Louisville, Indianapolis, Toledo	Approved after revision and withdrawn protest.
Wolverine	6/14/1999	7/11/2001	96 FERC ¶ 61,046	OR99-15		Detroit	Approved after revision and withdrawn protest.
Colonial	3/16/2000	6/13/2001	95 FERC ¶ 61,377	OR00-3	Corpus Christi, Houston, Beaumont, Port Arthur, Lake Charles, Baton Rouge, Birmingham/Montgomery, Philadelphia, New York	Philadelphia, New York	Approved without hearing after protests withdrawn.
Colonial	3/26/1999	5/16/2001	95 FERC ¶ 61,210	OR99-5	Corpus Christi, Houston, Beaumont, Port Arthur, Lake Charles, and Baton Rouge		Protest withdrawn. Markets approved.
TEPPCO	5/11/1999	4/25/2001	95 FERC ¶ 61,108	OR99-6	Shreveport	Little Rock[4], Shreveport/Arcadia[5], Cincinnati/-Dayton, and Memphis	Protest withdrawn. Markets approved after revision.
Wolverine	6/14/1999	9/29/2000	92 FERC ¶ 61,277	OR99-15	Chicago	Chicago, Elkhart, Grand Rapids[6], Detroit*, and Toledo	Contested application. MBR approved in uncontested markets.
Colonial	3/26/1999	8/1/2000	95 FERC ¶ 61,144	OR99-5	Corpus Christi*, Houston*, Beaumont*, Port Arthur*, Lake Charles*, and Baton Rouge*	Baton Rouge, Beaumont, Jackson, Lafayette	Contested application. MBRs approved in contested and uncontested destinations. Origins set for hearing.
TEPPCO	5/11/1999	7/31/2000	92 FERC ¶ 61,121	OR99-6	Indianapolis, Chicago, Shreveport*	Houston, Beaumont, St. Louis, Evansville, Indianapolis, Toledo, Little Rock*, Shreveport/Arcadia*, Cincinnati/Dayton*, and Memphis*	Contested application. MBRs approved in some markets, others set for hearing.
Explorer	10/15/1998	6/30/1999	87 FERC ¶ 61,374	OR99-1	Houston, Tulsa, St. Louis	Dallas, Tulsa, Houston, St. Louis, Chicago	Contested application. MBRs approved in all markets without hearing.
Longhorn	3/19/1998	6/30/1998	83 FERC ¶ 61,345	OR98-12	Galena Park, TX	El Paso	Contested application. MBRs approved without hearing
Kaneb	9/16/1997	5/18/1998	83 FERC ¶ 61,183	OR97-13	El Dorado, KS; McPherson, KS; Commerce City, CO; Cheyenne, WY; Sinclair, WY	Fargo, Omaha, Lincoln, Wichita, Denver, Casper	Protest withdrawn. Markets approved.
Colonial	7/21/1995	3/31/1997		OR95-9	Corpus Christi, Houston, Beaumont, Port Arthur, Lake Charles, Baton Rouge, Birmingham/Montgomery, Philadelphia, New York	Philadelphia, New York	Contested application. MBRs approved in experimental program after settlement
Magellan (as Williams)	1/16/1990	6/6/1995	71 FERC ¶ 61,291	IS90-21	[7]	Springfield, Kansas City, Lincoln, Quincy, Omaha, Eau Claire, Fargo, Des Moines*, Grand Forks*	k.a. Opinion No. 391-A.Some MBRs approved in experimental program following protest and hearing
Magellan (as Williams)	1/16/1990	7/28/1994	68 FERC ¶ 61,136	IS90-21	[7]	Chicago, St. Louis, Oklahoma City, Tulsa, Wichita, Springfield-Decatur, Peoria, Rockford, Wausau, Dubuque, Davenport, Columbia, Minneapolis, Springfield*, Kansas City*, Lincoln*, Quincy*, Omaha*, Eau Claire*, Fargo*, Des Moines*, Grand Forks*, Duluth*, Rochester*, Sioux City*, Topeka*, Grand Island*, Sioux Falls*, Aberdeen*, Quincy*, Cedar Rapids*, Waterloo*, Fort Dodge*	k.a. Opinion No. 391. Contested application. Some MBRs approved in experimental program
Buckeye	2/13/1987[8]	12/31/1990	53 FERC ¶ 61,473	IS87-14	[9]	Scranton, Pittsburgh, Harrisburg, Philadelphia, Columbus, Lima, Toledo, Detroit, Saginaw-Bay City, Fort Wayne, Kokomo-Marion, Indianapolis, Hartford, Seattle, Terre Haute, Syracuse*, Rochester*, Binghampton*, Cleveland*, Youngstown*, Buffalo, New York	k.a. Opinion No. 360. Some MBRs approved in experimental program while others are rejected and some have no finding.

*indicates markets that are applied for but not approved in the order. ** indicates markets that had their MBR status revoked. [1] Complaint, not application. [2] Sunoco revised its Harrisburg market to remove all but one destination terminal. [3] Marathon withdrew its Grand Rapids destination market. [4] TEPPCO withdrew its application to the Little Rock destination market. [5] TEPPCO withdrew its application to the Arcadia destination in the Shreveport/Arcadia destination market. [6] Wolverine withdrew its Grand Rapids destination market. [7] Magellan asked that these destination markets be approved for all origins. [8] Opinion 360 emerged from an appeal in a cost-based rate proceeding. This is the initial date of that proceeding. [9] Buckeye asked that these destination markets be approved for all origins.

A2.1 RPP Market Database Methodology

A2.1.1 Purpose

This document lays out how I built a database estimating monthly county-level refined petroleum product market statistics from 1986 to 2019 using publicly available data. I rely on methods commonly used in Federal Energy Regulatory Commission proceedings for evaluating market power of regulated common carriers. Consulting experts in such cases generally conduct market analyses for the year leading up to a filing or hearing, and therefore only collect data for the markets and time periods relevant to the instant proceeding. My aim was to use their methods to construct the full history of U.S. refined petroleum products markets since 1986. I estimate county×month volumes of:

- Local end-use consumption,
- Refinery production,
- Waterborne Receipts, and
- Waterborne Shipments

for each of the following refined petroleum products:[38]

- Motor gasoline,
- Aviation gasoline,
- Kerosene-type jet fuel (herein referred to as just "jet fuel"),
- Kerosene,
- Distillate No. 1, and
- Distillate No. 2.

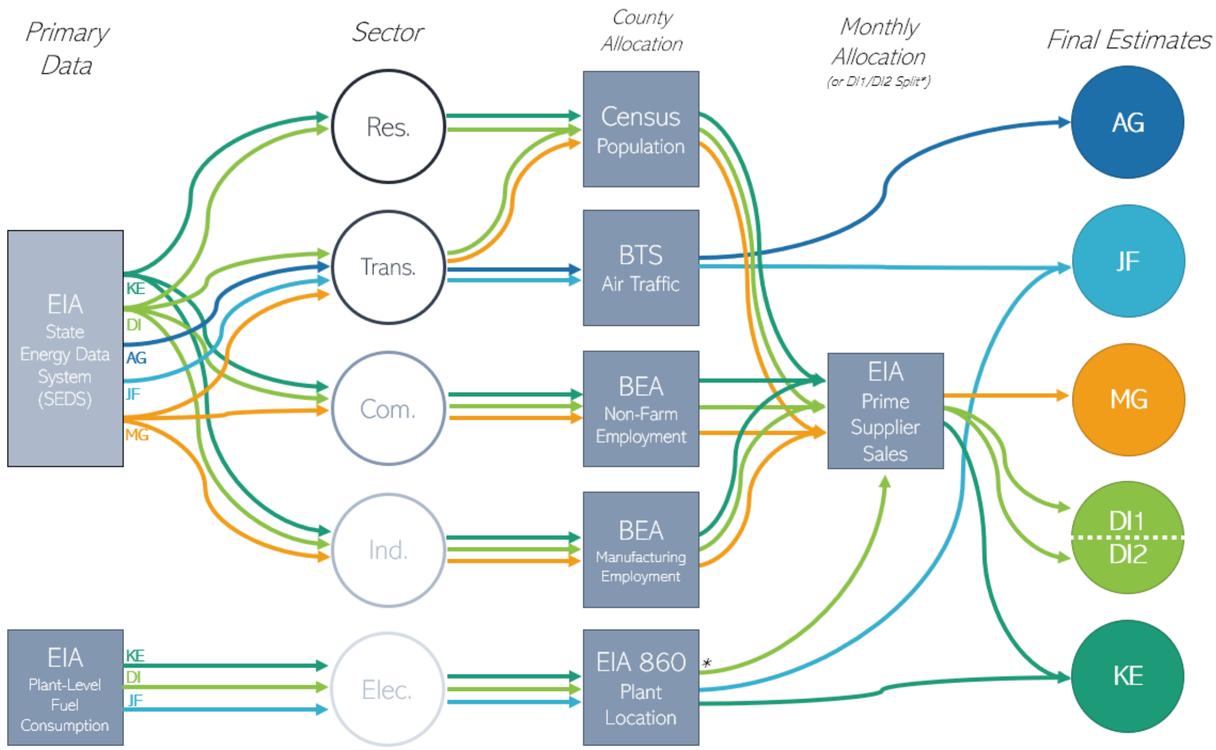
This dataset (455MB) is available upon request. Each of the following sections describes how I calculated these estimates.

[38] These products are considered “pipelineable” petroleum products.

A2.1.2 End-Use Consumption

To estimate county-level consumption, I follow a methodology described in expert testimony filed in the most recent *Colonial* rate case in January 2020.[39] The figure below shows the flow and allocation of data.

Figure A2.1: Consumption Schematic



KE = Kerosene, DI = Distillates, AG = Aviation Gasoline, JF = Jet Fuel, and MG = Motor Gasoline.

The primary data sources for end-use consumption are (1) Energy Information Agency's (EIA) State Energy Data System (SEDS) End-Use Consumption Data,[40] which provides annual state-level consumption data by sector (i.e., residential, transportation, commercial, industrial, electricity generation) and commodity (i.e., motor gasoline, aviation gasoline, jet fuel, kerosene, and distillate) and (2) EIA's 923 Fuel Consumption report,[41] which reports power plant consumption by month,

[39] *Colonial Pipeline*'s Exhibit No. CPC-00141 from its January 24th, 2020 filing can be found using FERC's eLibrary in Docket No. OR18-7-002 (consolidated).

[40] Obtained from https://www.eia.gov/state/seds.

[41] EIA plant-level fuel consumption available from Form EIA-932 at

plant, and fuel type. Though SEDS data include the electricity generation sector, the plant-level consumption data are reported monthly and are more easily linked to counties.

State-level consumption of the four sectors from the SEDS data need to be allocated to the county level. I allocate the kerosene and distillate in the residential sector using intercensal annual county population from the U.S. Census.[42] Because these products are generally used for heating homes, it is reasonable to believe consumption correlates with population.

I use the same population data to allocate transportation sector motor gasoline and distillate consumption, as these are mostly used for moving both people and goods for people. The remaining transportation sector commodities, aviation gasoline and jet fuel, relate to air travel. I allocate these data to counties using commercial aviation data from the Bureau of Transportation Statistics (BTS) Air Carrier Statistics,[43] which reports the number of enplaned passengers and the weight of enplaned freight and mail for commercial airports every month. Assuming on average a single passenger weighs 136 lbs, I sum the weight of these volumes to get total weight enplaned for each airport origin, which I aggregate to the county level. Because these data do not exist before 1990, I maintain 1990 county distribution of air freight to fill in missing years 1986 to 1989.

Because the commercial sector is directly related to commercial activity, I assign each of the three commodities (kerosene, distillate, and motor gasoline) to counties based on total nonfarm employment data from the Bureau of Economic Analysis (BEA).[44] Similarly, because the industrial sector is largely manufacturing, I allocate its commodities (kerosene, distillate, and motor gasoline) to counties using private non-farm manufacturing employment from the BEA. Where manufacturing data are omitted (not zero),[45] I fill in the missing data by maintaining the ratio of manufacturing to total nonfarm employment in the closest year.

The final step for the SEDS data is to disaggregate the annual county-level data, excluding the air transportation fuels that are already at the monthly level, to months using state- and commodity-

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https://www.eia.gov/electricity/data/eia923/.

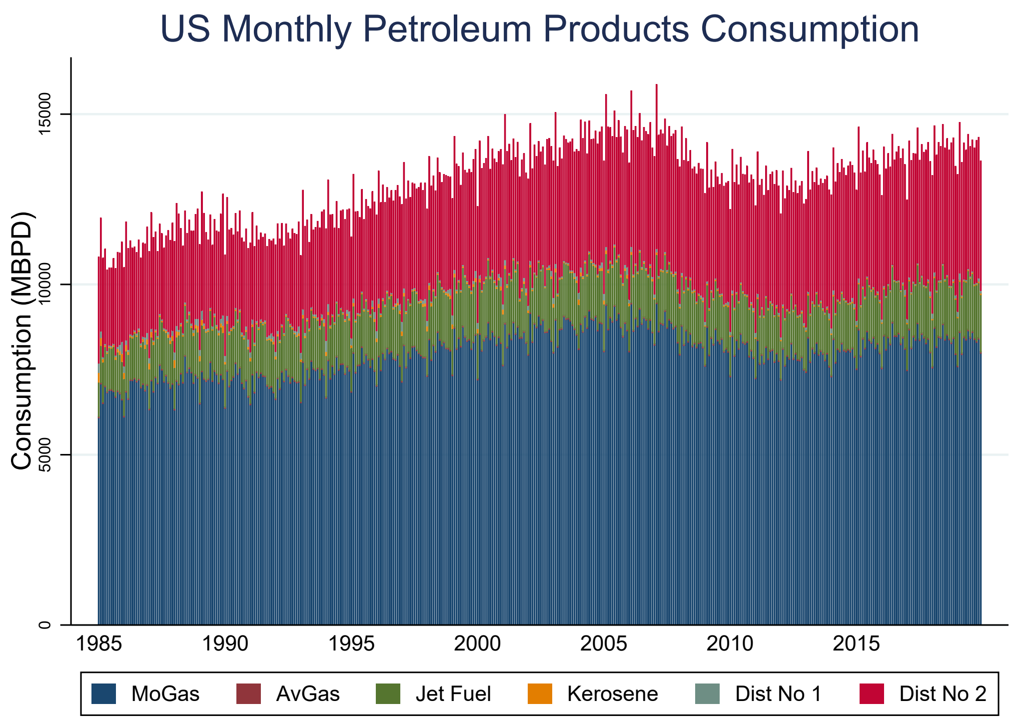
[42] Obtained from https://www.census.gov/data/tables/time-series/demo/popest/.

[43] Obtained from https://www.transtats.bts.gov.

[44] Obtained from https://apps.bea.gov/regional/downloadzip.cfm.

[45] Data is likely missing due to privacy concerns where there is a low number of manufacturers.

Figure A2.2: US Monthly Petroleum Products Consumption



level EIA Prime Supplier Sales data.[46] In rate cases, this step is used to adjust the available data to the months of the desired study period, as SEDS data often lag behind other EIA publications. The implicit assumption is that wholesale volume variation is highly related to end-use consumption variation.

For the electric generation sector, I begin with plant-level consumption of kerosene, distillate, and jet fuel and aggregate to the county level using EIA plant location data available from Form EIA-860.[47] These data are already reported monthly.

Before summing across the sectors to get total commodity consumption, I split distillate into Distillate No. 1 and Distillate No. 2 using the sales ratio from the EIA Prime Supplier Sales. I can then sum the commodities to obtain total refined products consumption for every county in the United States.

[46]Obtained from https://www.eia.gov/dnav/pet/.

[47]Obtained from https://www.eia.gov/electricity/data/eia860/.

A2.1.3 Refinery Production

The EIA compiles an annual list of operating refineries in the U.S., along with their crude distillation capacities.[48] These data begin in 1994. To supplement earlier years, I used refinery shutdown reports from old[49] (for 1991 to 1993) and older[50] (for 1986 to 1990) EIA documents, both of which report operating capacity at the time of the shutdown. The latter report also includes refinery reactivations and sales, which I used to trace the history of refineries. I aggregated annual capacities to the county level and multiply by EIA monthly refinery utilization rates[51] and EIA monthly refinery yields[52] for the relevant commodities reported by PADD subregion. This multiplier converts crude capacity to monthly refinery production estimates for each county.

A2.1.4 Waterborne Shipments/Receipts

Though my previous estimates roughly follow methods borrowed from FERC rate cases, I could not do the same for waterborne data. Typically, parties rely on the U.S. Army Corps of Engineers (USACE) shipment and receipt data reported annually by port. However these are only available in PDF format and offer insufficient coverage of the time frame of interest. Instead, I rely on USACE's Port Facility Workbook[53] to identify which facilities accommodate the commodities of interest and scrape textual data on oil storage capacity at these facilities. I then aggregate the capacities to the county level to get total county storage capacity. Under the assumption that this capacity has not changed significantly since the beginning of the study period, I allocate EIA's monthly PADD-to-PADD plus foreign imports commodity-specific refined products movements by tanker

[48] Obtained from https://www.eia.gov/petroleum/refinerycapacity/.

[49] Obtained from https://www.eia.gov/petroleum/refinerycapacity/table13.pdf.

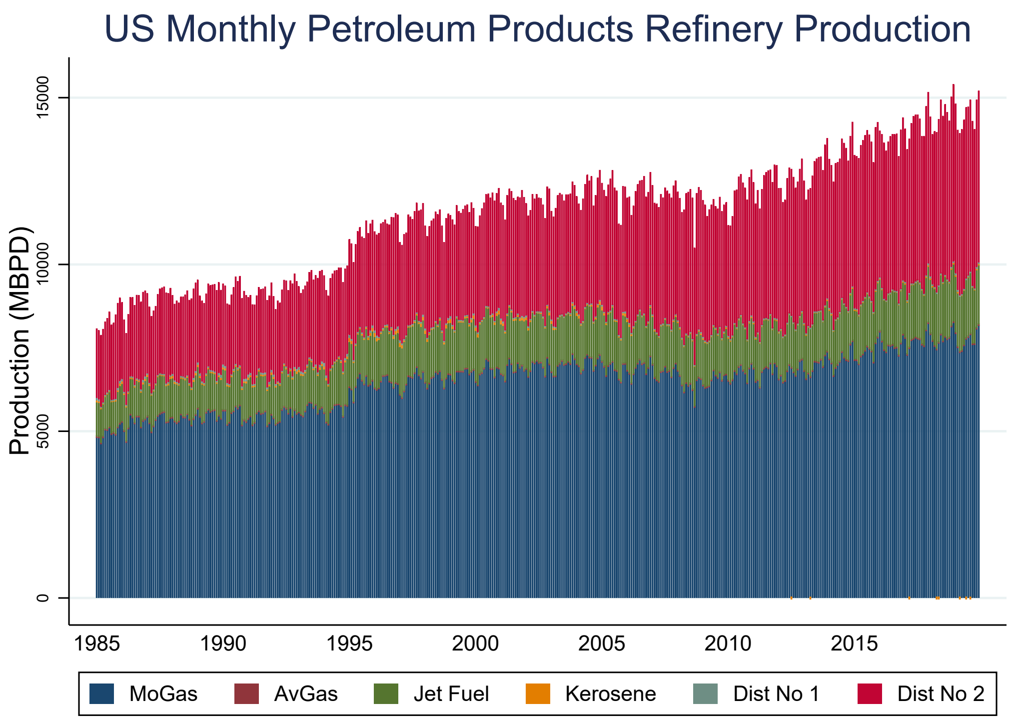
[50] Obtained from https://www.osti.gov/servlets/purl/6504843.

[51] Obtained from https://www.eia.gov/dnav/pet/. Because these reports exist only back to 1990, I impute 1990 utilization rates to the previous year.

[52] Obtained from https://www.eia.gov/dnav/pet/. These data begin in 1993. I imput 1993 yields for previous years.

[53] Obtained from https://publibrary.planusace.us/.

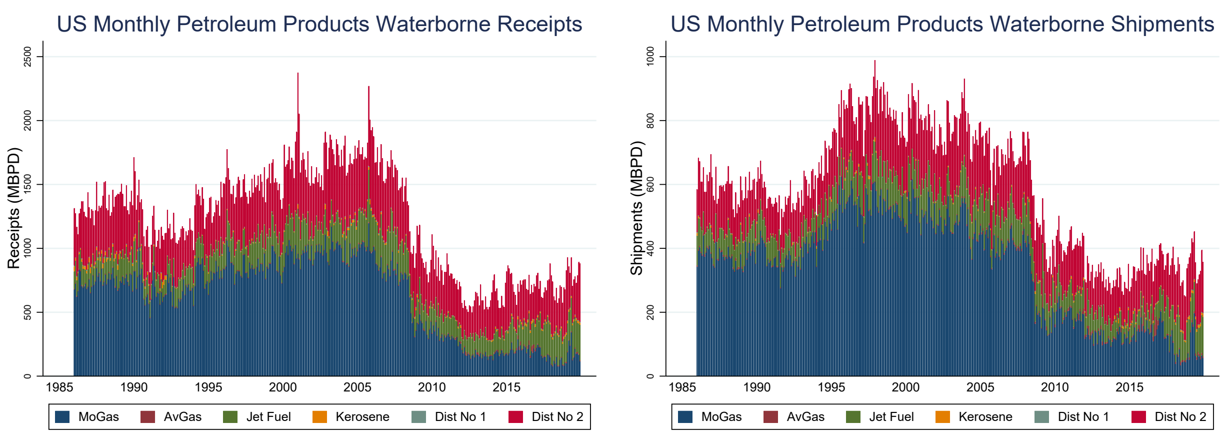
Figure A2.3: US Monthly Petroleum Products Refinery Production



and barge to each county weighted by its waterborne storage capacity.[54]

[54]Obtained from https://www.eia.gov. Note that this data cannot account for intra-PADD movements.

Figure A2.4: US Monthly Petroleum Products Waterborne Receipts and Shipments



Volumes might reflect multiple movements for the same barrel.

Table A2.2: Within-Carrier Spillovers Regression Output

	(1)	(2)	(3)	(4)
D	0.883***	0.889***	0.872***	0.869***
	(0.243)	(0.249)	(0.246)	(0.251)
Origin Demand$_{t-1}$	0.090***	0.089***	0.090***	0.089***
	(0.024)	(0.025)	(0.024)	(0.025)
D×Origin Demand$_{t-1}$	-0.059*	-0.059*	-0.059*	-0.057*
	(0.025)	(0.025)	(0.025)	(0.025)
MBR$_O$	-0.275	-0.288	-0.282	-0.282
	(0.236)	(0.260)	(0.238)	(0.260)
D×MBR$_O$	-0.843**	-0.848**	-0.832**	-0.829**
	(0.273)	(0.283)	(0.277)	(0.287)
Origin Demand$_{t-1}$×MBR$_O$	0.025	0.032	0.023	0.031
	(0.066)	(0.068)	(0.066)	(0.068)
D×Origin Demand$_{t-1}$×MBR$_O$	0.021	0.022	0.024	0.023
	(0.055)	(0.056)	(0.054)	(0.056)
Consumption$_{DCt-1}$	0.149**	0.160**	0.150**	0.160***
	(0.048)	(0.049)	(0.048)	(0.049)
Consumption$_{OCt-1}$	0.077	0.074	0.080	0.078
	(0.049)	(0.049)	(0.049)	(0.049)
Production$_{DCt-1}$	-0.369***	-0.363***	-0.371***	-0.366***
	(0.093)	(0.096)	(0.094)	(0.097)
Production$_{OCt-1}$	-0.048	-0.052	-0.046	-0.050
	(0.039)	(0.040)	(0.039)	(0.040)
WB Shipments$_{OCt-1}$	0.232**	0.218*	0.227*	0.217*
	(0.088)	(0.093)	(0.090)	(0.097)
WB Receipts$_{OCt-1}$	-0.272***	-0.279***	-0.272***	-0.279***
	(0.033)	(0.034)	(0.033)	(0.034)
WB Shipments$_{DCt-1}$	-0.563***	-0.587***	-0.559***	-0.584***
	(0.110)	(0.106)	(0.111)	(0.106)
WB Receipts$_{DCt-1}$	-0.099**	-0.113***	-0.101**	-0.113**
	(0.034)	(0.034)	(0.034)	(0.035)
Carriers$_{ODC}$	0.006	-0.002	0.015	0.021
	(0.019)	(0.056)	(0.027)	(0.068)
MBR Carriers$_{ODC}$	0.001	-0.024	0.009	-0.019
	(0.049)	(0.080)	(0.066)	(0.083)
Constant	-0.234	-0.201	-0.250	-0.245
	(0.120)	(0.153)	(0.132)	(0.170)
Orig×Comm FE	Y	N	Y	N
Dest×Comm FE	Y	N	Y	N
Orig×Dest×Comm FE	N	Y	N	Y
Carrier FE	N	N	Y	Y
Observations	276267	276267	276267	276267

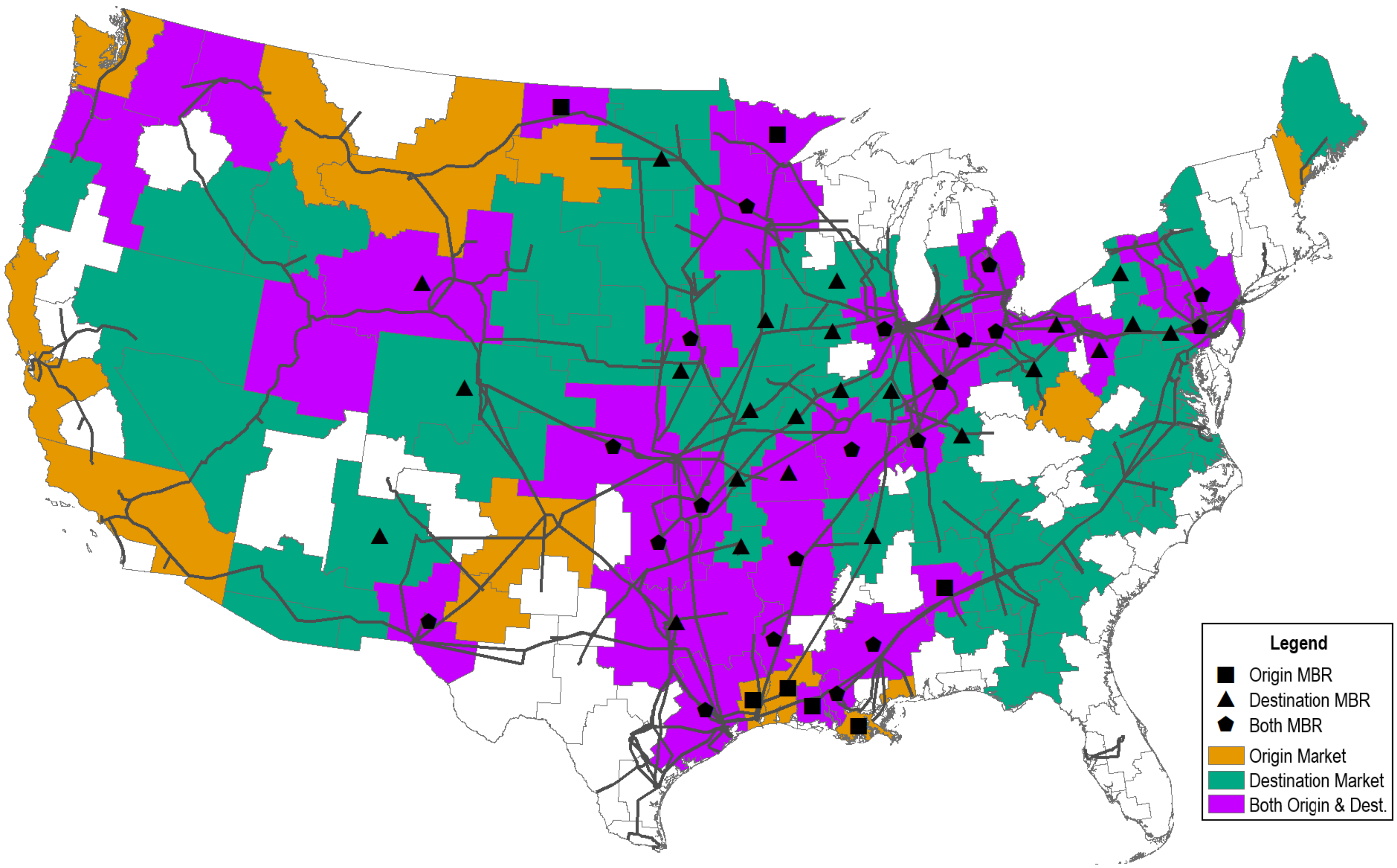
Standard errors clustered by origin market-destination market-commodity. Origin Demand refers to origin market total refined products refinery production, which represents total capacity demand. Lagged variables are denoted with a $t-1$ subscript. Carrier FE are not mutually exclusive and include only MBR-approved firms.

Table A2.3: Across-Carrier Spillovers Regression Output

	(1)	(2)	(3)	(4)
D=1	0.081	0.016	0.070	-0.002
	(0.184)	(0.200)	(0.184)	(0.201)
Origin Demand$_{t-1}$	0.084**	0.083**	0.079**	0.086**
	(0.029)	(0.031)	(0.029)	(0.030)
D×Origin Demand$_{t-1}$	-0.016	-0.013	-0.013	-0.015
	(0.026)	(0.028)	(0.026)	(0.028)
MBR$_O$	-0.682*	-0.798*	-0.697*	-0.770*
	(0.270)	(0.314)	(0.271)	(0.312)
D×MBR$_O$	0.520	0.579	0.515	0.597
	(0.318)	(0.343)	(0.321)	(0.345)
Origin Demand$_{t-1}$×MBR$_O$	-0.010	-0.045	-0.002	-0.043
	(0.123)	(0.138)	(0.124)	(0.136)
D×Origin Demand$_{t-1}$×MBR$_O$	-0.008	0.032	-0.013	0.033
	(0.121)	(0.135)	(0.120)	(0.132)
Consumption$_{DCt-1}$	0.176***	0.206***	0.175***	0.207***
	(0.042)	(0.040)	(0.041)	(0.040)
Consumption$_{OCt-1}$	0.070	0.073	0.077	0.082
	(0.050)	(0.051)	(0.051)	(0.052)
Production$_{DCt-1}$	-0.357***	-0.348***	-0.363***	-0.350***
	(0.096)	(0.099)	(0.096)	(0.100)
Production$_{OCt-1}$	-0.014	-0.012	-0.013	-0.011
	(0.041)	(0.043)	(0.041)	(0.043)
WB Shipments$_{OCt-1}$	0.235**	0.214*	0.236**	0.221*
	(0.084)	(0.093)	(0.087)	(0.098)
WB Receipts$_{OCt-1}$	-0.258***	-0.260***	-0.260***	-0.260***
	(0.034)	(0.036)	(0.034)	(0.036)
WB Shipments$_{DCt-1}$	-0.477***	-0.528***	-0.475***	-0.523***
	(0.113)	(0.097)	(0.114)	(0.098)
WB Receipts$_{DCt-1}$	-0.102**	-0.138***	-0.108**	-0.138***
	(0.034)	(0.032)	(0.033)	(0.033)
Carriers$_{ODC}$	0.013	-0.003	0.023	0.059
	(0.020)	(0.066)	(0.030)	(0.081)
Constant	-0.026	0.057	-0.025	-0.043
	(0.135)	(0.178)	(0.137)	(0.189)
Orig×Comm FE	Y	N	Y	N
Dest×Comm FE	Y	N	Y	N
Orig×Dest×Comm FE	N	Y	N	Y
Carrier FE	N	N	Y	Y
Observations	255569	255569	255569	255569

Standard errors clustered by origin market-destination market-commodity. Origin Demand refers to origin market total refined products refinery production, which represents total capacity demand. Lagged variables are denoted with a $t-1$ subscript. Carrier FE are not mutually exclusive and include only MBR-approved firms.

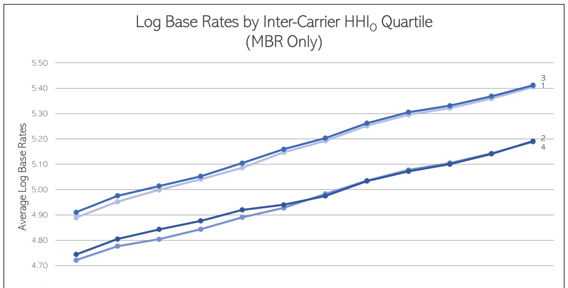
Figure A3.1: Map of Markets and Petroleum Product Pipelines



Markets are defined using the BEA's 1995 definition for their Economic Areas. Pipeline Map supplied by EIA's Petroleum Product Pipeline shapefile available at https://www.eia.gov (last updated 4/28/2020). Note that this current pipeline map may not reflect all services available since 2007. Markets only reflect those that contain services in the balanced dataset.

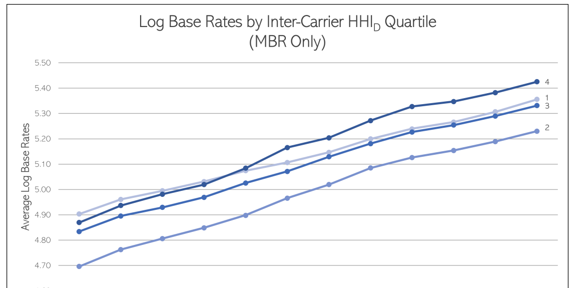
Figure A3.2: Log Market-Based Rates (2008-2019)

(a) By Origin Market Inter-Carrier HHI Quartile



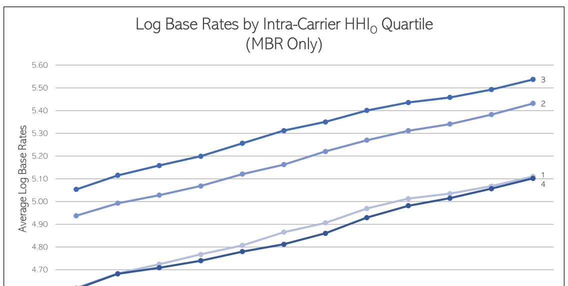
	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
1	4.89	4.95	5.00	5.04	5.09	5.15	5.19	5.25	5.30	5.32	5.36	5.41
2	4.72	4.78	4.80	4.84	4.89	4.93	4.98	5.04	5.08	5.10	5.14	5.19
3	4.91	4.98	5.01	5.05	5.10	5.16	5.20	5.26	5.31	5.33	5.37	5.41
4	4.74	4.81	4.84	4.88	4.92	4.94	4.97	5.03	5.07	5.10	5.14	5.19

(b) By Destination Market Inter-Carrier HHI Quartile



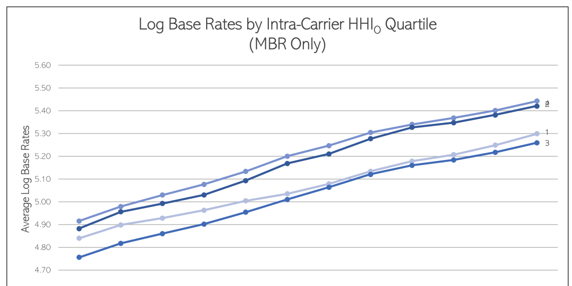
	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
1	4.90	4.96	4.99	5.03	5.07	5.11	5.15	5.20	5.24	5.27	5.31	5.36
2	4.70	4.76	4.81	4.85	4.90	4.97	5.02	5.08	5.13	5.15	5.19	5.23
3	4.83	4.90	4.93	4.97	5.03	5.07	5.13	5.18	5.23	5.25	5.29	5.33
4	4.87	4.94	4.98	5.02	5.08	5.17	5.20	5.27	5.33	5.35	5.38	5.43

(c) By Origin Market Intra-Carrier HHI Quartile



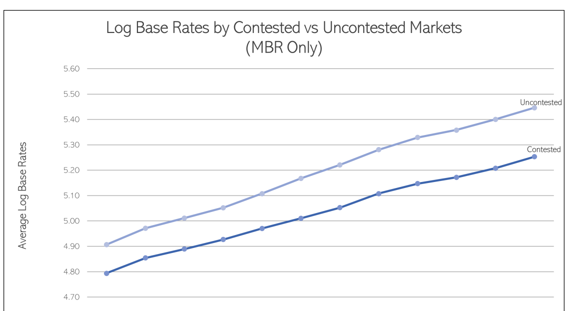
	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
1	4.62	4.68	4.72	4.77	4.81	4.86	4.91	4.97	5.01	5.03	5.07	5.11
2	4.94	4.99	5.03	5.07	5.12	5.16	5.22	5.27	5.31	5.34	5.38	5.43
3	5.05	5.11	5.16	5.20	5.26	5.31	5.35	5.40	5.44	5.46	5.49	5.54
4	4.62	4.68	4.71	4.74	4.78	4.81	4.86	4.93	4.98	5.01	5.06	5.10

(d) By Destination Market Intra-Carrier HHI Quartile



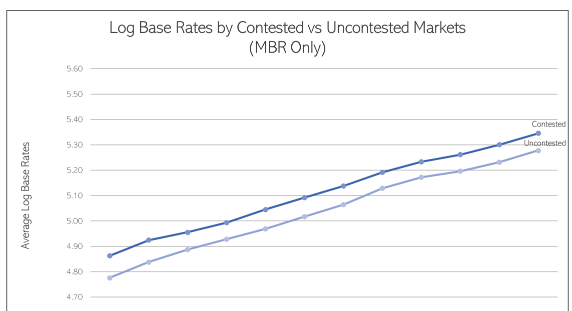
	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
1	4.84	4.90	4.93	4.96	5.00	5.04	5.08	5.13	5.18	5.21	5.25	5.30
2	4.92	4.98	5.03	5.08	5.13	5.20	5.25	5.30	5.34	5.37	5.40	5.44
3	4.76	4.82	4.86	4.90	4.95	5.01	5.06	5.12	5.16	5.18	5.22	5.26
4	4.88	4.96	4.99	5.03	5.09	5.17	5.21	5.28	5.33	5.35	5.38	5.42

(e) By Contested vs Uncontested Origin Markets



	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Uncontested	4.91	4.97	5.01	5.05	5.11	5.17	5.22	5.28	5.33	5.36	5.40	5.45
Contested	4.79	4.85	4.89	4.93	4.97	5.01	5.05	5.11	5.15	5.17	5.21	5.25

(f) By Contested vs Uncontested Destination Markets

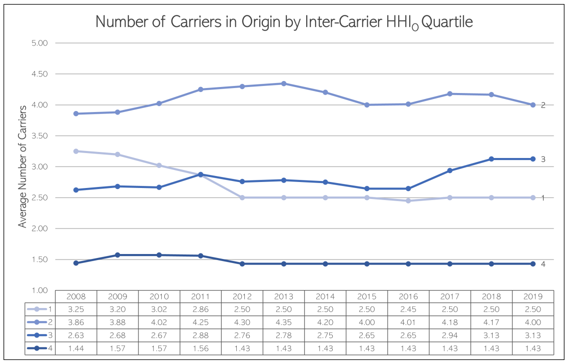


	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Uncontested	4.78	4.84	4.89	4.93	4.97	5.02	5.06	5.13	5.17	5.20	5.23	5.28
Contested	4.86	4.92	4.96	4.99	5.05	5.09	5.14	5.19	5.23	5.26	5.30	5.35

Note: Data from Law IQ tariff database. Base Rates are reported in cents per barrel. Log is the natural log. Inter-carrier quartiles bin markets relative to all other markets. Intra-carrier quartiles bin markets within each carrier's markets (i.e., the same market can be in two different bins).

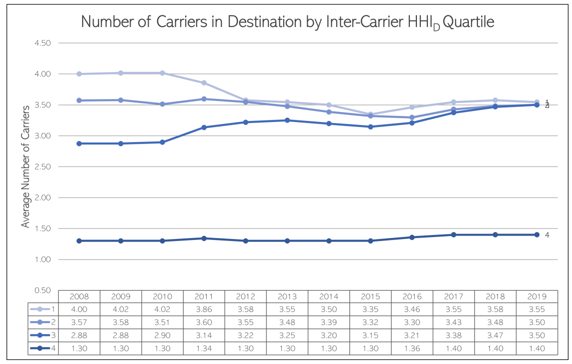
Figure A3.3: Number of Carriers (2008-2019)

(a) By Origin Market Inter-Carrier HHI Quartile



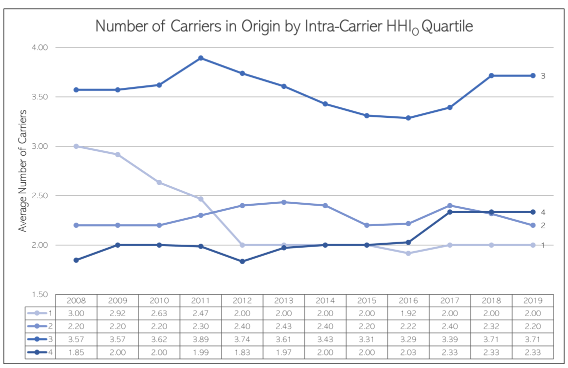
	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
1	3.25	3.20	3.02	2.86	2.50	2.50	2.50	2.50	2.45	2.50	2.50	2.50
2	3.86	3.88	4.02	4.25	4.30	4.35	4.20	4.00	4.01	4.18	4.17	4.00
3	2.63	2.68	2.67	2.88	2.76	2.78	2.75	2.65	2.65	2.94	3.13	3.13
4	1.44	1.57	1.57	1.56	1.43	1.43	1.43	1.43	1.43	1.43	1.43	1.43

(b) By Destination Market Inter-Carrier HHI Quartile



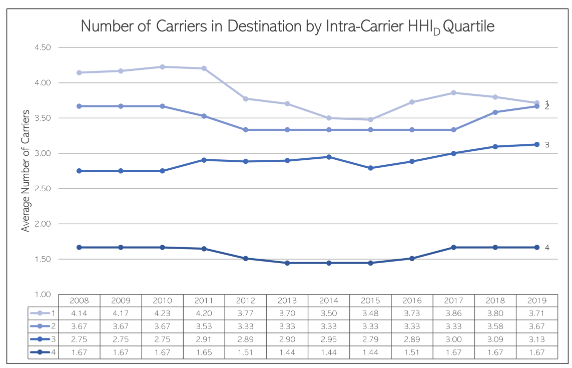
	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
1	4.00	4.02	4.02	3.86	3.58	3.55	3.50	3.35	3.46	3.55	3.58	3.55
2	3.57	3.58	3.51	3.60	3.55	3.48	3.39	3.32	3.30	3.43	3.48	3.50
3	2.88	2.88	2.90	3.14	3.22	3.25	3.20	3.15	3.21	3.38	3.47	3.50
4	1.30	1.30	1.30	1.34	1.30	1.30	1.30	1.30	1.36	1.40	1.40	1.40

(c) By Origin Market Intra-Carrier HHI Quartile



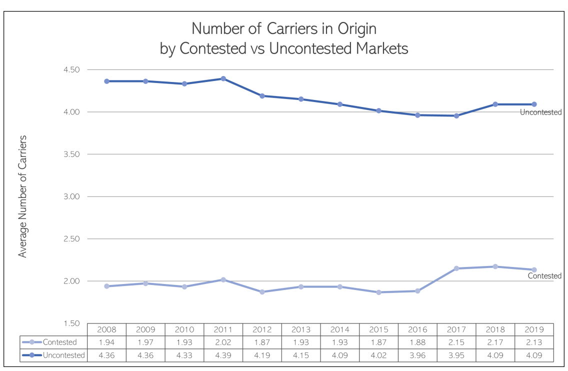
	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
1	3.00	2.92	2.63	2.47	2.00	2.00	2.00	2.00	1.92	2.00	2.00	2.00
2	2.20	2.20	2.20	2.30	2.40	2.43	2.40	2.20	2.22	2.40	2.32	2.20
3	3.57	3.57	3.62	3.89	3.74	3.61	3.43	3.31	3.29	3.39	3.71	3.71
4	1.85	2.00	2.00	1.99	1.83	1.97	2.00	2.00	2.03	2.33	2.33	2.33

(d) By Destination Market Intra-Carrier HHI Quartile



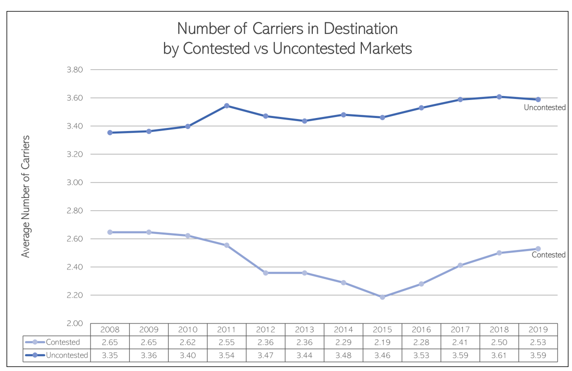
	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
1	4.14	4.17	4.23	4.20	3.77	3.70	3.50	3.48	3.73	3.86	3.80	3.71
2	3.67	3.67	3.67	3.53	3.33	3.33	3.33	3.33	3.33	3.33	3.58	3.67
3	2.75	2.75	2.75	2.91	2.89	2.90	2.95	2.79	2.89	3.00	3.09	3.13
4	1.67	1.67	1.67	1.65	1.51	1.44	1.44	1.44	1.51	1.67	1.67	1.67

(e) By Contested vs Uncontested Origin Markets



	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Contested	1.94	1.97	1.93	2.02	1.87	1.93	1.93	1.87	1.88	2.15	2.17	2.13
Uncontested	4.36	4.36	4.33	4.39	4.19	4.15	4.09	4.02	3.96	3.95	4.09	4.09

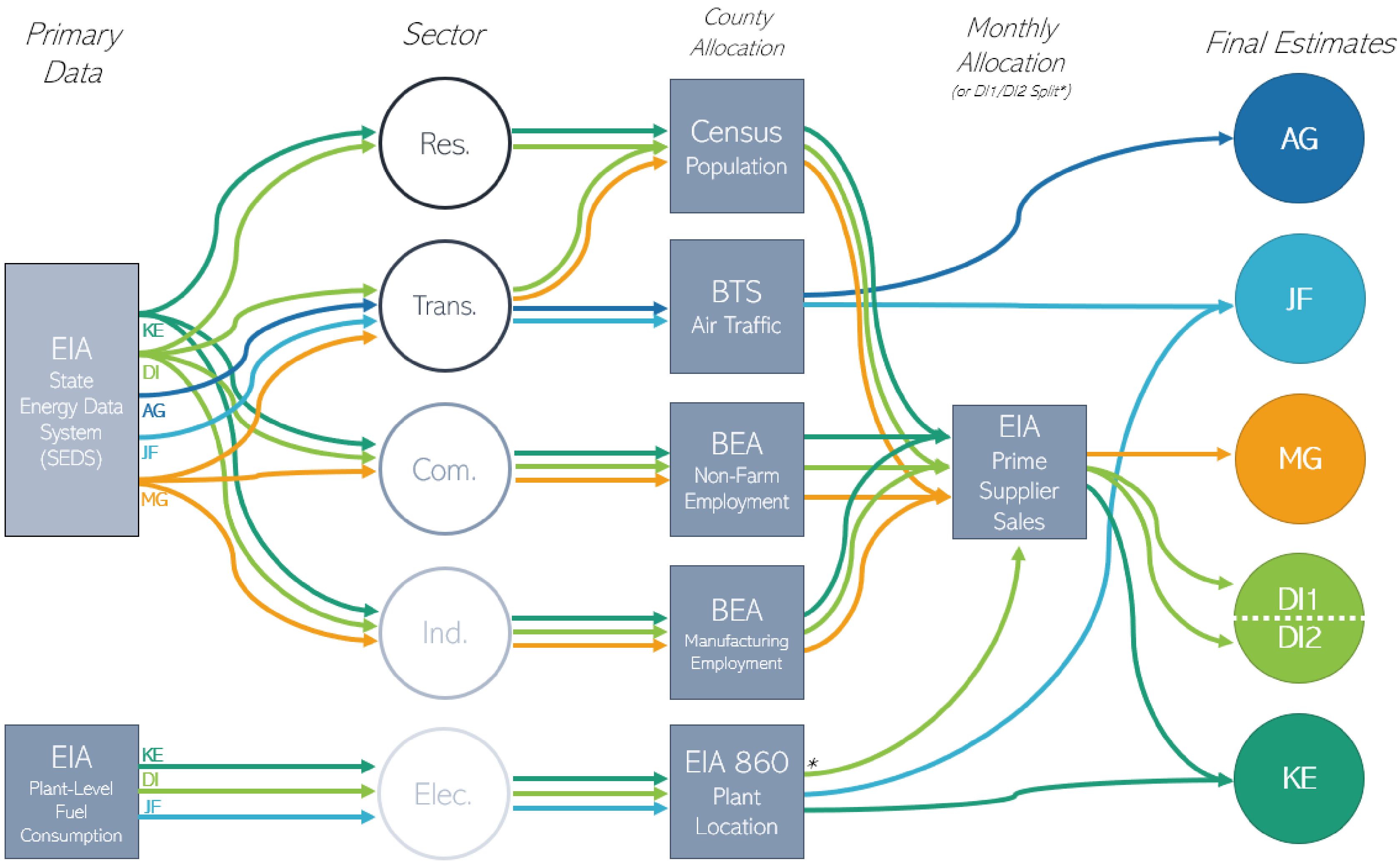
(f) By Contested vs Uncontested Destination Markets



	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Contested	2.65	2.65	2.62	2.55	2.36	2.36	2.29	2.19	2.28	2.41	2.50	2.53
Uncontested	3.35	3.36	3.40	3.54	3.47	3.44	3.48	3.46	3.53	3.59	3.61	3.59

Note: Data from Law IQ tariff database. Number of carriers with active services. Inter-carrier quartiles bin markets relative to all other markets. Intra-carrier quartiles bin markets within each carrier's markets (i.e., the same market can be in two different bins).

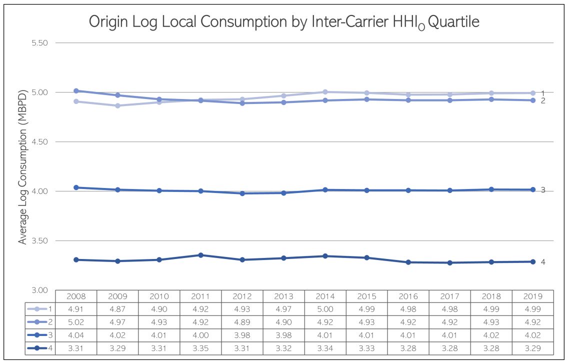
Figure A3.4: Consumption Database Construction



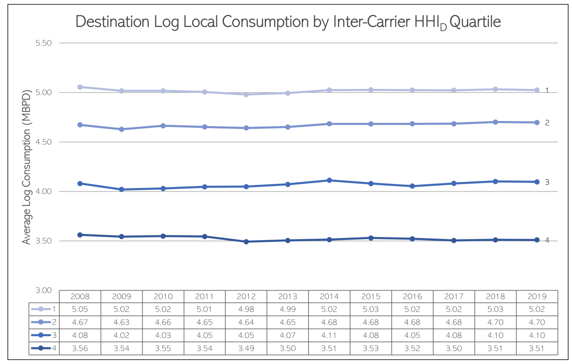
Note: KE = Kerosene, DI = Distillate, AG = Aviation Gasoline, JF = Jet Fuel, and MG = Motor Gasoline. EIA SEDS data available at https://www.eia.gov/state/seds. EIA plant-level fuel consumption available from Form EIA-932 at https://www.eia.gov/electricity/data/eia923/. EIA plant location data available from Form EIA-860 at https://www.eia.gov/electricity/data/eia860/. EIA prime supplier data available at https://www.eia.gov/dnav/pet/. Census population data from https://www.census.gov/data/tables/time-series/demo/popest/. BTS Air Traffic data available from https://www.transtats.bts.gov. BEA non-farm and manufacturing employment from https://apps.bea.gov/regional/downloadzip.cfm.

Figure A3.5: Log Refined Products Consumption (2008-2019)

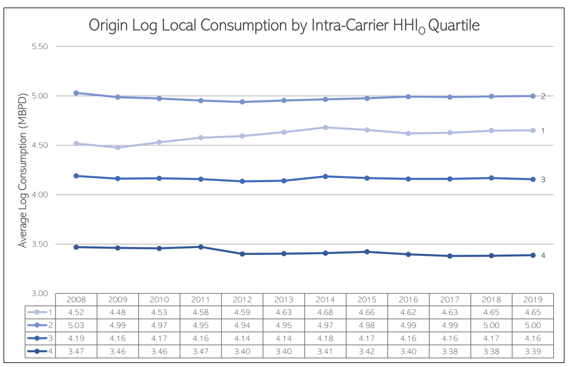
(a) By Origin Market Inter-Carrier HHI Quartile



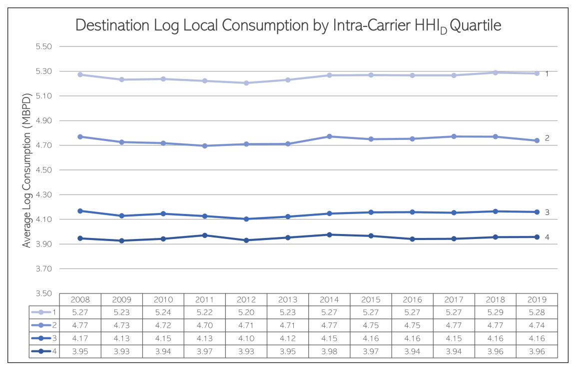
(b) By Destination Market Inter-Carrier HHI Quartile



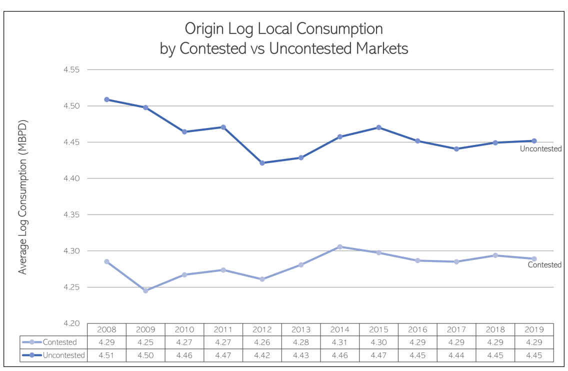
(c) By Origin Market Intra-Carrier HHI Quartile



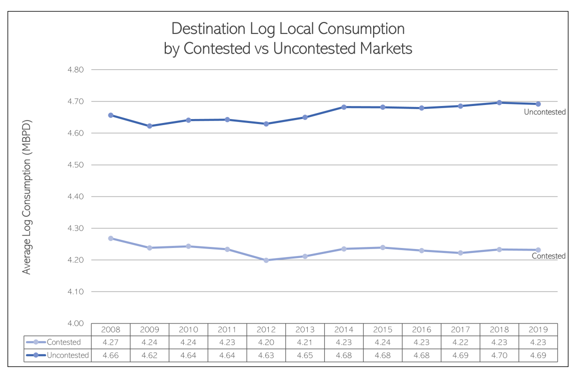
(d) By Destination Market Intra-Carrier HHI Quartile



(e) By Contested vs Uncontested Origin Markets



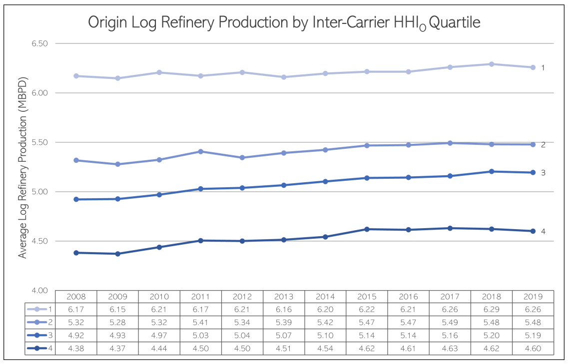
(f) By Contested vs Uncontested Destination Markets



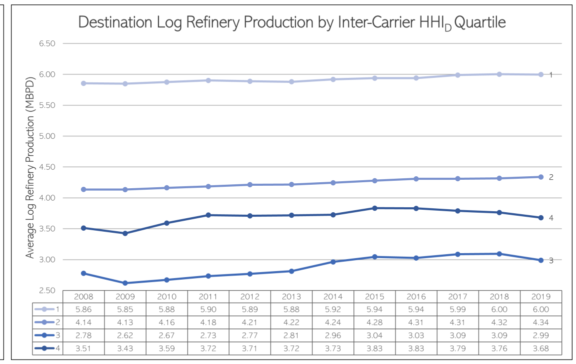
Note: Refined products include motor gasoline, aviation gasoline, jet fuel, kerosene, distillate no. 1 and distillate no. 2. Consumption estimates are calculated using the method depicted in the diagram found in A3.4. Log is natural log. Inter-carrier quartiles bin markets relative to all other markets. Intra-carrier quartiles bin markets within each carrier's markets (i.e., the same market can be in two different bins).

Figure A3.6: Log Refinery Production (2008-2019)

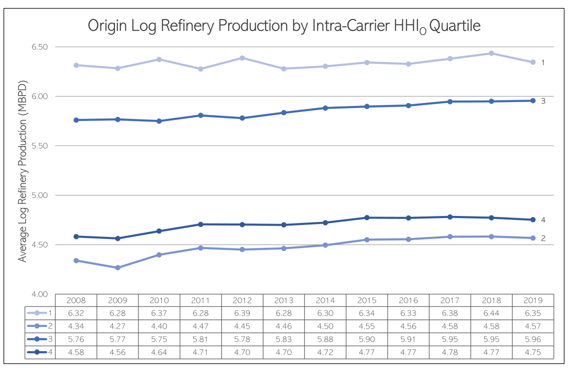
(a) By Origin Market Inter-Carrier HHI Quartile



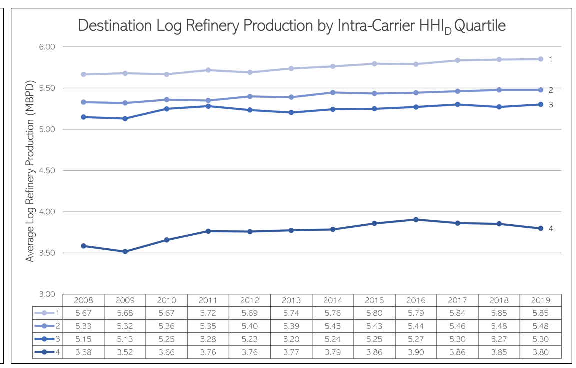
(b) By Destination Market Inter-Carrier HHI Quartile



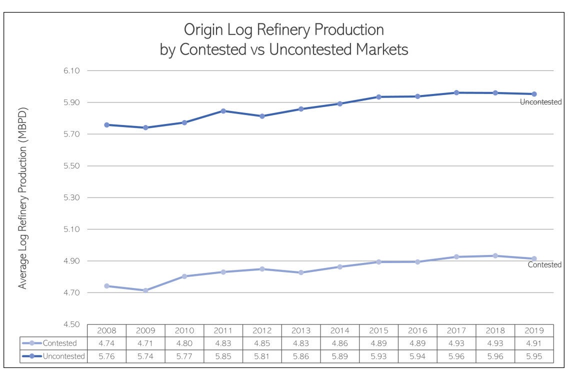
(c) By Origin Market Intra-Carrier HHI Quartile



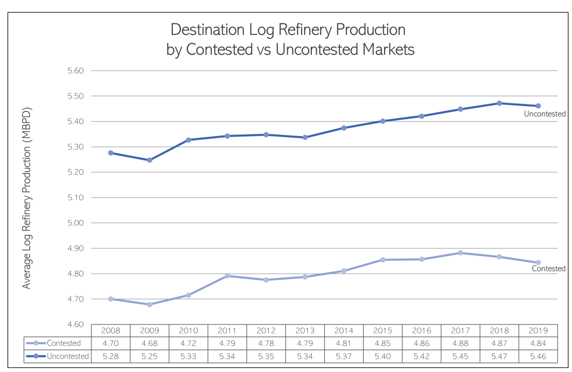
(d) By Destination Market Intra-Carrier HHI Quartile



(e) By Contested vs Uncontested Origin Markets



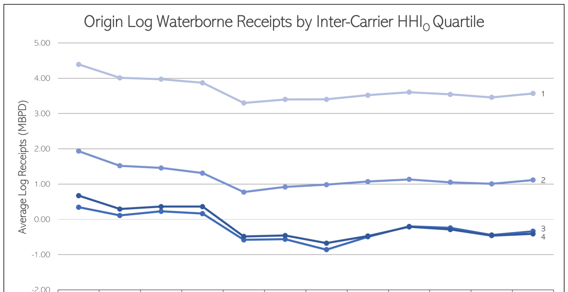
(f) By Contested vs Uncontested Destination Markets



Note: Refinery production data from EIA refinery capacity report (https://www.eia.gov/petroleum/refinerycapacity/), utilization (https://www.eia.gov/dnav/pet/), and yield (https://www.eia.gov/dnav/pet/). Refined products include motor gasoline, aviation gasoline, jet fuel, kerosene, distillate no. 1 and distillate no. 2. Log is natural log. Inter-carrier quartiles bin markets relative to all other markets. Intra-carrier quartiles bin markets within each carrier's markets (i.e., the same market can be in two different bins).

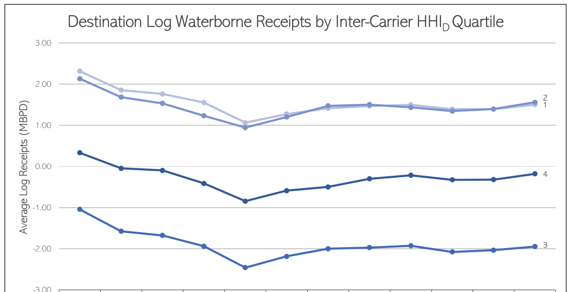
Figure A3.7: Log Waterborne Receipts (2008-2019)

(a) By Origin Market Inter-Carrier HHI Quartile



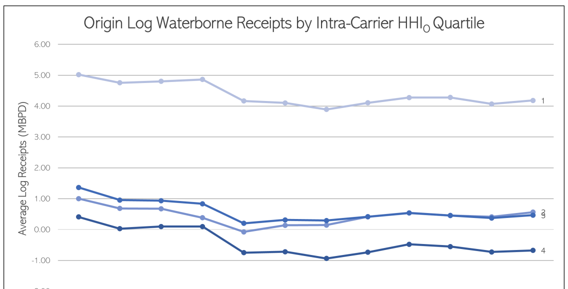
	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
1	4.39	4.01	3.97	3.87	3.30	3.40	3.40	3.52	3.61	3.54	3.46	3.57
2	1.94	1.52	1.46	1.31	0.77	0.92	0.98	1.07	1.13	1.05	1.01	1.12
3	0.35	0.11	0.23	0.16	-0.58	-0.56	-0.86	-0.50	-0.20	-0.24	-0.44	-0.34
4	0.67	0.29	0.36	0.36	-0.48	-0.46	-0.67	-0.47	-0.21	-0.29	-0.46	-0.41

(b) By Destination Market Inter-Carrier HHI Quartile



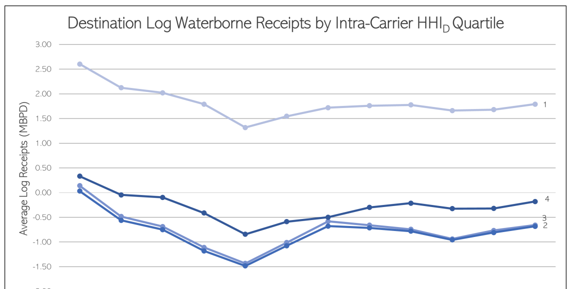
	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
1	2.32	1.85	1.76	1.55	1.06	1.27	1.41	1.47	1.50	1.39	1.39	1.50
2	2.13	1.68	1.53	1.23	0.94	1.20	1.47	1.50	1.44	1.35	1.39	1.56
3	-1.04	-1.58	-1.68	-1.94	-2.46	-2.19	-2.00	-1.97	-1.93	-2.08	-2.03	-1.95
4	0.33	-0.05	-0.10	-0.41	-0.85	-0.59	-0.50	-0.30	-0.21	-0.33	-0.32	-0.18

(c) By Origin Market Intra-Carrier HHI Quartile



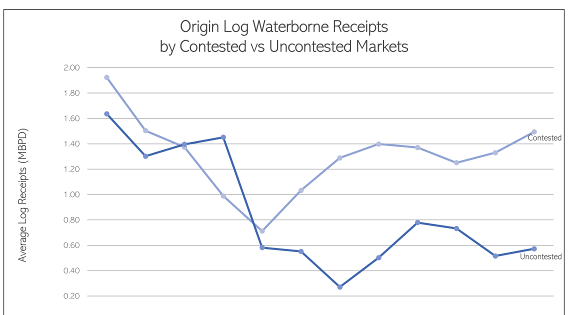
	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
1	5.02	4.76	4.80	4.86	4.16	4.10	3.89	4.11	4.28	4.28	4.07	4.18
2	1.00	0.69	0.67	0.38	-0.07	0.14	0.15	0.41	0.54	0.45	0.41	0.56
3	1.36	0.96	0.94	0.83	0.20	0.31	0.29	0.42	0.54	0.46	0.37	0.47
4	0.41	0.03	0.10	0.10	-0.75	-0.72	-0.94	-0.74	-0.48	-0.55	-0.73	-0.67

(d) By Destination Market Intra-Carrier HHI Quartile



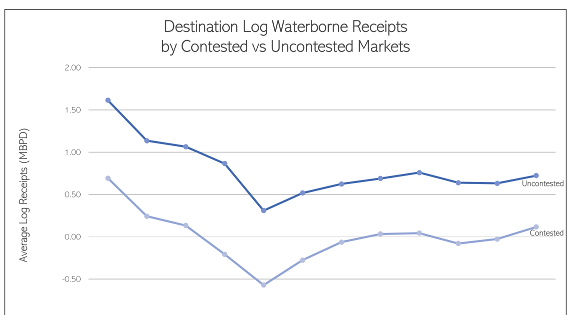
	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
1	2.60	2.12	2.02	1.79	1.32	1.55	1.72	1.76	1.78	1.66	1.68	1.79
2	0.14	-0.48	-0.69	-1.11	-1.43	-1.01	-0.58	-0.66	-0.74	-0.94	-0.77	-0.66
3	0.03	-0.56	-0.75	-1.18	-1.48	-1.08	-0.68	-0.71	-0.78	-0.96	-0.81	-0.68
4	0.33	-0.05	-0.10	-0.41	-0.85	-0.59	-0.50	-0.30	-0.21	-0.33	-0.32	-0.18

(e) By Contested vs Uncontested Origin Markets



	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Contested	1.92	1.50	1.37	0.99	0.71	1.03	1.29	1.40	1.37	1.25	1.33	1.49
Uncontested	1.64	1.30	1.40	1.45	0.58	0.55	0.27	0.50	0.78	0.73	0.52	0.57

(f) By Contested vs Uncontested Destination Markets

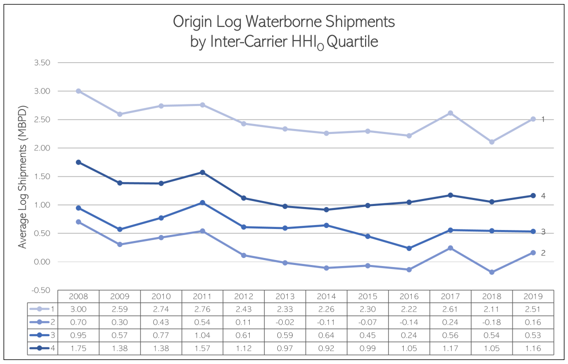


	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Contested	0.69	0.24	0.13	-0.21	-0.57	-0.28	-0.06	0.03	0.04	-0.08	-0.03	0.12
Uncontested	1.62	1.14	1.07	0.87	0.31	0.52	0.62	0.69	0.76	0.64	0.63	0.72

Note: Waterborne receipt data from EIA (https://www.eia.gov), allocated to counties using port facility storage reported by USACE (https://publibrary.planusace.us/). Log is natural log. Inter-carrier quartiles bin markets relative to all other markets. Intra-carrier quartiles bin markets within each carrier's markets (i.e., the same market can be in two different bins).

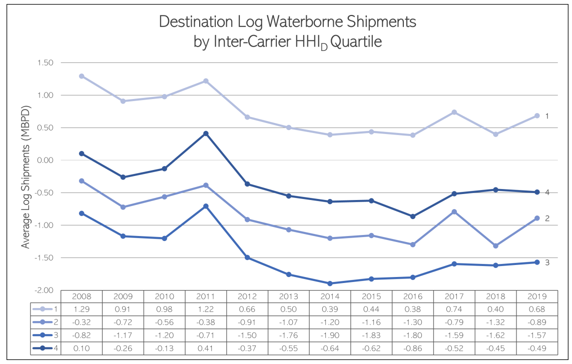
Figure A3.8: Log Waterborne Shipments (2008-2019)

(a) By Origin Market Inter-Carrier HHI Quartile



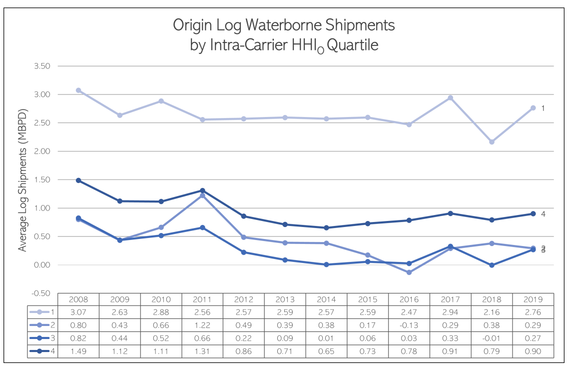
	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
1	3.00	2.59	2.74	2.76	2.43	2.33	2.26	2.30	2.22	2.61	2.11	2.51
2	0.70	0.30	0.43	0.54	0.11	-0.02	-0.11	-0.07	-0.14	0.24	-0.18	0.16
3	0.95	0.57	0.77	1.04	0.61	0.59	0.64	0.45	0.24	0.56	0.54	0.53
4	1.75	1.38	1.38	1.57	1.12	0.97	0.92	0.99	1.05	1.17	1.05	1.16

(b) By Destination Market Inter-Carrier HHI Quartile



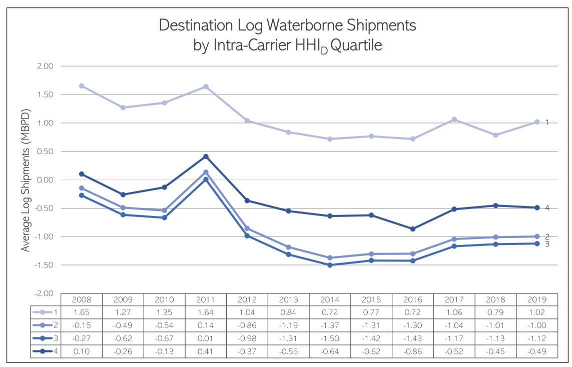
	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
1	1.29	0.91	0.98	1.22	0.66	0.50	0.39	0.44	0.38	0.74	0.40	0.68
2	-0.32	-0.72	-0.56	-0.38	-0.91	-1.07	-1.20	-1.16	-1.30	-0.79	-1.32	-0.89
3	-0.82	-1.17	-1.20	-0.71	-1.50	-1.76	-1.90	-1.83	-1.80	-1.59	-1.62	-1.57
4	0.10	-0.26	-0.13	0.41	-0.37	-0.55	-0.64	-0.62	-0.86	-0.52	-0.45	-0.49

(c) By Origin Market Intra-Carrier HHI Quartile



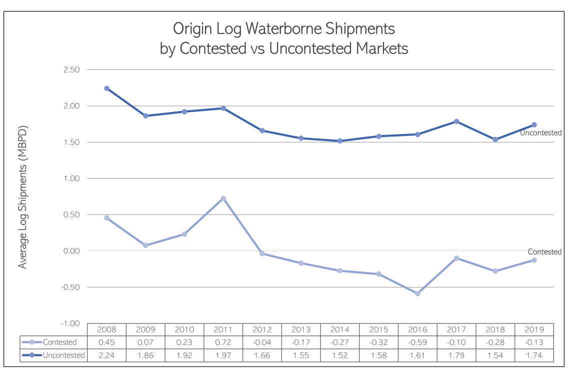
	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
1	3.07	2.63	2.88	2.56	2.57	2.59	2.57	2.59	2.47	2.94	2.16	2.76
2	0.80	0.43	0.66	1.22	0.49	0.39	0.38	0.17	-0.13	0.29	0.38	0.29
3	0.82	0.44	0.52	0.66	0.22	0.09	0.01	0.06	0.03	0.33	-0.01	0.27
4	1.49	1.12	1.11	1.31	0.86	0.71	0.65	0.73	0.78	0.91	0.79	0.90

(d) By Destination Market Intra-Carrier HHI Quartile



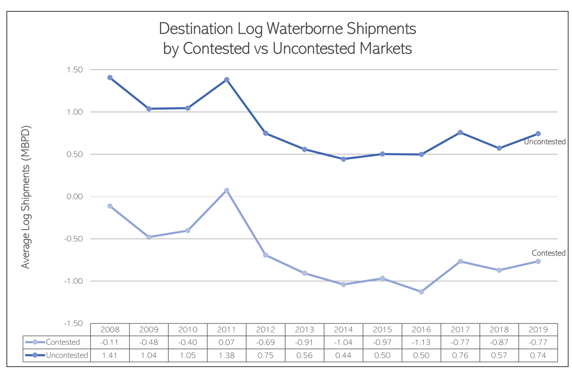
	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
1	1.65	1.27	1.35	1.64	1.04	0.84	0.72	0.77	0.72	1.06	0.79	1.02
2	-0.15	-0.49	-0.54	0.14	-0.86	-1.19	-1.37	-1.31	-1.30	-1.04	-1.01	-1.00
3	-0.27	-0.62	-0.67	0.01	-0.98	-1.31	-1.50	-1.42	-1.43	-1.17	-1.13	-1.12
4	0.10	-0.26	-0.13	0.41	-0.37	-0.55	-0.64	-0.62	-0.86	-0.52	-0.45	-0.49

(e) By Contested vs Uncontested Origin Markets



	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Contested	0.45	0.07	0.23	0.72	-0.04	-0.17	-0.27	-0.32	-0.59	-0.10	-0.28	-0.13
Uncontested	2.24	1.86	1.92	1.97	1.66	1.55	1.52	1.58	1.61	1.79	1.54	1.74

(f) By Contested vs Uncontested Destination Markets

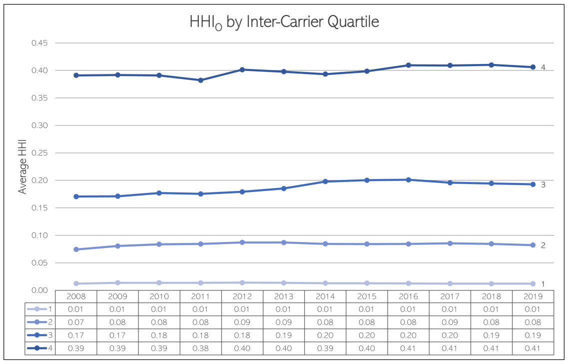


	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Contested	-0.11	-0.48	-0.40	0.07	-0.69	-0.91	-1.04	-0.97	-1.13	-0.77	-0.87	-0.77
Uncontested	1.41	1.04	1.05	1.38	0.75	0.56	0.44	0.50	0.50	0.76	0.57	0.74

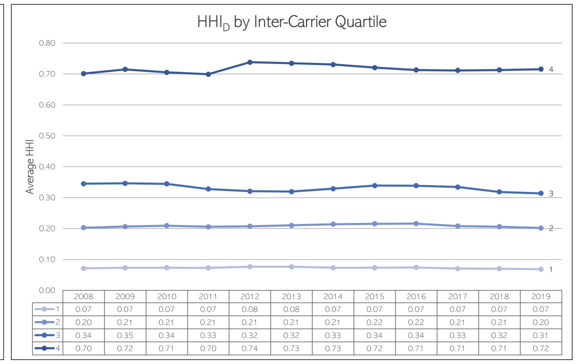
Note: Waterborne shipment data from EIA (https://www.eia.gov), allocated to counties using port facility storage reported by USACE (https://publibrary.planusace.us/). Log is natural log. Inter-carrier quartiles bin markets relative to all other markets. Intra-carrier quartiles bin markets within each carrier's markets (i.e., the same market can be in two different bins).

Figure A3.9: Herfindahl-Hirschman Index (HHI) (2008-2019)

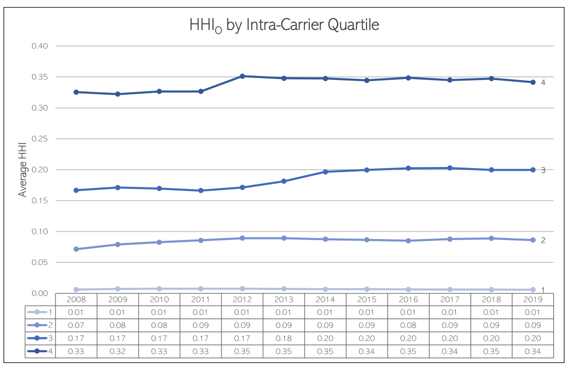
(a) By Origin Market Inter-Carrier HHI Quartile



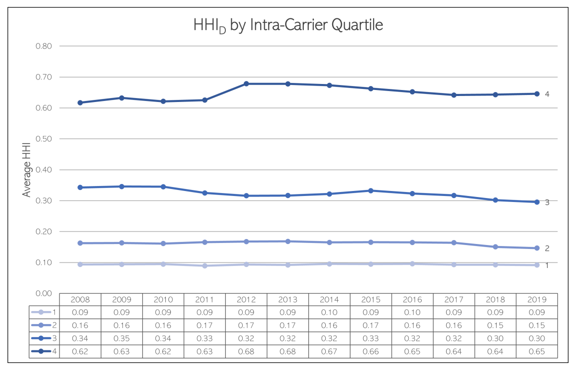
(b) By Destination Market Inter-Carrier HHI Quartile



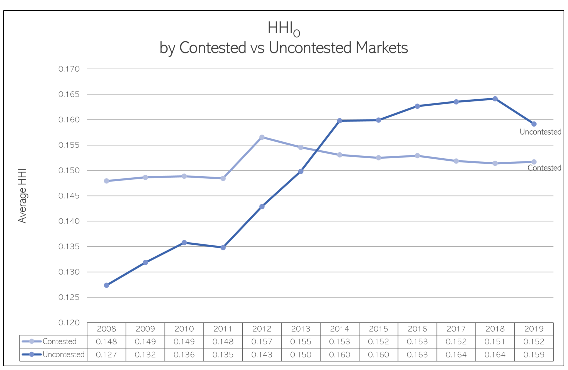
(c) By Origin Market Intra-Carrier HHI Quartile



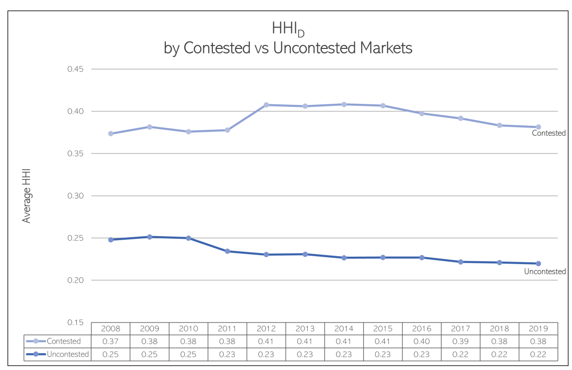
(d) By Destination Market Intra-Carrier HHI Quartile



(e) By Contested vs Uncontested Origin Markets



(f) By Contested vs Uncontested Destination Markets



Note: HHIs are calculated following the DOJ-Adjusted Capacity Method found in FERC market-based rates proceedings. In origin markets, waterborne shipments are subtracted from refinery production plus waterborne receipts (demand). This net demand is then divided evenly across competing alternatives, including pipeline carriers and local consumption, up to capacity (or level of consumption) to calculate carrier market share, which are then squared and summed across carriers. Similarly, in destination markets waterborne receipts are subtracted from local consumption plus waterborne shipments (demand). This net demand is then divided evenly across competing alternatives, including pipeline carriers and local refinery production, to calculate market shares, which are then squared and summed across carriers. Data limitations required the assumption that carrier capacity out of origin markets equalled median local consumption across markets and carrier capacity into destination markets equalled median refinery production across all markets. The lowest quartile origin markets all had zero refinery production and therefore zero HHIs. Inter-carrier quartiles bin markets relative to all other markets. Intra-carrier quartiles bin markets within each carrier's markets (i.e., the same market can be in two different bins).

Table A3.4: Origin Market Vulnerability Status

	Inter-Carrier				Intra-Carrier					
Origin Market	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Uncontested	Contested
Fort Wayne, IN	x				x				x	
Indianapolis, IN	x				x				x	
Minot, ND	x				x				x	
New York-No New Jersey-Long Island, NY-NJ	x				x				x	
Omaha, NE-IA	x				x				x	
Chicago-Gary-Kenosha, IL-IN-WI	x				x					x
Houston-Galveston-Brazoria, TX	x				x					x
St Louis, MO-IL		x			x	x			x	
Philadelphia-Wilmington-Atlantic City, PA		x			x		x			x
Detroit-Ann Arbor-Flint, MI		x				x			x	
Minneapolis-St Paul, MN-WI		x				x			x	
Jackson, MS		x				x				x
New Orleans, LA		x				x				x
Tulsa, OK			x			x	x			x
Little Rock-North Little Rock, AR			x			x			x	
Toledo, OH			x				x	x	x	
Beaumont-Port Arthur, TX			x				x	x		x
Oklahoma City, OK			x				x		x	
Lake Charles, LA			x				x			x
Wichita, KS			x				x			x
Evansville-Henderson, IN-KY				x			x		x	
Amarillo, TX				x				x	x	
Duluth-Superior, MN-WI				x				x	x	
Shreveport-Bossier City, LA				x				x	x	
Baton Rouge, LA				x				x		x
Lafayette, LA				x				x		x

Table A3.5: Origin Market Services by Vulnerability Measure (2008-2019)

	Inter-Carrier Quartile					Intra-Carrier Quartile							
	1	2	3	4	Total	1	2	3	4	Total	Uncontested	Contested	Total
Rate (cents per bbl)	166.699	137.975	204.869	127.828	168.685	158.332	173.721	200.575	125.274	167.894	219.402	153.237	168.685
	(122.856)	(56.863)	(99.532)	(52.888)	(92.464)	(113.322)	(77.128)	(101.177)	(50.306)	(91.087)	(126.966)	(72.261)	(92.464)
HHI_O	0.022	0.075	0.165	0.296	0.153	0.029	0.089	0.186	0.274	0.152	0.155	0.152	0.153
	(0.012)	(0.028)	(0.072)	(0.109)	(0.111)	(0.015)	(0.026)	(0.086)	(0.117)	(0.115)	(0.153)	(0.095)	(0.111)
HHI_D	0.361	0.375	0.376	0.408	0.380	0.297	0.423	0.374	0.371	0.376	0.328	0.396	0.380
	(0.292)	(0.294)	(0.295)	(0.294)	(0.294)	(0.268)	(0.314)	(0.281)	(0.301)	(0.297)	(0.279)	(0.297)	(0.294)
Refinery Prod.$_{O,t-1}$ (MMBPD)	1.236	0.681	0.427	0.280	0.550	1.099	0.614	0.443	0.359	0.580	0.178	0.664	0.550
	(0.731)	(0.549)	(0.327)	(0.179)	(0.515)	(0.688)	(0.528)	(0.366)	(0.290)	(0.530)	(0.117)	(0.535)	(0.515)
Waterborne Shipments$_{O,t-1}$ (MMBPD)	0.129	0.024	0.003	0.006	0.023	0.099	0.021	0.005	0.005	0.025	0.000	0.030	0.023
	(0.096)	(0.029)	(0.007)	(0.004)	(0.052)	(0.100)	(0.028)	(0.008)	(0.004)	(0.054)	(0.001)	(0.058)	(0.052)
Consumption$_{O,t-1}$ (MMBPD)	0.193	0.266	0.142	0.218	0.194	0.298	0.171	0.149	0.252	0.204	0.121	0.216	0.194
	(0.226)	(0.340)	(0.187)	(0.268)	(0.258)	(0.356)	(0.242)	(0.212)	(0.261)	(0.266)	(0.113)	(0.285)	(0.258)
Waterborne Receipts$_{D,t-1}$ (MMBPD)	0.020	0.056	0.010	0.031	0.027	0.064	0.023	0.016	0.031	0.029	0.001	0.035	0.027
	(0.076)	(0.128)	(0.055)	(0.097)	(0.091)	(0.137)	(0.084)	(0.070)	(0.095)	(0.095)	(0.004)	(0.103)	(0.091)
Distance (000s of km)	1.212	0.957	1.034	1.254	1.078	1.027	1.055	1.191	1.147	1.113	0.739	1.181	1.078
	(0.776)	(0.627)	(0.559)	(0.601)	(0.622)	(0.779)	(0.553)	(0.588)	(0.676)	(0.637)	(0.458)	(0.629)	(0.622)
Carriers$_{O,t-1}$	4.957	4.096	3.987	1.763	3.680	4.951	4.612	3.223	2.251	3.692	2.220	4.125	3.680
	(2.354)	(2.169)	(1.587)	(0.673)	(1.996)	(2.011)	(2.273)	(1.315)	(1.324)	(2.053)	(1.197)	(1.978)	(1.996)
Carriers$_{D,t-1}$	2.915	2.986	2.899	2.627	2.868	3.351	2.725	2.864	2.783	2.880	3.190	2.771	2.868
	(1.583)	(1.585)	(1.446)	(1.379)	(1.490)	(1.678)	(1.503)	(1.427)	(1.442)	(1.511)	(1.438)	(1.492)	(1.490)
Services per Carrier$_{O,t-1}$	71.375	90.887	125.348	87.112	103.206	72.539	124.056	122.013	91.029	107.463	107.033	102.040	103.206
	(74.041)	(46.118)	(70.989)	(47.343)	(64.995)	(66.018)	(57.362)	(70.086)	(42.304)	(63.222)	(86.201)	(56.938)	(64.995)
Services per Carrier$_{D,t-1}$	40.245	38.808	44.420	41.726	42.024	39.100	46.578	46.496	44.591	44.897	44.305	41.329	42.024
	(32.908)	(26.532)	(35.326)	(32.011)	(32.483)	(30.872)	(31.173)	(35.502)	(29.038)	(32.125)	(40.945)	(29.391)	(32.483)
MBR	0.521	0.335	0.473	0.244	0.399	0.545	0.376	0.472	0.456	0.451	0.631	0.328	0.399
	(0.500)	(0.472)	(0.499)	(0.430)	(0.490)	(0.498)	(0.484)	(0.499)	(0.498)	(0.498)	(0.483)	(0.470)	(0.490)
N (Service × Year)	10452	23616	41796	18756	94620	13296	25536	25128	19776	83736	22092	72528	94620
No. of Services	871	1968	3483	1563	7885	1108	2128	2094	1648	6978	1841	6044	7885

Standard deviations in parentheses. HHI_O and HHI_D are calculated in accordance with Equations (3.12) and (3.13), respectively.

Table A3.6: Destination Market Vulnerability Status

	Inter-Carrier				Intra-Carrier					
Destination Market	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Uncontested	Contested
Toledo, OH	x				x	x			x	
Tulsa, OK	x				x	x				x
Baton Rouge, LA	x				x		x			x
Philadelphia-Wilmington-Atlantic City, PA	x				x				x	
Chicago-Gary-Kenosha, IL-IN-WI	x				x					x
Houston-Galveston-Brazoria, TX	x				x					x
Minneapolis-St Paul, MN-WI	x				x					x
New York-No New Jersey-Long Island, NY-NJ	x				x					x
St Louis, MO-IL	x					x	x			x
Wichita, KS		x			x	x			x	
Detroit-Ann Arbor-Flint, MI		x			x		x			x
Denver-Boulder-Greeley, CO		x			x				x	
Indianapolis, IN		x				x	x		x	
Evansville-Henderson, IN-KY		x				x			x	
Oklahoma City, OK		x				x			x	
Lincoln, NE		x				x				x
Omaha, NE-IA		x				x				x
Memphis, TN-AR-MS		x					x		x	
Dallas-Fort Worth, TX		x						x		x
Columbus, OH			x				x		x	
Madison, WI			x				x		x	
State College, PA			x				x		x	
Columbia, MO			x				x			x
Elkhart-Goshen, IN			x				x			x
Jackson, MS			x				x			x
Kansas City, MO-KS			x				x			x
Fargo-Moorhead, ND-MN			x				x	x		x
Fort Wayne, IN			x					x	x	
Davenport-Moline-Rock Island, IA-IL				x				x	x	
Lafayette, LA				x				x	x	
Little Rock-North Little Rock, AR				x				x	x	
Louisville, KY-IN				x				x	x	
Shreveport-Bossier City, LA				x				x	x	
Springfield, IL				x				x		x

Table A3.7: Destination Market Services by Vulnerability Measure (2008-2019)

	Inter-Carrier Quartile					Intra-Carrier Quartile							
	1	2	3	4	Total	1	2	3	4	Total	Uncontested	Contested	Total
Rate (cents per bbl)	195.781	155.573	178.829	206.028	181.071	186.739	185.588	178.067	191.885	185.158	162.467	189.444	181.071
	(111.532)	(72.642)	(113.736)	(96.863)	(102.476)	(114.135)	(64.659)	(105.401)	(86.753)	(102.764)	(73.109)	(112.234)	(102.476)
HHI_O	0.160	0.128	0.139	0.110	0.144	0.151	0.115	0.134	0.136	0.140	0.134	0.148	0.144
	(0.139)	(0.073)	(0.120)	(0.080)	(0.118)	(0.129)	(0.062)	(0.113)	(0.095)	(0.114)	(0.106)	(0.122)	(0.118)
HHI_D	0.059	0.205	0.333	0.769	0.186	0.074	0.200	0.254	0.582	0.186	0.240	0.161	0.186
	(0.026)	(0.045)	(0.152)	(0.213)	(0.188)	(0.051)	(0.061)	(0.111)	(0.303)	(0.193)	(0.253)	(0.144)	(0.188)
Refinery Prod.$_{O,t-1}$ (MMBPD)	0.627	0.479	0.376	0.717	0.544	0.546	0.417	0.625	0.677	0.555	0.634	0.503	0.544
	(0.549)	(0.479)	(0.383)	(0.628)	(0.518)	(0.505)	(0.475)	(0.571)	(0.564)	(0.527)	(0.591)	(0.477)	(0.518)
Waterborne Shipments$_{O,t-1}$ (MMBPD)	0.027	0.018	0.010	0.044	0.022	0.021	0.018	0.031	0.028	0.023	0.035	0.016	0.022
	(0.057)	(0.055)	(0.035)	(0.081)	(0.056)	(0.049)	(0.057)	(0.068)	(0.067)	(0.057)	(0.069)	(0.047)	(0.056)
Consumption$_{O,t-1}$ (MMBPD)	0.511	0.151	0.077	0.035	0.303	0.515	0.062	0.110	0.150	0.312	0.151	0.372	0.303
	(0.368)	(0.140)	(0.039)	(0.023)	(0.332)	(0.352)	(0.045)	(0.053)	(0.208)	(0.334)	(0.116)	(0.372)	(0.332)
Waterborne Receipts$_{D,t-1}$ (MMBPD)	0.120	0.001	0.000	0.001	0.057	0.115	0.000	0.001	0.000	0.059	0.010	0.078	0.057
	(0.167)	(0.003)	(0.000)	(0.001)	(0.130)	(0.165)	(0.001)	(0.003)	(0.001)	(0.131)	(0.016)	(0.151)	(0.130)
Distance (000s of km)	1.424	0.646	0.596	0.722	1.010	1.339	0.712	0.783	0.688	1.045	1.108	0.966	1.010
	(0.804)	(0.435)	(0.379)	(0.361)	(0.742)	(0.865)	(0.340)	(0.508)	(0.371)	(0.750)	(0.821)	(0.699)	(0.742)
Carriers$_{O,t-1}$	3.735	3.961	3.249	4.186	3.745	3.699	3.700	3.705	4.106	3.741	3.770	3.734	3.745
	(2.028)	(1.867)	(1.974)	(2.168)	(1.995)	(2.023)	(1.908)	(2.085)	(1.848)	(2.004)	(2.077)	(1.956)	(1.995)
Carriers$_{D,t-1}$	4.018	3.824	3.343	1.034	3.696	3.923	4.083	3.666	1.935	3.694	2.773	4.111	3.696
	(1.841)	(0.727)	(1.002)	(0.175)	(1.539)	(1.766)	(0.836)	(1.060)	(1.146)	(1.566)	(1.356)	(1.432)	(1.539)
Services per Carrier$_{O,t-1}$	97.022	93.594	105.985	152.025	100.225	99.360	124.954	106.378	104.992	105.833	95.699	102.262	100.225
	(70.603)	(76.694)	(73.043)	(86.510)	(74.848)	(66.631)	(76.535)	(80.527)	(83.190)	(73.909)	(74.705)	(74.824)	(74.848)
Services per Carrier$_{D,t-1}$	65.893	38.545	23.781	20.381	48.115	68.800	37.755	34.957	18.868	51.067	38.050	52.645	48.115
	(41.742)	(32.053)	(19.698)	(8.241)	(39.075)	(38.541)	(28.164)	(33.379)	(8.421)	(38.669)	(33.843)	(40.404)	(39.075)
MBR	0.904	0.863	0.851	1.000	0.887	0.940	0.929	0.967	0.982	0.948	0.894	0.885	0.887
	(0.294)	(0.344)	(0.356)	(0.000)	(0.316)	(0.237)	(0.256)	(0.179)	(0.133)	(0.221)	(0.308)	(0.319)	(0.316)
N (Service × Year)	20160	13080	7164	2124	42528	20280	6792	8724	3996	39792	13200	29328	42528
No. of Services	1680	1090	597	177	3544	1690	566	727	333	3316	1100	2444	3544

Standard deviations in parentheses. HHI_O and HHI_D are calculated in accordance with Equations (3.12) and (3.13), respectively.

Table A3.8: FERC Shift Effect on Log MBR Rates in Concentrated Origin Markets

	Continuous HHI				Top vs Lower HHI Quartile				Contested vs	
	with Interaction		w/o Interaction		Inter-Carrier		Intra-Carrier		Uncontested Markets	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
ATT	-0.008	-0.008	0.028***	0.027**	0.006	0.005	0.011***	0.011***	-0.013***	-0.014***
	(0.013)	(0.012)	(0.011)	(0.011)	(0.003)	(0.003)	(0.003)	(0.003)	(0.004)	(0.004)
Placebo	-0.022	-0.024	-0.007	-0.003	0.001	0.001	-0.004	-0.003	0.004	0.001
	(0.013)	(0.014)	(0.010)	(0.011)	(0.003)	(0.004)	(0.003)	(0.003)	(0.005)	(0.005)
2008 (t_0 - 4)	-0.065**	-0.068**	-0.028	-0.025	-0.002	-0.001	-0.011**	-0.011**	0.016*	0.011
	(0.025)	(0.026)	(0.020)	(0.021)	(0.006)	(0.007)	(0.004)	(0.004)	(0.007)	(0.007)
2009 (t_0 - 3)	-0.012	-0.014	0.003	0.007	0.002	0.003	-0.000	0.000	0.003	0.000
	(0.013)	(0.015)	(0.011)	(0.012)	(0.004)	(0.004)	(0.003)	(0.003)	(0.005)	(0.005)
2010 (t_0 - 2)	0.010*	0.010	0.006	0.009*	0.001	0.002	0.000	0.001	-0.006*	-0.009**
	(0.005)	(0.005)	(0.004)	(0.004)	(0.001)	(0.001)	(0.001)	(0.002)	(0.003)	(0.003)
2012 (t_0)	0.037***	0.042***	0.029***	0.030***	0.007***	0.007***	0.010***	0.010***	-0.005	-0.005
	(0.008)	(0.008)	(0.006)	(0.006)	(0.002)	(0.002)	(0.002)	(0.002)	(0.003)	(0.003)
2013 (t_0 + 1)	0.022	0.020	0.022*	0.020	0.007*	0.006	0.018***	0.019***	-0.001	-0.001
	(0.014)	(0.014)	(0.011)	(0.011)	(0.003)	(0.003)	(0.003)	(0.003)	(0.005)	(0.005)
2014 (t_0 + 2)	0.013	0.012	0.021	0.020	0.004	0.002	0.015***	0.015***	-0.009	-0.010*
	(0.018)	(0.018)	(0.014)	(0.014)	(0.004)	(0.004)	(0.004)	(0.004)	(0.005)	(0.005)
2015 (t_0 + 3)	0.009	0.008	0.045***	0.046***	0.007*	0.007	0.017***	0.017***	-0.009*	-0.011**
	(0.016)	(0.016)	(0.012)	(0.012)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
2016 (t_0 + 4)	-0.020	-0.019	0.032*	0.035*	0.004	0.004	0.010**	0.011***	-0.011*	-0.014**
	(0.016)	(0.016)	(0.013)	(0.014)	(0.004)	(0.004)	(0.003)	(0.003)	(0.005)	(0.005)
2017 (t_0 + 5)	-0.015	-0.013	0.039**	0.040**	0.006	0.005	0.006	0.007	-0.019***	-0.021***
	(0.017)	(0.017)	(0.015)	(0.015)	(0.004)	(0.004)	(0.004)	(0.004)	(0.005)	(0.005)
2018 (t_0 + 6)	-0.047**	-0.049**	0.022	0.016	0.006	0.004	0.003	0.003	-0.022***	-0.024***
	(0.018)	(0.017)	(0.016)	(0.016)	(0.005)	(0.004)	(0.004)	(0.004)	(0.005)	(0.005)
2019 (t_0 +7)	-0.062***	-0.065***	0.016	0.011	0.005	0.003	0.006	0.006	-0.027***	-0.029***
	(0.018)	(0.017)	(0.017)	(0.017)	(0.005)	(0.005)	(0.004)	(0.004)	(0.006)	(0.006)
HHI_o		40.763***		46.658***						46.623***
		(2.762)		(3.084)						(3.084)
HHI_d		-22.858***		-34.253***		-17.573***		-17.577***		-34.238***
		(1.911)		(2.480)		(3.152)		(3.152)		(2.481)
$HHI_o \times HHI_d$		-2.721***								
		(0.145)								
Distance × Cost Index	0.207***	-0.045*	0.166***	-0.039	0.166***	-0.022	0.165***	-0.022	0.167***	-0.039
	(0.037)	(0.022)	(0.035)	(0.022)	(0.035)	(0.022)	(0.035)	(0.022)	(0.035)	(0.022)
Refinery $Production_{o,t-1}$	0.028***	0.049***	0.034***	0.050***	0.036***	0.050***	0.035***	0.048***	0.029***	0.047***
	(0.008)	(0.008)	(0.008)	(0.008)	(0.007)	(0.007)	(0.007)	(0.007)	(0.009)	(0.009)
Waterborne $Shipments_{o,t-1}$	-0.003	-0.002	-0.003	-0.003	-0.003	-0.003	-0.003	-0.003	-0.005*	-0.005*
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
$Consumption_{d,t-1}$	-0.136***	-0.104***	-0.129***	-0.095***	-0.127***	-0.096***	-0.128***	-0.098***	-0.138***	-0.105***
	(0.022)	(0.021)	(0.024)	(0.023)	(0.024)	(0.023)	(0.024)	(0.023)	(0.024)	(0.023)
Waterborne $Deliveries_{d,t-1}$	0.012***	0.011***	0.016***	0.014***	0.016***	0.015***	0.017***	0.015***	0.016***	0.014***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.003)	(0.002)
No. of $Carriers_{o,t-1}$	0.008***	0.008***	0.008***	0.008***	0.008***	0.008***	0.007***	0.008***	0.006***	0.007***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
No. of $Carriers_{d,t-1}$	0.000	-0.004	0.005**	0.001	0.005***	0.002	0.005**	0.001	0.005***	0.001
	(0.001)	(0.002)	(0.001)	(0.002)	(0.001)	(0.002)	(0.001)	(0.002)	(0.001)	(0.002)
No. of $Services_{o,t-1}$	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	-0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
No. of $Services_{d,t-1}$	0.000	-0.000	0.000	0.000**	0.000	0.000*	0.000	0.000*	0.000	0.000**
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Carrier-Service FE	Y	N	Y	N	Y	N	Y	N	Y	N
Market FE	N	Y	N	Y	N	Y	N	Y	N	Y
Year FE	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
N	32292	32292	32292	32292	32292	32292	32292	32292	32292	32292

All standard errors are clustered at the service level. All regressions include commodity-specific time trends and carrier-specific time trends. *p < 0.05, **p < 0.01, and ***p < 0.001. "Interaction" refers to the interaction of the origin and destination market continuous HHIs. *ATT* is the average of post-treatment effects (i.e., 2012-2019). *Placebo* is the average of pre-treatment effects (i.e., 2008-2011). HHI_o and HHI_d refer to the pre-event continuous HHI measures in columns 1-4 and an indicator for being in the top quartile for the remaining columns.

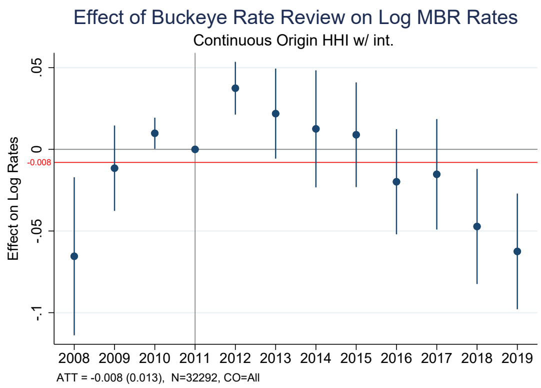
Table A3.9: FERC Shift Effect on Log MBR Rates in Vulnerable Destination Markets

	Continuous HHI				Top vs Lower HHI Quartile				Contested vs	
	with Interaction		w/o Interaction		Inter-Carrier		Intra-Carrier		Uncontested Markets	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
ATT	0.058***	0.055***	0.091***	0.086***	0.090***	0.084***	0.050***	0.048***	-0.001	-0.003
	(0.013)	(0.013)	(0.008)	(0.008)	(0.007)	(0.008)	(0.004)	(0.005)	(0.003)	(0.003)
Placebo	-0.038***	-0.027**	-0.016	-0.002	0.027***	0.035***	-0.006	0.000	0.005	0.006*
	(0.011)	(0.012)	(0.009)	(0.008)	(0.007)	(0.007)	(0.005)	(0.005)	(0.003)	(0.003)
2008 (t_0 - 4)	-0.069***	-0.062***	-0.024*	-0.009	0.033***	0.040***	-0.014*	-0.007	0.011**	0.012**
	(0.015)	(0.016)	(0.011)	(0.010)	(0.008)	(0.009)	(0.007)	(0.007)	(0.004)	(0.004)
2009 (t_0 - 3)	-0.034*	-0.020	-0.014	0.006	0.037***	0.048***	0.001	0.008	0.006	0.008*
	(0.014)	(0.015)	(0.010)	(0.009)	(0.009)	(0.009)	(0.006)	(0.006)	(0.004)	(0.004)
2010 (t_0 - 2)	-0.010	-0.001	-0.011*	-0.002	0.012***	0.017***	-0.007*	-0.002	-0.002	-0.001
	(0.006)	(0.006)	(0.005)	(0.004)	(0.003)	(0.004)	(0.003)	(0.003)	(0.002)	(0.002)
2012 (t_0)	0.058***	0.057***	0.042***	0.040***	0.039***	0.037***	0.027***	0.024***	-0.006***	-0.007***
	(0.009)	(0.008)	(0.006)	(0.006)	(0.006)	(0.006)	(0.003)	(0.003)	(0.001)	(0.001)
2013 (t_0 + 1)	0.059***	0.057***	0.057***	0.053***	0.063***	0.057***	0.042***	0.041***	-0.001	-0.003
	(0.016)	(0.016)	(0.011)	(0.010)	(0.013)	(0.013)	(0.006)	(0.006)	(0.002)	(0.002)
2014 (t_0 + 2)	0.057**	0.051**	0.063***	0.056***	0.054***	0.046***	0.044***	0.040***	0.002	-0.000
	(0.017)	(0.017)	(0.011)	(0.010)	(0.012)	(0.012)	(0.005)	(0.005)	(0.003)	(0.003)
2015 (t_0 + 3)	0.060***	0.058***	0.093***	0.092***	0.080***	0.076***	0.061***	0.059***	-0.000	-0.001
	(0.015)	(0.015)	(0.008)	(0.008)	(0.008)	(0.009)	(0.005)	(0.005)	(0.003)	(0.003)
2016 (t_0 + 4)	0.081***	0.081***	0.125***	0.127***	0.121***	0.118***	0.062***	0.062***	-0.001	-0.002
	(0.019)	(0.020)	(0.012)	(0.013)	(0.011)	(0.013)	(0.007)	(0.008)	(0.003)	(0.004)
2017 (t_0 + 5)	0.075***	0.074***	0.123***	0.121***	0.120***	0.114***	0.052***	0.052***	-0.003	-0.005
	(0.019)	(0.019)	(0.012)	(0.012)	(0.011)	(0.013)	(0.006)	(0.007)	(0.004)	(0.004)
2018 (t_0 + 6)	0.050**	0.046*	0.116***	0.106***	0.121***	0.111***	0.056***	0.053***	-0.002	-0.004
	(0.019)	(0.018)	(0.013)	(0.013)	(0.011)	(0.012)	(0.007)	(0.008)	(0.004)	(0.004)
2019 (t_0 +7)	0.026	0.019	0.109***	0.097***	0.122***	0.110***	0.056***	0.052***	-0.001	-0.004
	(0.018)	(0.018)	(0.013)	(0.014)	(0.012)	(0.012)	(0.007)	(0.008)	(0.004)	(0.004)
HHI_o		40.763***		46.428***		18.245***		19.478***		46.707***
		(2.762)		(3.079)		(3.105)		(2.906)		(3.084)
HHI_d		-22.858***		-34.108***						-34.286***
		(1.911)		(2.467)						(2.483)
$HHI_o \times HHI_d$		-2.721***								
		(0.145)								
Distance × Cost Index	0.207***	-0.045*	0.207***	-0.037	0.186***	-0.018	0.213***	-0.072**	0.163***	-0.040
	(0.037)	(0.022)	(0.037)	(0.022)	(0.036)	(0.023)	(0.038)	(0.022)	(0.036)	(0.022)
Refinery Production$_{o,t-1}$	0.028***	0.049***	0.025**	0.044***	0.032***	0.046***	0.019**	0.041***	0.036***	0.050***
	(0.008)	(0.008)	(0.008)	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)
Waterborne Shipments$_{o,t-1}$	-0.003	-0.002	-0.002	-0.002	-0.001	-0.001	-0.005*	-0.004*	-0.002	-0.002
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Consumption$_{d,t-1}$	-0.136***	-0.104***	-0.130***	-0.090***	-0.095***	-0.068***	-0.177***	-0.141***	-0.119***	-0.082***
	(0.022)	(0.021)	(0.022)	(0.021)	(0.020)	(0.019)	(0.026)	(0.024)	(0.026)	(0.025)
Waterborne Deliveries$_{d,t-1}$	0.012***	0.011***	0.013***	0.011***	0.015***	0.014***	0.008***	0.007***	0.016***	0.013***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
No. of Carriers$_{o,t-1}$	0.008***	0.008***	0.008***	0.009***	0.008***	0.008***	0.008***	0.008***	0.007***	0.008***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
No. of Carriers$_{d,t-1}$	0.000	-0.004	0.001	-0.003	0.003*	-0.000	0.006***	0.001	0.005***	0.001
	(0.001)	(0.002)	(0.001)	(0.002)	(0.001)	(0.002)	(0.001)	(0.002)	(0.001)	(0.002)
No. of Services$_{o,t-1}$	0.000	0.000	0.000	0.000	0.000*	0.000	0.000*	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
No. of Services$_{d,t-1}$	0.000	-0.000	0.000	0.000*	-0.000	0.000	-0.000	-0.000*	0.000	0.000**
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Carrier-Service FE	Y	N	Y	N	Y	N	Y	N	Y	N
Market FE	N	Y	N	Y	N	Y	N	Y	N	Y
Year FE	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
N	32292	32292	32292	32292	32292	32292	32292	32292	32292	32292

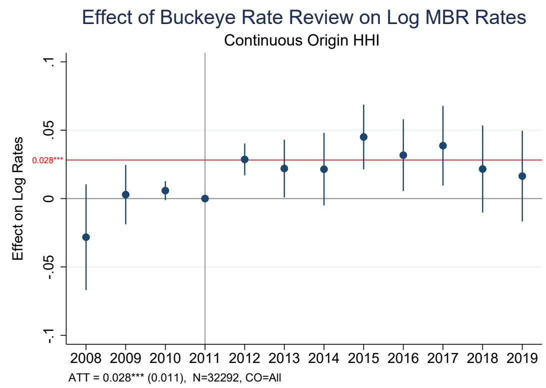
All standard errors are clustered at the service level. All regressions include commodity-specific time trends and carrier-specific time trends. *p < 0.05, **p < 0.01, and ***p < 0.001. "Interaction" refers to the interaction of the origin and destination market continuous HHIs. *ATT* is the average of post-treatment effects (i.e., 2012-2019). *Placebo* is the average of pre-treatment effects (i.e., 2008-2011). HHI_o and HHI_d refer to the pre-event continuous HHI measures in columns 1-4 and an indicator for being in the top quartile for the remaining columns.

Figure A3.10: Origin Market Event Studies (w/ Carrier-Service FE)

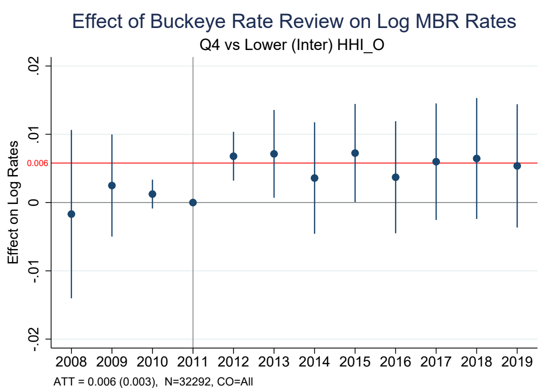
(a) Continuous HHI with Interaction (w/ Carrier-Service FE)



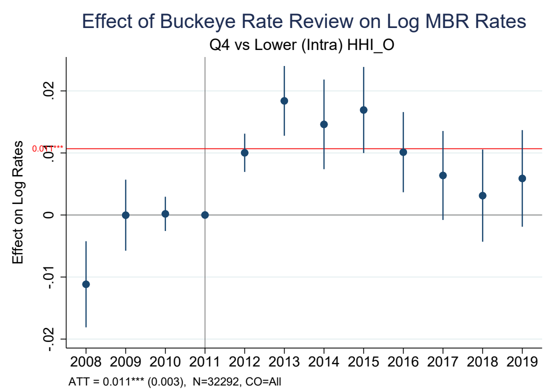
(b) Continuous HHI w/o Interaction (w/ Carrier-Service FE)



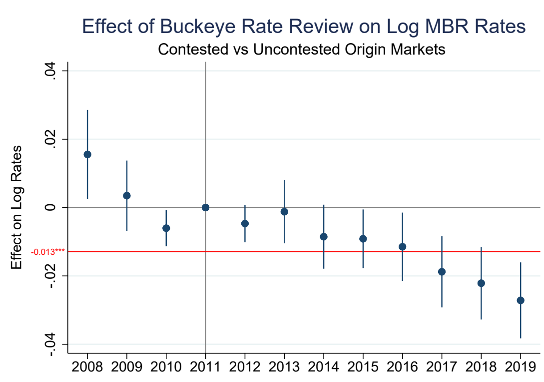
(c) Top vs. Lower Inter-Carrier HHI Quartile (w/ Carrier-Service FE)



(d) Top vs. Lower Intra-Carrier HHI Quartile (w/ Carrier-Service FE)



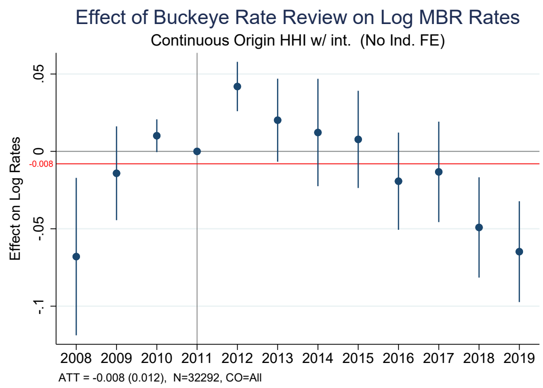
(e) Contested vs. Uncontested Markets (w/ Carrier-Service FE)



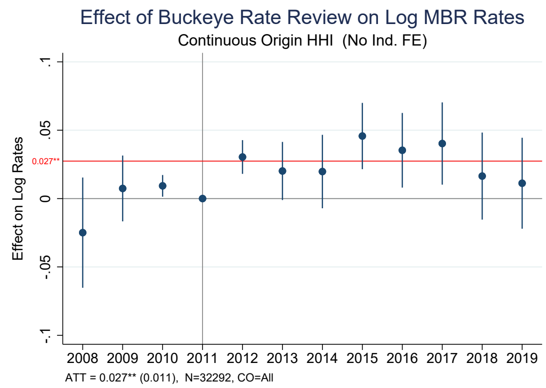
Note: All standard errors are clustered at the service level. Vertical lines show 95% confidence intervals. Post-treatment average is designated by the red line. ${}^{*}p < 0.05$, ${}^{**}p < 0.01$ and ${}^{***}p < 0.001$.

Figure A3.11: Origin Market Event Studies (w/o Carrier-Service FE)

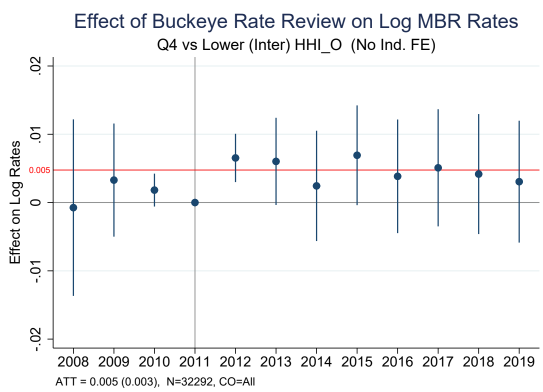
(a) Continuous HHI with Interaction (w/o Carrier-Service FE)



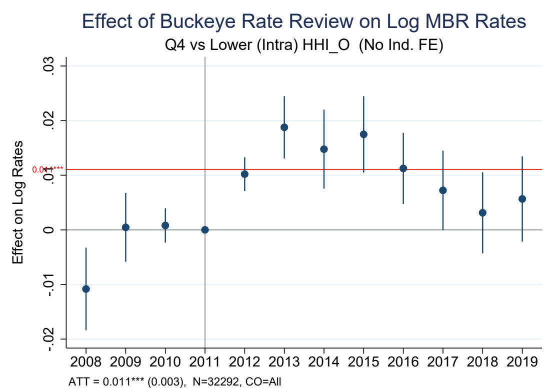
(b) Continuous HHI w/o Interaction (w/o Carrier-Service FE)



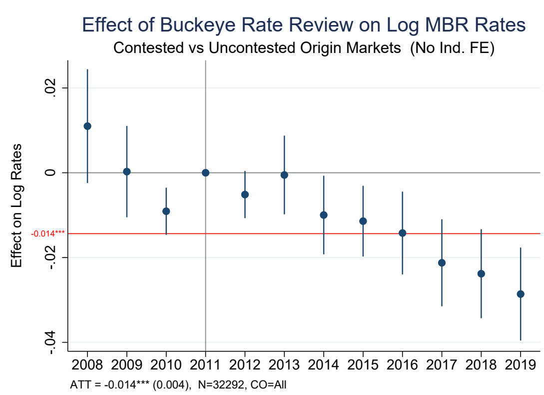
(c) Top vs. Lower Inter-Carrier HHI Quartile (w/o Carrier-Service FE)



(d) Top vs. Lower Intra-Carrier HHI Quartile (w/o Carrier-Service FE)



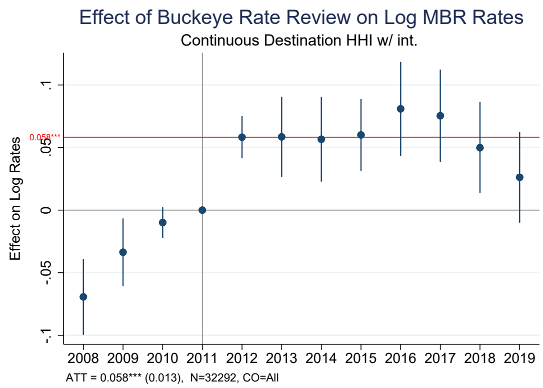
(e) Contested vs. Uncontested Markets (w/ Carrier-Service FE)



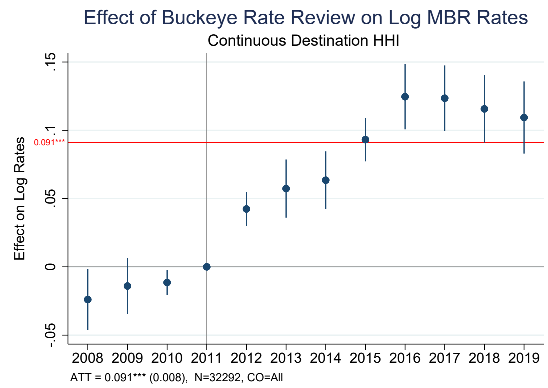
Note: All standard errors are clustered at the service level. Vertical lines show 95% confidence intervals. Post-treatment average is designated by the red line. $^{*}p < 0.05$, $^{**}p < 0.01$ and $^{***}p < 0.001$.

Figure A3.12: Destination Market Event Studies (w/ Carrier-Service FE)

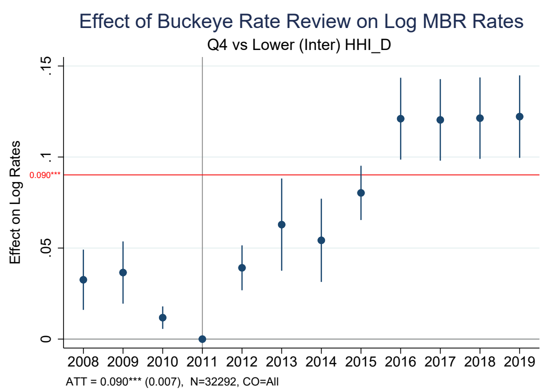
(a) Continuous HHI with Interaction (w/ Carrier-Service FE)



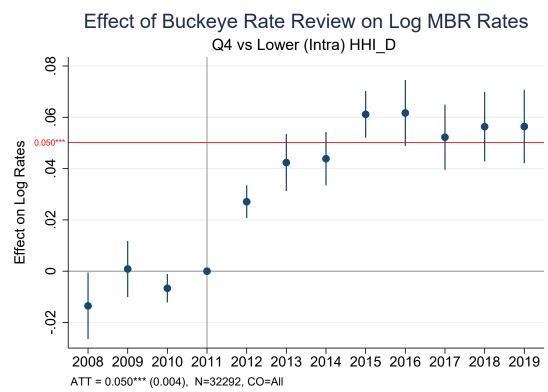
(b) Continuous HHI w/o Interaction (w/ Carrier-Service FE)



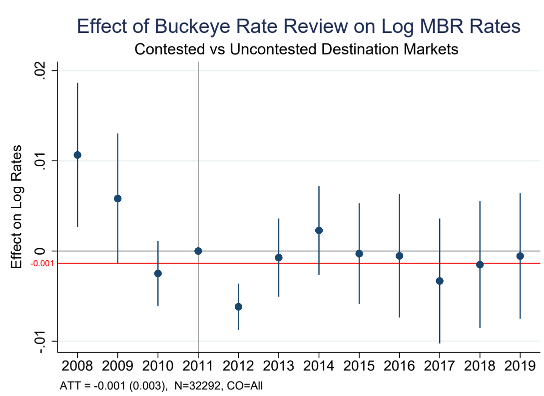
(c) Top vs. Lower Inter-Carrier HHI Quartile (w/ Carrier-Service FE)



(d) Top vs. Lower Intra-Carrier HHI Quartile (w/ Carrier-Service FE)



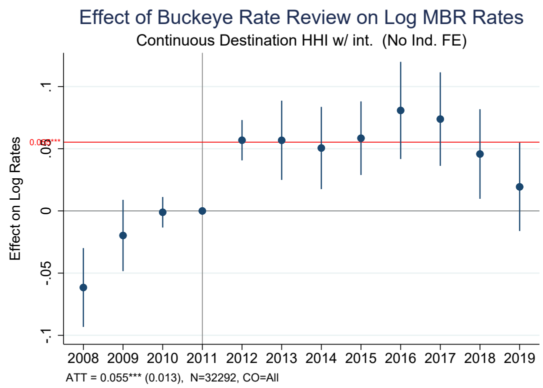
(e) Contested vs. Uncontested Markets (w/ Carrier-Service FE)



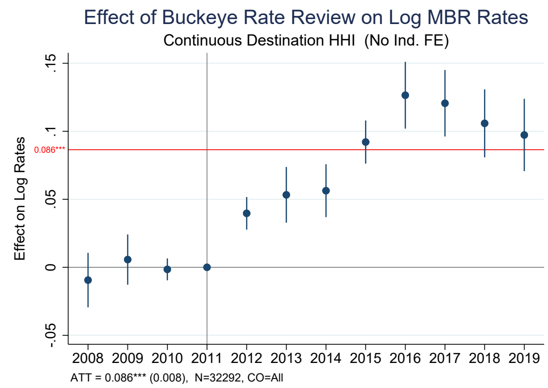
Note: All standard errors are clustered at the service level. Vertical lines show 95% confidence intervals. Post-treatment average is designated by the red line. $^{*}p < 0.05$, $^{**}p < 0.01$ and $^{***}p < 0.001$.

Figure A3.13: Destination Market Event Studies (w/o Carrier-Service FE)

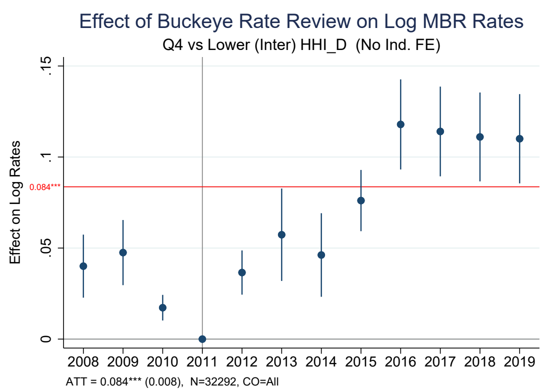
(a) Continuous HHI with Interaction (w/o Carrier-Service FE)



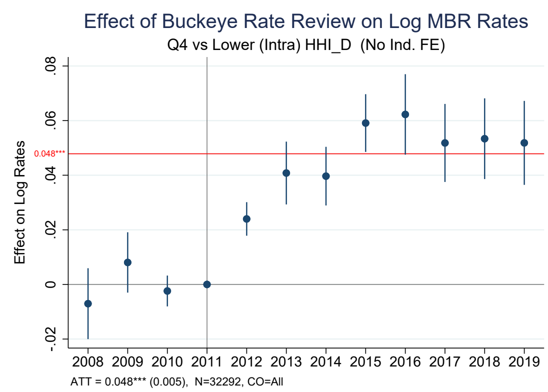
(b) Continuous HHI w/o Interaction (w/o Carrier-Service FE)



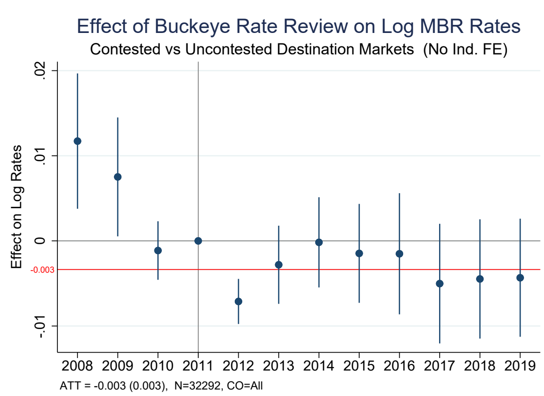
(c) Top vs. Lower Inter-Carrier HHI Quartile (w/o Carrier-Service FE)



(d) Top vs. Lower Intra-Carrier HHI Quartile (w/o Carrier-Service FE)



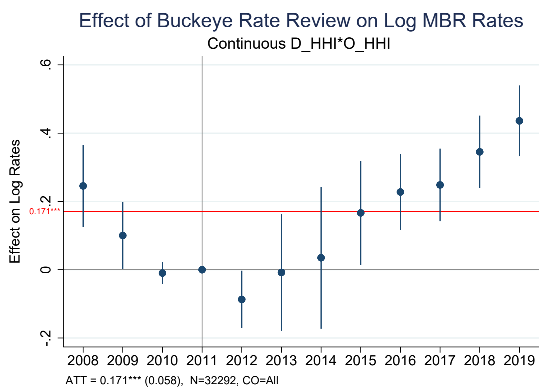
(e) Contested vs. Uncontested Markets (w/ Carrier-Service FE)



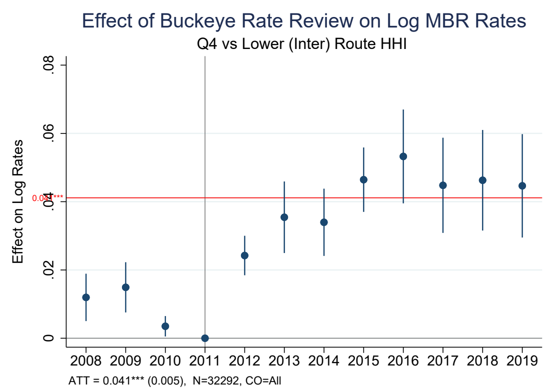
Note: All standard errors are clustered at the service level. Vertical lines show 95% confidence intervals. Post-treatment average is designated by the red line. $^{*}p < 0.05$, $^{**}p < 0.01$ and $^{***}p < 0.001$.

Figure A3.14: Route (Origin-Destination Pair) MBR Event Studies

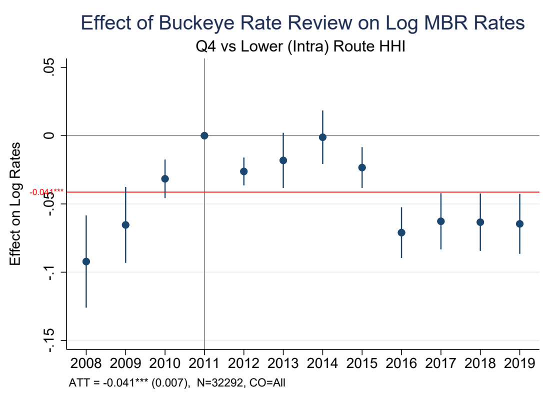
(a) Continuous HHI with Interaction (w/ Carrier-Service FE)



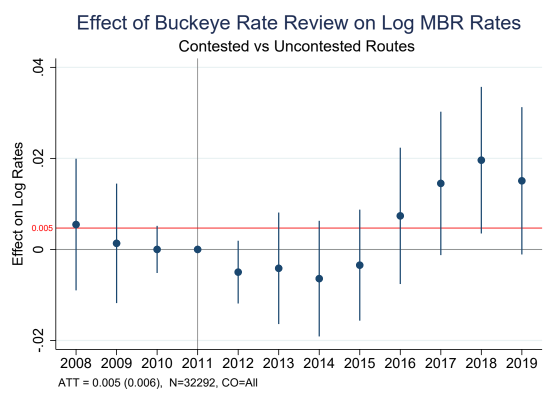
(b) Top vs. Lower Inter-Carrier HHI Quartile (w/ Carrier-Service FE)



(c) Top vs. Lower Intra-Carrier HHI Quartile (w/ Carrier-Service FE)



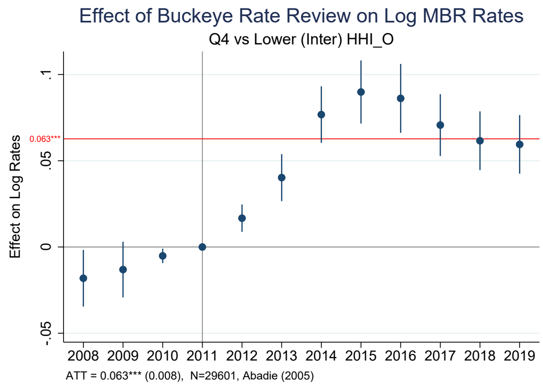
(d) Contested vs. Uncontested Markets (w/ Carrier-Service FE)



Note: All standard errors are clustered at the service level. Vertical lines show 95% confidence intervals. Post-treatment average is designated by the red line. $^{*}p < 0.05$, $^{**}p < 0.01$ and $^{***}p < 0.001$. Underlying regression tables available upon request.

Figure A3.15: Abadie (2005) Event Studies

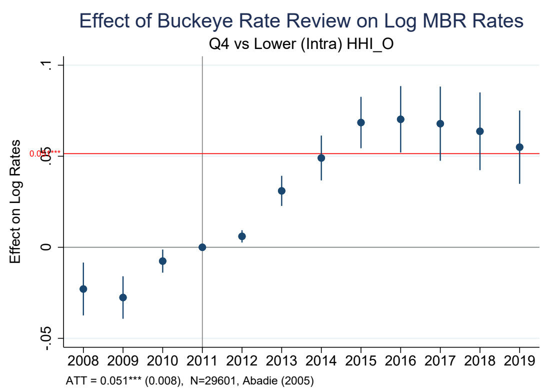
(a) Top vs. Lower Inter-Carrier Origin HHI Quartile



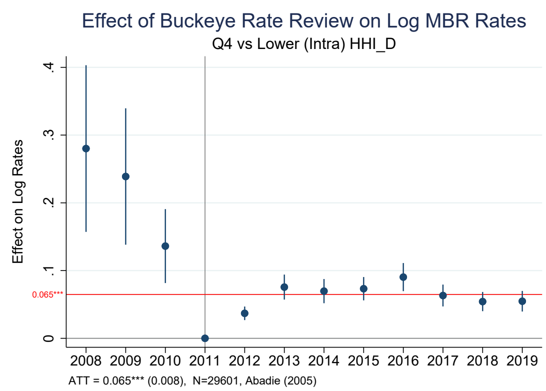
(b) Top vs. Lower Inter-Carrier Destination HHI Quartile

Not available. Insufficient Data.

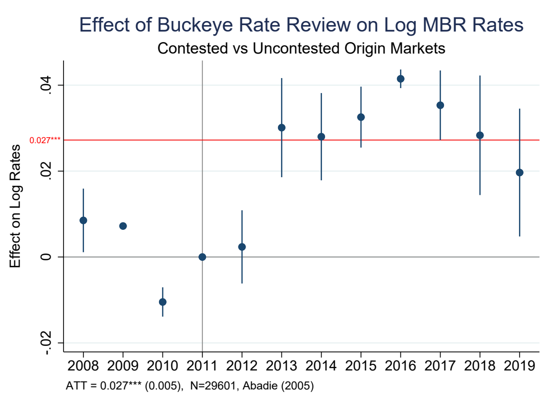
(c) Top vs. Lower Intra-Carrier Origin HHI Quartile



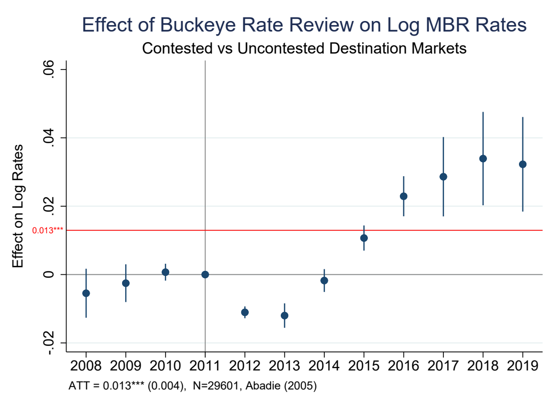
(d) Top vs. Lower Intra-Carrier Destination HHI Quartile



(e) Contested vs. Uncontested Origin Markets



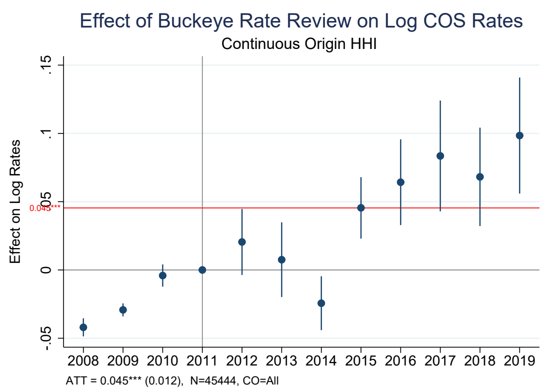
(f) Contested vs. Uncontested Destination Markets



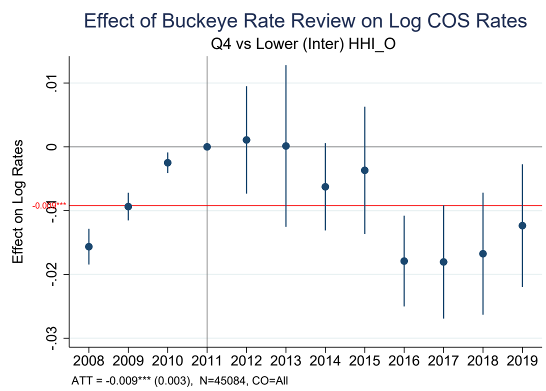
Note: All standard errors are clustered at the service level. Vertical lines show 95% confidence intervals. Post-treatment average is designated by the red line. $^{*}p < 0.05, ^{**}p < 0.01$ and $^{***}p < 0.001$. Underlying regression tables available upon request.

Figure A3.16: Origin Market Event Studies - COS (w/ Carrier-Service FE)

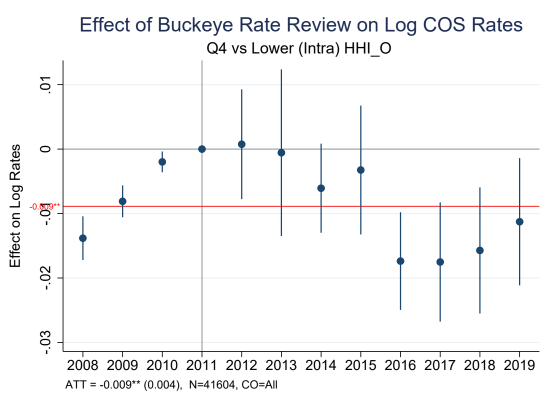
(a) Continuous HHI w/o Interaction (w/ Carrier-Service FE)



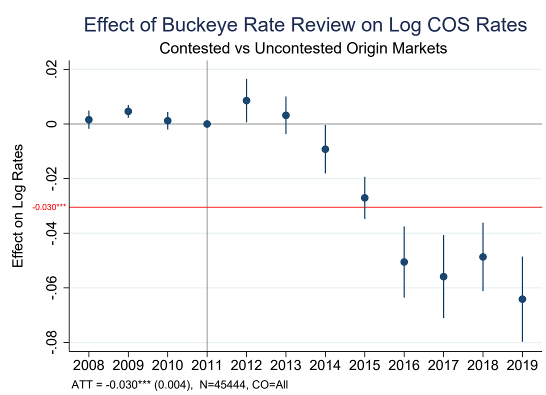
(b) Top vs. Lower Inter-Carrier HHI Quartile (w/ Carrier-Service FE)



(c) Top vs. Lower Intra-Carrier HHI Quartile (w/ Carrier-Service FE)



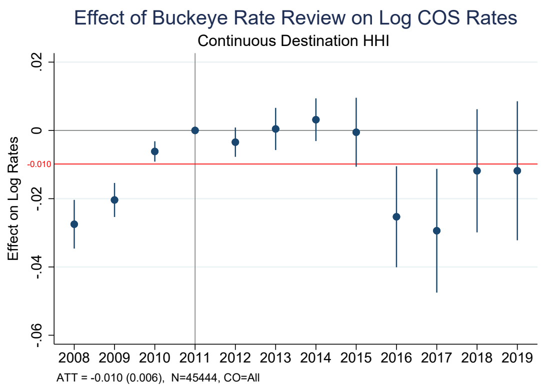
(d) Contested vs. Uncontested Markets (w/ Carrier-Service FE)



Note: All standard errors are clustered at the service level. Vertical lines show 95% confidence intervals. Post-treatment average is designated by the red line. $^{*}p < 0.05, ^{**}p < 0.01$ and $^{***}p < 0.001$. Underlying regression tables available upon request.

Figure A3.17: Destination Market Event Studies - COS (w/ Carrier-Service FE)

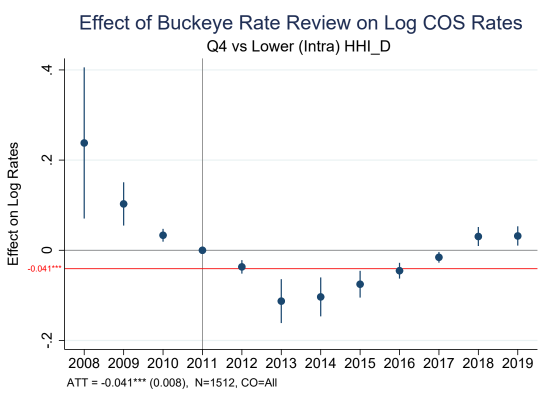
(a) Continuous HHI w/o Interaction (w/ Carrier-Service FE)



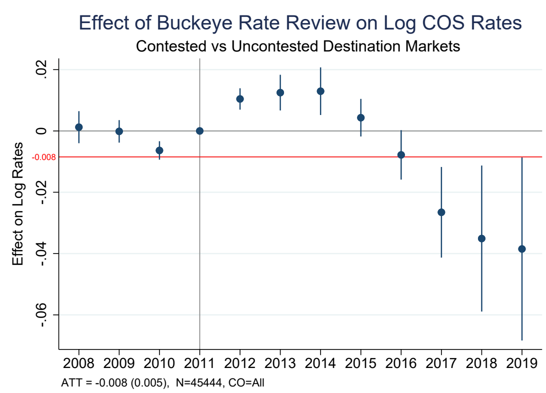
(b) Top vs. Lower Inter-Carrier HHI Quartile (w/ Carrier-Service FE)

Not available. Insufficient Data.

(c) Top vs. Lower Intra-Carrier HHI Quartile (w/ Carrier-Service FE)



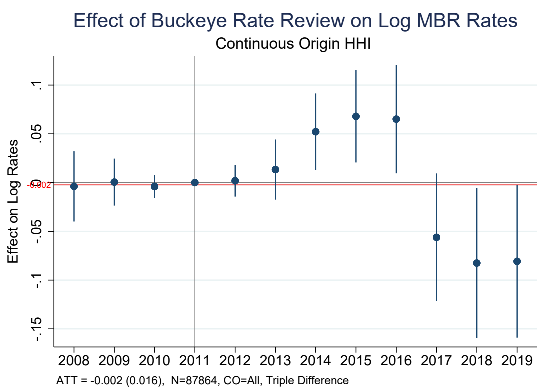
(d) Contested vs. Uncontested Markets (w/ Carrier-Service FE)



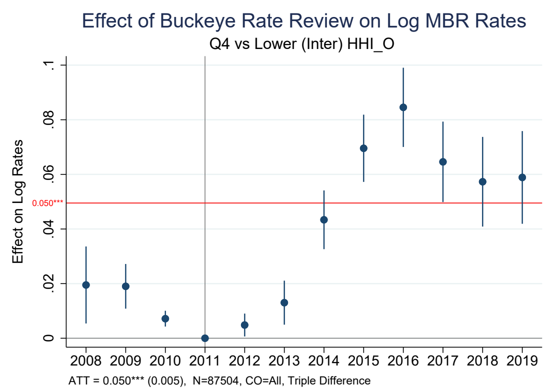
Note: All standard errors are clustered at the service level. Vertical lines show 95% confidence intervals. Post-treatment average is designated by the red line. $^{*}p < 0.05$, $^{**}p < 0.01$ and $^{***}p < 0.001$. Underlying regression tables available upon request.

Figure A3.18: Triple Difference Event Studies (Origin Markets)

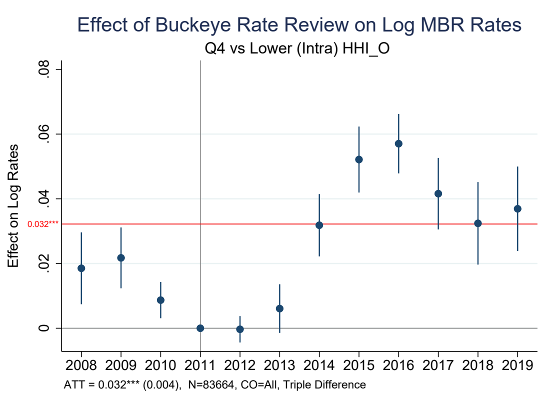
(a) Continuous HHI w/o Interaction (w/ Carrier-Service FE)



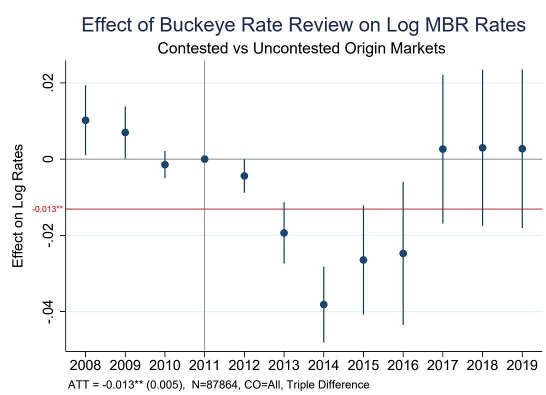
(b) Top vs. Lower Inter-Carrier HHI Quartile (w/ Carrier-Service FE)



(c) Top vs. Lower Intra-Carrier HHI Quartile (w/ Carrier-Service FE)



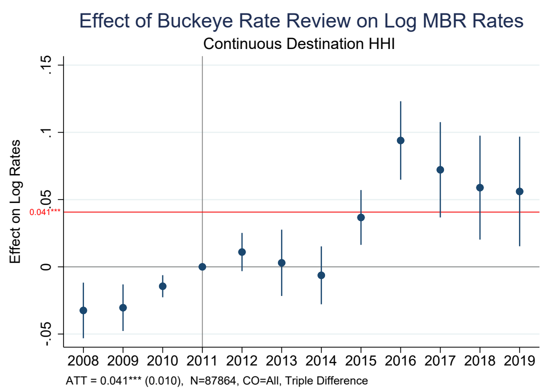
(d) Contested vs. Uncontested Markets (w/ Carrier-Service FE)



Note: All standard errors are clustered at the service level. Vertical lines show 95% confidence intervals. Post-treatment average is designated by the red line. $^{*}p < 0.05$, $^{**}p < 0.01$ and $^{***}p < 0.001$. Underlying regression tables available upon request.

Figure A3.19: Triple Difference Event Studies (Destination Markets)

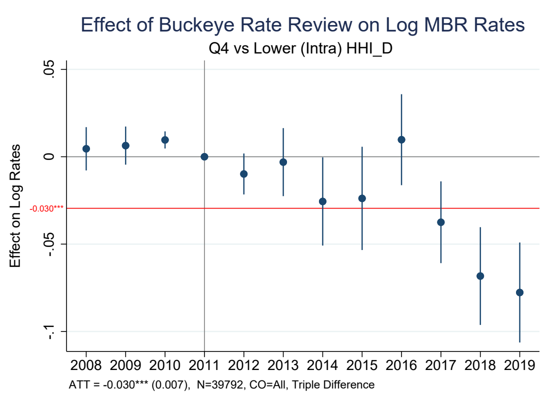
(a) Continuous HHI w/o Interaction (w/ Carrier-Service FE)



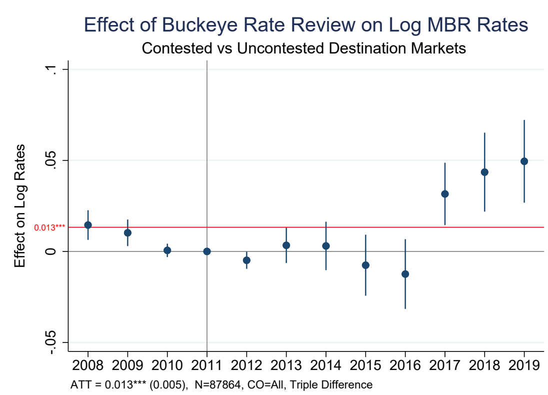
(b) Top vs. Lower Inter-Carrier HHI Quartile (w/ Carrier-Service FE)

Not available. Insufficient Data.

(c) Top vs. Lower Intra-Carrier HHI Quartile (w/ Carrier-Service FE)



(d) Contested vs. Uncontested Markets (w/ Carrier-Service FE)



Note: All standard errors are clustered at the service level. Vertical lines show 95% confidence intervals. Post-treatment average is designated by the red line. $^{*}p < 0.05,^{**}p < 0.01$ and $^{***}p < 0.001$. Underlying regression tables available upon request.

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