Open Price Contracts, Locked-In Buyers, and Opportunism

Michael D. Noel* and Hongjie Qiang†

August 29, 2022

Abstract

There is a large literature on incomplete contracts, but one prominent type of incomplete contract has largely gone unnoticed. An "open price contract" is one in which a buyer commits to purchasing goods from a seller even though the price has not been agreed upon at the time of signing. Open price contracts generally give the seller the right to set prices ex post, and the buyer is then obligated to purchase from the seller at those prices. This gives rise to obvious incentives for short-run opportunistic pricing by the seller, but also disincentives from long-run reputational consequences. In this article, we focus on a specific application where open price contracts are common and test for opportunistic ex-post pricing by sellers on locked-in buyers. We find that sellers' long-run reputational incentives dominate opportunistic incentives, consistent with lessons from the relational contracts literature.

JEL Classification Codes: L11, L14, L24, L81, K12

Keywords: Incomplete Contracts, Open Price Contracts, Open Price Terms, Opportunistic Pricing, Lock-in, Locked-in Buyers, Cost Passthrough, Wholesale, Fuel, Gasoline

1 Introduction

The theory of contracts has attracted much attention from economists over the past thirty years, and for good reason. Contracting is ubiquitous in our world and endogenously arises in response to dynamic inefficiencies that are likely to occur in their absence. Theorists have long studied optimal contract design in a variety of situations, including moral hazard (Shavell (1979), Grossman and Hart (1983)), adverse selection (Baron and Myerson (1982), Maskin and Riley (1984)), and uncertainty over future states of the world (Grossman and Hart (1986), Hart and Moore (1988), and Hart and Moore (1990)). This last field of research is called incomplete contracting, and stems from

*Texas Tech University, michael.noel@ttu.edu.

†Central South University, hongjie.qiang@csu.edu.cn; research funding by the "Basic Science Center Project: the theory and application of resource and environment management in the digital economy era (72088101)", from the National Natural Science Foundation of China.

the idea that it can be difficult to forecast, and thus contract upon, all possible states of the world in advance. When an unexpected state of the world occurs and requires contract renegotiations, the potential for opportunistic behavior by one or both parties ex post can lead to hold-up problems and inefficiency ex ante. Assigning residual decisionmaking rights to one party or the other can improve the outcome (Aghion and Holden (2011), Hart (2017)), but the assignment of rights also meaningfully affects the distribution of surplus. A large empirical literature has examined various aspects of incomplete contracts, such as contract design, efficiency, competitive effects, and others, in a variety of real world settings (Hoppe and Schmitz (2010), Antras and Staiger (2012), and Bajari et al. (2014) and others).

In spite of the interest in incomplete contracts generally, one very prominent type of incomplete contract has received less attention in the literature. "Open price contracts" or "open price term" contracts are incomplete contracts in which a very fundamental component of the contract - namely the price - is not set in advance.[1] In an open price contract, a buyer commits to purchasing products from a seller over a specified period of time before there is any agreement as to what the price will be. In most cases, the seller holds residual rights to set prices and change them from time to time as desired, and the buyer is then locked-in and obligated to purchase at the prices so set and so changed. It is essentially an upside-down ultimatum game in which the buyer decides whether to buy first, and the seller sets the prices second.[2]

It may seem unwise for a buyer to commit to buying without knowing the price in advance, but these types of contracts are ubiquitous in the economy. Most industries that operate on a franchise model – from restaurants to clothing outlets to gasoline stations – utilize some form of open price term in their franchisor-franchisee contracts. They tend to be long term contracts in which franchisees pay a fee, secure a license to use the franchisor's name, and agree to purchase most major inputs from the franchisor (or its approved vendors) over the life of the contract. Because it is difficult to negotiate the price of inputs for each future period of time and each possible realization

[1] A search through economics journals in standard databases for "open price term" or "open price contract" produced no results.

[2] A key difference between the open price contract and its cousin the cost-plus contract is that under a cost-plus contract the cost-plus margin is agreed upon in advance and buyers can dispute any costs claimed by the seller if they appear unreasonable or unnecessary. In an open price contract, they cannot - the price they are given is the price.

of the world, open price terms are used and generally assign pricing rights to the seller. There is a large literature on franchising contracts in general, but studies tend to focus on other aspects of franchise contracts such as integration choice (Brickley and Dark (1987), Lafontaine (1992), Vita (2000), Forbes and Lederman (2009)) or franchise fee structure (Bhattacharyya and Lafontaine (1995), Lafontaine and Shaw (1999), Lafontaine and Slade (2007)), while saying less about the open price terms contained in these contracts.

In this article, we examine the effects of open price contracts on surplus distribution. We test whether open price contracts do or do not give rise to opportunistic pricing by the party that has ex post control over prices (the seller) at the expense of the party that is locked-in (the buyer) and captive to the first party's choices.

One might expect that the holder of residual pricing rights - in this case the seller - would set ex post prices in a way to maximize its own surplus under the contract. Locked-in buyers could in principle be slowly bankrupted under such a contract, but would not rationally enter into such a contract with this expectation. The seller's concern for its own long run reputation and its ability to recruit new buyers in the future is the obvious counteracting force that can limit its short run opportunistic pricing incentives on these buyers.[3]

In this way, our study is closely related to the relational contracts literature. Relational contracts are "informal agreements and unwritten codes of conduct" that affect how firms interact with another (Baker et al. (2002)) – essentially, self-enforcing agreements "characterized by the ability of one party to terminate the contract with the other following the detection of an undesired action by the latter" (Kosova and Sertsios (2018)). While a buyer cannot terminate a contract in our context, as it is still a formal contract, a buyer can refuse to renew and alert other potential signees to what it believes are undesirable pricing actions on the part of the seller, thus harming the seller's long run reputation and its ability to sign up new buyers (Klein and Leffler (1981), MacLeod (2007)). We expect that reputational incentives and the long run value of a seller's current and

[3] A second limiting factor is a legal one. Section 2-305 of the Uniform Commercial Code (UCC) specifies how a party with residual price-setting rights in an open price contract is to exercise this right. (Each state has adopted the UCC in some form into state law.) It requires a seller with price-setting rights to set its prices in "good faith", where "good faith" is defined in UCC 2-103 as "honesty in fact and observance of reasonable commercial standards of fair dealing". As is so often the case, the statute is somewhat vague in its wording and the precise meaning of "reasonable" and "standards" and "fair" is not always agreed upon, but it does suggest a litigation risk if a seller's prices are too far out of the ordinary (e.g. Mathis v. Exxon (2002), Shell v. HRN (2004)).

expected future relationships should be important in governing some notion of fair or consistent short run pricing on the part of the seller, at least in the eyes of the buyer.

A large theoretical literature has emerged examining relational contracts under a variety of situations and assumptions, including in the presence of asymmetric information (Levin (2003), Halac (2012)) and involving disagreements among parties over whether an opportunistic behavior has actually taken place (Li and Matouschek (2013)).[4] One interesting result from the asymmetric information models especially relevant for us is that the more-informed firm may take an action that is not in its short-run best interest if doing so helps avoid reputation-damaging perceptions of price opportunism from the less-informed firms it deals with. In our context, this means it is possible that a seller could potentially set prices inefficiently *low* to its locked-in buyers, even when price opportunistic incentives are present, and even when higher prices would be justified by cost increases, simply because it seeks to prevent less-informed buyers from misinterpreting higher prices as opportunistic behavior, causing reputational damage and the eventual loss of its long run relationships.

So to what extent do sellers engage in short run opportunistic pricing with buyers locked into open price contracts, and to what extent would buyers be naturally accepting of some degree of price opportunism on the part of sellers when entering into these contracts? Or do sellers not engage in opportunistic pricing at all? Given the buyers do not know sellers' costs as well as sellers' do, could sellers actually do the opposite of opportunistic pricing, setting prices especially low exactly when the incentive for opportunistic pricing is the highest? The latter would be a fascinating result if found to be true.

In this article, we explore these questions empirically. We contribute to the incomplete contracts literature and the relational contracts literature, by examining the balance between short-run price opportunistic incentives under an open price contract on one hand, and long-run reputational incentives on the other, using a clean example of a relational element within an otherwise formal contract, and using an empirical identification methodology that (as we will discuss) is unique to the literature.

[4] Other recent models analyzing various aspects of relational contracts include Board (2011), Argyres et al. (2020), Fong and Li (2017), Chassang (2010), Barron and Powell (2019), and Zanarone (2013).

We are looking for very specific contract-induced competitive price effects, so a macro-style cross-industry analysis would not be as helpful. Institutional detail would be lost and the cross-industry aggregation would obscure the effects of interest. So we examine price opportunism in the context of a specific application, one that will allow us to control for institutional detail, and one that will prove to be particularly amenable to a clean identification strategy. We select the wholesale motor fuels industry.

The wholesale fuels industry is characterized by open price contracts between franchisors and franchisees, which surround the purchase of the central industry input – fuel. The gas station dealer (franchisee, or buyer) agrees to purchase all of its fuel needs from the wholesaler (franchisor, or seller) over the life of the contract at prices that are only announced by the seller ex post and changed from time to time as the seller sees fit. There are several ways a seller could price opportunistically, but we are led to one particular manifestation of price opportunism that has been the source of numerous lawsuits on unfair pricing and contract interference. It is also one that is related to a phenomenon of much interest to economists in the gasoline literature - that wholesalers may pass through its cost increases more quickly and its cost decreases more slowly on locked-in buyers. Unlike the previous literature, we are not concerned about whether asymmetric passthrough exists – it is well known that it does. Rather, our interest is in whether any such effects will be substantially more pronounced on a wholesaler's locked-in buyers who are subject to open price contracts than to a wholesaler's unrestricted buyers who are not bound by such contracts. We examine other manifestations of price opportunism as well – as simple as a seller suddenly raising prices on a buyer after signing an open price contract – but the cost passthrough effect will prove to be the most interesting.

While we would expect the wholesale gasoline industry to be reasonably representative of other franchise industries that use open price contracts (and we know that asymmetric cost passthrough is also common across other industries (Peltzman (2000)), we focus on the wholesale gasoline industry because it offers two key methodological advantages.

First, unlike most other franchise industries, the wholesale gasoline industry operates under a dual-sales-channel paradigm, meaning that we can observe two types of buying arrangements at the same time – one in which wholesale fuel is sold under open price contracts, and one in which the physically identical wholesale fuel is sold on the unrestricted market without obligation. This makes it straightforward to compare a seller's pricing practices to its locked-in buyers on one hand and its unrestricted buyers on the other. We do this in our first analysis.

The obvious limitation with this approach is that it is a straight cross-sectional comparison across buyer types, and buyers can self-select into these buyer types. While we do not expect the selection issue to create any meaningful bias in our specific context for several reasons discussed later, we recognize that the treatment (of entering into an open price contract) is not randomly assigned and may be correlated with unobservable buyer characteristics that themselves affect seller pricing. Essentially, it creates a potential omitted variables bias (the omitted variable being the selection process itself) that can impact our cross-buyer comparisons (Clougherty et al. (2016)).

For this reason, we exploit a unique natural experiment in the industry that has the benefit of avoiding these types of issues entirely. With this natural experiment, we can compare sellers' pricing behavior not across different (potentially self-selected) buyer types but within the same buyer type and, in fact, within the exact same buyer and even within the exact same contract, all at the exact same time. Since we have the same locked-in buyer on both sides of these comparisons (at the same time), we are able to perfectly hold all buyer unobservables fixed and our within-buyer comparisons cannot be infected by unobservable buyer characteristics that vary across buyer type.

We defer a detailed explanation of the natural experiment until later, as it requires some institutional background, but to preview, it is based on comparing seller pricing behavior to the same locked-in buyer at the same time under two different degrees of price opportunistic *potential*. The natural experiment surrounds a large and historic shock to the added cost of refining premium grade gasoline in the early 2010s (up and above that of regular grade), which forced sellers to fundamentally rethink how they set premium grade prices in the first place. The shock was large, unanticipated, and unprecedented. Importantly, it was substantially different in nature to the everyday crude-based cost shocks that regularly cause prices to rise and fall and that are familiar to all involved. Unlike everyday crude shocks, the premium shock moved sellers and buyers into largely uncharted territory with little historical precedent to rely on for what to do, and created a blank slate and therefore a unique opportunity for sellers to engage in opportunistic pricing if so desired.

Essentially, we have two fundamentally different types of shocks that correspond to two different levels of "surprise" (or variance) in the realized state of the world, with the premium shock corresponding to a greater "surprise" in the state of the world and thus a greater opportunity for a seller to exercise opportunistic pricing on its locked-in buyers. In our second analysis, we compare these two types of shocks and test whether greater "surprises" lead to greater degrees of opportunistic pricing on the same locked-in buyers, with all buyer unobservables fixed.

We need not ignore unrestricted buyers in this second analysis, however, as they can still be used as an additional layer of control. They are neither locked-in nor subject to opportunistic pricing under either type of shock as they are free to shop around as desired in the competitive market. Thus, our analysis takes the usual form of a natural experiment with two dimensions of control. But rather than the usual treatment/control group dimension and before/after time dimension, our first dimension is the market's level of "surprise" following a cost shock, and the second dimension is the buyer's level of "susceptibility" to that surprise. Such a natural experiment is unique in the literature and represents the second methodological advantage we gain by studying the wholesale gasoline industry.

The results of our two analyses agree. Our prior was that we would either find a high degree of price opportunism (if reputational constraints were weak) or a low degree of price opportunism (if reputational constraints were strong) but what we actually find is a *negative* degree of price opportunism. Not only do sellers in our application *not* price more opportunistically when the opportunity arises, they actually price *less* opportunistically exactly when they have the greatest opportunity to. We think this is an especially interesting result. It is consistent with the relational contracts literature in which reputational effects and the value of long run relationships take center stage, and consistent in particular with asymmetric-information relational models where sellers have to be especially cautious of protecting their reputation against any real or perceived transgressions with current or potential locked-in buyers. Essentially, sellers are providing their locked-in buyers with a form of market price volatility insurance, that is neither written nor required by the open price contract, and that helps insulate them from market price volatility stemming from unusual events. The same insurance is not provided to unrestricted buyers that have no long term commitment with the seller.

Our study thus contributes to the empirical literature on relational contracts by exploring the trade-off between short run opportunism and long run reputational concerns but in a well identified way, something that has been difficult to do in the literature.[5]. Macchiavello and Morjaria (2021) point out that identification is a persistent challenge because 1) relational contracts are difficult to measure in the first place and 2) data is typically thin and most often limited to questionnaires or surveys. It is especially problematic for studies in developing nations where formal contract enforcement is weak and relational contracts are the norm (Gamage and Priyanath (2019), Ajwang (2020), Yang et al. (2020), Zhou et al. (2021), Macchiavello and Morjaria (2021)).[6]

Fortunately, these problems do not arise here. We examine a clear relational element (the open price term) in an otherwise largely formal contract in the United States, with excellent and complete ex-post price data on how that relational aspect was resolved and to whose benefit. We have substantial variation in the degree of opportunistic incentives across buyers and grades, and can isolate the important "unwritten" element of the contract – the price of fuel – using a dual identification methodology that shows how sellers strike a balance between the opportunistic pricing incentive on one hand and reputational concerns on the other, in an unusually clean setting.

Ours is also the first study that we are aware of to look at open price contracts specifically. Given the ubiquitous nature of these contracts in the U.S., it is surprising how little has been done on open price contracts, and we hope that the current study will kickstart new research in this interesting area. In all, we contribute to four existing literatures – incomplete contracts, relational contracts, gasoline pricing and competition, and franchisor-franchisee relationships – plus what we hope will become a new literature on open price contracts.

The remainder of this study is organized as follows. Section 2 begins with the institutional background necessary to frame the identification strategy, and Section 3 describes the data. Section 4 outlines our methodology, and Sections 5 through 8 contain our main empirical results. Section 5 presents the first analysis and tests for price opportunism by comparing sellers' pricing behavior to

[5] Brown et al. (2004) state that the "ideal data set for studying the effects of [relational contracts] is exoegenous ceteris paribus in the degree of third party enforceability. The problem is, however, that is seems almost impossible to find or generate field data that approximates this ideal data set." We argue that we have this data set. In our context, competitive spot markets for unbranded fuel enforce day-by-day competitive pricing for unrestricted buyers. No such spot market exists for branded fuel sold under open price contracts, only reputational consequences.

[6] The nature of the relational contract is that it is not written, so researchers often turn to questionnaires and surveys.

different buyer types. Section 6 presents the second analysis and tests for greater price opportunism following shocks corresponding to greater degrees of "surprise" in the state of the world. Section 7 takes an alternative approach and analyzes the potential for opportunistic pricing using dynamic and non-parametric methods. Section 8 is an ancillary analysis motivated by our main findings and investigates how the differential effects we find upstream impact competition downstream. Section 9 concludes.

2 Contracts, Branding, and Wholesale Pricing

Our study is about open price contracts and not about wholesale fuels per se, but it is necessary to review the structure of the wholesale fuels supply chain to frame the analyses.

Wholesale gasoline is generally sold by a seller (the refiner) to a buyer (the retailer) either directly or through a middleman. Sales are divided into two channels, "branded gasoline" and "unbranded gasoline". Branded gasoline is defined as gasoline sold at a station that carries a major refiner brand name and unbranded gasoline is defined as gasoline sold at a station that does not. Examples of stations selling branded gasoline are Shell, Chevron, and ExxonMobil branded stations, and examples of stations selling unbranded gasoline include Costco, Quiktrip, and Love's.

There is little relationship today between the name on a retail gasoline station and the refiner that actually refines the gasoline sold there.[7] Gasoline produced by the various refineries are mixed together in common pipelines and transported to common storage tanks before reaching their final destinations. Spot market contracts among refiners dictate how much each refiner owns and is able to sell to its branded or unbranded buyers in each city. There is also little relationship between the name on a branded retail gasoline station and the company that actually operates the station. Branded stations are rarely operated by refiners in the U.S. anymore, and the refiner's brand name is simply leased as part of the supply relationship.[8]

While thirty years ago it could be argued that branded stations were of a higher quality than unbranded stations, this is a more difficult argument to make today. Some of the largest and most

[7] Contrast this to a Ford new car dealership that sells new Ford cars made by Ford.

[8] It was common for refiners to own and operate retail stations under their own brand name prior to the 2000s, after which almost all major refiners divested their retail assets.

successful chains are unbranded chains, which include supermarket-affiliated chains (e.g. Safeway, H.E.B., Stop and Shop), hypermarket-affiliated chains (e.g. Costco, Murphy's (Wal-Mart), Sam's Club), convenience store chains (e.g. Stripes, 7-Eleven, Circle K), and travel centers (e.g. Flying J, Love's, Petro). And whether branded or unbranded, the physical gasoline sold at each station is, for all intents and purposes, the same.[9]

The primary distinction between branded and unbranded gasoline is a contractual one. Branded gasoline is sold under a long term supply contract between the seller (the refiner) and the buyer (the retailer) that contains an open price term. It is best suited to buyers that are capital constrained and cannot make the costly investments to build brand recognition of their own. The contract comes with the right to use the refiner's name, and the refiner generally pays the up-front cost to rebrand and renovate the station. As the cost of renovating a station can reach several hundred thousand dollars and the cost of building brand recognition even greater, the open price contract is the only sensible option for many buyers. In return, the buyer pays an upcharge for branded gasoline over unbranded gasoline and agrees to purchase all of its wholesale fuel needs from the seller for the length of the contract, generally five to fifteen years. The open price term virtually always gives the seller the authority to set wholesale prices and change them as desired over time.

Unbranded gasoline, in contrast, is most often sold in the unrestricted market without an open price contract. Unbranded buyers are generally free to price-shop and buy from any seller on any given day, switching between sellers as desired.[10] Unbranded buyers are responsible for their own branding and renovations, and cannot display or advertise the name of the refiner that supplies them. But the fuel is the same. This channel is best suited to buyers that are not capital constrained, have made the necessary investments to build their own brand recognition, and do not need to pay extra for a fuel that comes with benefits (e.g. financing, branding) that they do not need.

The different contractual arrangements does affect a seller's short run incentives ex post, how-

[9]Some refiners promote an additive package in conjunction with branded sales (e.g V-Power, Techron), but the reality is that the additive package used in conjunction with unbranded sales is functionally similar and often identical, only absent the advertising. All refiners must add a government-mandated blend of additives (i.e. detergents) to sales of all gasoline.

[10]Some unbranded buyers enter into supply contracts as well, but these are most often based on agreed-upon formulas (pegged off crude oil prices or another measure of upstream prices) and are not open price contracts with prices at the discretion of the seller.

ever. In the branded case, an increase in a seller's wholesale prices has potential retail consequences but no wholesale consequences, since its wholesale buyers are locked-in by contract and must buy even at the higher price. A seller's loss of wholesale sales is thus limited to the loss in retail sales by its locked-in buyers. In the unbranded case, however, an increase in the seller's wholesale prices has both retail consequences and wholesale consequences. A seller's loss of wholesale sales includes both the retail losses of its buyers who choose to remain its buyers, and a complete loss of wholesale sales for any buyers who switch to a different seller. As a result, we would expect more potential for short-run price opportunism in the former case, i.e. on locked-in buyers, because the seller's short-run losses are smaller for a given price increase. Whether we see price opportunism in practice however will depend on how the seller balances this incentive with its long run reputational concerns. If there is an "unwritten code of conduct" under which buyers expect sellers to not engage in opportunistic pricing even when the opportunity presents itself, we may observe little or no opportunistic pricing at all. If buyers are less than perfectly informed about sellers' costs (as we expect) and react to even perceived instances of price opportunism, we may observe sellers pricing especially carefully on its locked-in buyers.

3 Data

We will be examining the rate at which cost shocks are passed through to wholesale prices and, in an ancillary analysis, how those wholesale prices are passed through to retail prices. Our analysis utilizes pricing data consisting of daily-frequency prices at three different exchange points along the vertical supply chain for gasoline. The first set of prices are "spot prices" which are charged by sellers to buyers of bulk quantities of gasoline, often jobbers or other refiners, at one of the seven major refinery hubs in the United States.[11] They are commonly used as a measure of sellers' opportunity costs, since when sellers ship fuel to individual cities and sell to individual gas stations directly, they forego the opportunity to sell that fuel in bulk to other refiners and other large buyers, at the spot price, at the refinery hub. They are also actual costs in many cases - when a seller is short on supply to meet its contractual obligations, it can buy at spot, and when it has

[11] They are the Pacific Northwest, San Francisco, Los Angeles, Group 3 (Tulsa, Oklahoma), Chicago, Gulf Coast and New York Harbor.

a surplus, it can sell. We follow the gasoline literature and use spot prices to represent sellers' costs of producing wholesale gasoline. The spot market is the earliest point in the physical supply chain for which there are separate regular and premium grade products, though there is not yet a distinction between branded and unbranded gasoline.

The second set of prices are "rack prices" which are sellers' output prices for wholesale gasoline, i.e. the prices charged to most individual wholesale buyers (retailers), before discounts or other adjustments. Rack prices include a spot price component, transportation costs to city terminals (but not delivery to retail stations), the costs of additional contract considerations (in the case of branded gasoline), and seller margins. There are separate rack prices for regular and premium grade gasoline and it is the earliest point along the chain for which there are separate prices for branded and unbranded gasoline as well. The former is sold under open price contracts and the latter is most often not.

The third set of prices are the familiar "retail prices" charged by wholesale buyers to consumers for a gallon of gasoline. We have separate retail prices for branded and unbranded stations, and for regular and premium grade gasoline.

All three price series are collected from the Oil Price Information Service (OPIS) for the Northwestern United States from January 1, 2011 to December 31, 2015, a period of 1826 days. The relevant spot price for the region is the Pacific Northwest spot price, and we have average rack and retail prices for three major cities within the region - Seattle, Washington; Portland, Oregon; and Eugene, Oregon. Summary statistics are shown in Table 1.

4 Methodological Outline

We identify several potential manifestations of price opportunism by sellers on their locked-in buyers, from the most obvious to more subtle ones that have generated a lot of discussion in legal and economic circles. We note up front that the fact that branded gasoline sells for a premium is not an example of incomplete contracting or price opportunism. The premium, which includes the license to use the seller's brand name and other supply considerations, is well known by the parties at the time of signing.

The most obvious manifestation of price opportunism would be if a seller were to suddenly increase prices and margins to locked-in buyers shortly after signing, absent any cost or demand shock and absent any similar increase on other buyers. We can rule this out simply by construction of open price contracts in the industry. The wholesale price paid by a seller's branded rack buyers is based on the seller's branded rack price, which is a publicly posted price and the same for all its branded contractees, less a set of discounts that are specific to the buyer. Importantly, the branded rack price is common knowledge to all current and potential buyers and does not depend on when a buyer signed a contract. The discounts on the other hand do vary across buyers but they are also written into the contract, and known in advance. Thus they are not examples of incomplete contracting. The key result of this pricing structure is that when posted branded rack prices rise and fall, buyers' final prices necessarily rise and fall in a similar way, for all branded buyers buying at rack from the same seller. Final prices may differ due to different negotiated discounts, but cannot systematically diverge in unexpected ways for one branded buyer immediately after signing versus another buyer many years after signing.

The manifestation that receives the bulk of attention from economists and industry is if a seller were to quietly apply a less favorable set of short run pricing dynamics to its locked-in buyers than its unrestricted buyers. The argument is that a seller could stealthily extract additional surplus from its locked-in buyers by pushing through cost changes, cost increases in particular, more quickly onto these locked-in buyers. This would increase profits even if the difference in steady state margins across the buyer types (as seen and as expected by buyers) remained constant. Such a manifestation would be difficult for buyers to detect and for courts to verify, and carries with it a degree of plausible deniability. After all, rack price increases of a certain magnitude are presumptively justified by cost increases of a similar magnitude. The question of whether there were subtle differences in short-run pricing dynamics from one buyer type to the other, in the midst of these transitions, can easily be lost. Detection requires a comprehensive, industry-wide price dynamics analysis, which is often beyond the ability of individual buyers, but is our comparative advantage here.

We test for this using two distinct identification methodologies. The first is to simply and directly test if sellers pass through cost changes into wholesale prices more aggressively for locked-in buyers than unrestricted buyers. We calculate spot-to-rack cost passthrough rates for each pre-determined buyer type, for regular grade gasoline, and estimate cost passthrough rates with a series of vector autoregressive error-correction models (VAR-ECM) in the spirit of Engle and Granger (1987). We estimate:

$$\Delta p_{it} = \sum_{j=0}^{s} \beta_j \Delta c_{i,t-j} + \sum_{j=1}^{r} \gamma_j \Delta p_{i,t-j} + \theta z_{i,t-1} + \varepsilon_{it} \tag{1}$$

where p denotes the downstream price, c denotes the upstream price, and s and r are lag lengths determined by the Bayesian Information Criterion. The ε is an independent and normally distributed error term, and we cluster standard errors at the city-level. The z_{it} represents the current deviation from the long run equilibrium, or error correction term, and is given by:

$$z_{it} = p_{i,t-1} - \alpha_0 - \alpha_1 c_{i,t-1} - X_{it}\Phi \tag{2}$$

where the X_{it} contain a set of city-specific indicator variables to control for cross-city differences. We estimate the model separately for locked-in and unrestricted buyers to allow all coefficients to be freely estimated. Note that since spot prices and rack prices are uniform across individual buyers within a buyer type within a given city, there is no variation in either the left or right hand side variables that could be dependent on unobserved buyer characteristics, conditional on type.

The raw regression results in VAR-ECM models can be difficult to interpret, so we follow the standard practice in the literature and report the impulse response functions generated from these models.[12] The impulse response functions (IRFs) are the t-period cumulative response in downstream prices to a one-unit permanent change in the upstream price at time $t = 0$:

$$IRF_{it} = \widehat{p_{it}} - \widehat{p_{i,t-1}} + IRF_{i,t-1} \tag{3}$$

or

[12] Regression output is available in the online appendix provided to this journal or from the authors upon request.

$$
\begin{aligned}
IRF_{it} &= \widehat{\beta}_t + \sum_{j=1}^{t} \widehat{\gamma}_j (IRF_{i,t-j} - IRF_{i,t-j-1}) \\
&\quad + \theta(IRF_{i,t-1} - \widehat{\alpha_1}) + IRF_{i,t-1} \qquad (4)
\end{aligned}
$$

for $t \geq 1$, where $IRF_{i,0} = 0$.

While the above analysis is based on a symmetric VAR-ECM model, we recognize that price opportunism may manifest itself in a more asymmetric form. Sellers may pass costs through to their locked-in branded buyers especially quickly only when the cost change is an increase, and especially slowly when it is a decrease, compared to its unrestricted unbranded buyers. If so, the symmetric model may be masking price opportunism by averaging a high passthrough rate on cost increases with a low passthrough rate on cost decreases for locked-in branded buyers. To test this, we estimate an asymmetric version of Equations 1 and 2 given by:

$$
\begin{aligned}
\Delta p_{it} &= \sum_{j=0}^{s} \beta_j^+ \Delta c_{i,t-j}^+ + \sum_{j=0}^{s} \beta_j^- \Delta c_{i,t-j}^- + \sum_{j=1}^{r} \gamma_j^+ \Delta p_{i,t-j}^+ + \sum_{j=1}^{r} \gamma_j^- \Delta p_{i,t-j}^- \\
&\quad + \theta^+ z_{i,t-1}^+ + \theta^- z_{i,t-1}^- + \varepsilon_{it} \qquad (5)
\end{aligned}
$$

where

$$
z_{it} = p_{i,t-1} - \alpha_0 - \alpha_1 c_{i,t-1} - X_{it}\Phi \qquad (6)
$$

and where $z_{it}^+ = \max(0, z_{it})$ and $z_{it}^- = \min(z_{it}, 0)$. The Δc_{it}^+, Δc_{it}^-, Δp_{it}^+, and Δp_{it}^- are all similarly defined and X is the same as before.

This methodology is related to the "speed of passthrough" and "rockets and feathers" phenomenon that has garnered much attention in the gasoline literature. It is well known that cost increases for regular grade gasoline tend to be passed though to output prices with a lag (Lewis and Noel (2011), Marion and Muehlegger (2011), Knittel et al. (2017), Blair et al. (2017), Ahundjanov and Noel (2019)) and that regular grade gasoline cost increases are sometimes passed through more quickly than cost decreases (Borenstein et al. (1997), Bachmeier and Griffin (2003), Deltas (2008), Noel (2009), Lewis (2011)). The relevant question here is not whether rockets and feathers is present in our setting, which would not be unusual, but whether any rockets and feathers effect is stronger on locked-in branded buyers.

We interpret especially fast and aggressive passthrough of a seller's cost shocks, increases in particular, on its locked-in branded buyers vis-a-vis unrestricted unbranded buyers as an example of price opportunism. We interpret equal passthrough rates as evidence that long run reputational effects fully offset short run opportunistic effects. If we were to find especially slow and cautious passthrough of a seller's cost shocks on its locked-in branded buyers vis-a-vis unrestricted unbranded buyers, we would interpret this as the opposite of price opportunism – an example of a market volatility insurance policy offered by sellers to their locked-in buyers and not to its unrestricted buyers. This would essentially be an unwritten insurance policy provided by sellers to only their locked-in buyers to shield them from excessive market price fluctuations. Such a result would be consistent with relationship building incentives as noted in the relational contracts literature.

Since these are simple cross-buyer comparisons, we recognize the potential for a self-selection bias. We do not expect that self-selection is likely to be an issue in our context because the branded vis-a-vis unbranded choice turns out to be largely pre-determined based on the characteristics of the buyer. A (branded) open price contract is often the only feasible choice for constrained buyers who are unable or unwilling to finance the construction of their own stations, invest in multiple stations, and/or build up its own brand reputation over time. A modern gasoline station today can take up to two years to build and cost over two million dollars (including an attached convenience store), before considering the time and effort put into building brand awareness. Unlike decades past when stations were small and "mom and pop" stations were more feasible, successful stations in large cities today need to be large, modern, clean, and generally carry a well-recognized brand. For constrained buyers, this can only be accomplished through the branded channel, which makes an open price contract their only feasible choice. In fact, many branded buyers not only lease the brand name but also the physical station itself from the supplier. For buyer-owned stations, suppliers often provide funds for reimaging the station with its own name and other ongoing improvements, all of which contributes to a higher price on branded gasoline over unbranded gasoline.

In contrast, the unbranded channel is often the only efficient or sensible choice for less constrained buyers. Whereas refiner brand names were once critical to a station's reputation, today some of the most successful gasoline operators use non-refiner brands at the pump. A buyer with sufficient capital to build its own modern stations who has invested in its own brand reputation (e.g. QuikTrip or Loves) has little need for brand or financial support from the supplier and little interest in paying more for branded fuel to get it. The unbranded channel is the obvious choice for these buyers.

The pre-determined nature of contract choice is evident in the data. The data contains prices for 761 stations, of which 416 are branded and 355 are unbranded (consistent with a roughly 50-50 split nationally). About half of the branded contracts in effect would have come up for renewal during our sample period yet we find that stations rarely switch between branded and unbranded status. Less than one percent of stations in our sample made such a switch, suggesting that contract choice is largely pre-determined and not endogeneous by selection.

A related concern that still applies when buyer type choice is predetermined is that those who buy branded fuel (with an open price contract) and those who buy unbranded fuel (without an open price contract) may be fundamentally different in some way, having nothing to do with contract choice, but that also affects seller pricing. If so, we may incorrectly attribute differences in seller pricing from these other reasons to price opportunism arising from the contract.

The most obvious difference between the two buyer types aside from the contract under which they operate is that one sells branded fuel and the other sells unbranded fuel, and these are sold to different types of consumers. It is well known that end-consumers of branded fuel are more inelastic, which matters for seller pricing. To be clear upfront, our analysis never compares price levels directly, so the fact that branded and unbranded fuel sells at different prices is not an example of price opportunism and does not play a role in the analysis. We focus on short run pricing dynamics – the speed of passthrough of cost shocks in particular – and our identifying assumption is that passthrough rates would be the same for both locked-in buyers and unrestricted buyers absent the open price contract. The concern then is that if sellers pass cost increases through to locked-in buyers more quickly than to unrestricted buyers simply because the locked-in buyers serve more inelastic (branded) consumers, independent of contract, we may incorrectly attribute that difference to price opportunism by the seller on its locked-in buyer when it is simple elasticity-based price discrimination.

Fortunately, it is easy to rule out this concern simply because our results go the opposite way of the bias it suggests. To preview, we will find *slower* passthrough of cost increases on locked-in buyers overall, i.e. a *negative* degree of price opportunism. This is inconsistent with the suggested bias which would work towards faster and not slower passthrough of cost increases on locked-in buyers. Thus, if there were a bias working against our estimated negative relationship, our coefficients would simply be understated (biased towards zero) and our conclusions even stronger.

Another related concern is that unbranded buyers today tend to be larger on average than branded buyers in the United States, which could lead sellers to price less opportunistically on unbranded buyers (for fear of losing the large business they bring). But our finding of a negative degree of price opportunism on locked-in branded buyers, i.e. especially conservative pricing on locked-in buyers, again goes in the opposite direction of such a bias.

There is another way to alleviate these types of selection and endogeneity concerns altogether. The concerns above all stem from the fact that our comparisons are simple cross-sectional comparisons across different types of buyers. It is well known that cross-sectional comparisons are prone to omitted variables biases. We can sidestep these issues altogether with our second methodology, which is based on a unique natural experiment in the literature.

In this second methodology, we exploit a natural experiment that relies on comparing sellers' price responses to two different kinds of exogenous cost shocks which correspond to two different degrees of surprise in the state of the world. In the analysis, we can hold the buyer type, and even the buyer itself, fixed in the analysis. We can even hold the time fixed as the two types of shocks we study are happening essentially simultaneously. By holding the buyer fixed and all buyer unobservables fixed, and making comparisons within the same locked-in buyer at the same time but for two very different and random shocks, the above concerns about self-selection and omitted variables bias are rendered moot.

As background, the natural experiment surrounds a large, unanticipated, and unprecedented shock to the cost of producing higher octane grades of gasoline, such as premium grade gasoline, in the early 2010s. The shock was the result of a historic increase in the price of octane enhancers, which are chemicals added to gasoline to make higher octane blends such as premium grade gasoline. The cost of octane enhancers are the primary source of the price difference between regular grade and higher octane grades.[13] Importantly, the historic shock occurred concurrently with, and on top of, the usual and everyday shocks that buyers and sellers are normally accustomed to, which regularly move gasoline prices around.

The octane cost shock was unusual not just because of its size, but also because it forced a fundamental reevaluation by sellers about how to set premium grade gasoline prices in the first place. Premium grade gasoline was historically priced fundamentally differently from regular grade gasoline. While regular grade rack prices were set freely by each seller each day according to the usual ups and downs of crude prices and other factors, the short-cut used by sellers was to set premium grade gasoline rack prices according to an internal formula. Premium grade rack prices were derived as the sum of the regular grade rack price and a fixed per-gallon premium-regular rack price differential. The differential varied by seller, but was often in the neighborhood of fifteen cents per gallon, and importantly was time-invariant. It had been essentially unchanged for many years. The differential was not written into the contract and not enforceable, but was easily seen by comparing posted premium and regular grade rack prices over time. The time-invariance property made price-setting administratively simpler for sellers and did not cause problems because the cost differential between premium and regular grade gasolines had been relatively stable anyway. But this all changed in the early 2010s when the cost of high octane blendstocks began to soar to record levels.

The shock to the cost of producing premium grade gasoline relative to regular grade gasoline is the quintessential kind of shock to the realized state of the world imagined in the incomplete contracts literature – it was large, unanticipated, and unprecedented. There was little precedent for how high sellers would increase premium rack prices when their long-used algorithm no longer worked, and the surprise in the state of the world was high. This is in contrast to the more "usual"

[13] Several factors led to the increase in high octane blendstocks. Cheap methyl tertiary-butyl ether (MTBE) was banned in 2006 after being detected in groundwater, and ethanol, which has a high octane rating and partly replaced MTBE, largely stalled at a 10% mixture. The recent U.S. boom in crude oil production largely produces crude that is higher in paraffins which depresses octane levels and requires additional enhancer volumes. Stricter environmental regulations to remove sulphur from gasoline also remove some of the octane in the production process. Refiners were forced into increasingly more expensive sources of octane to compensate.

type of cost shocks that sellers and buyers face everyday, stemming from the ups and downs of crude oil prices and inventory levels (that determine regular grade rack prices and the regular grade component of premium grade rack prices), which led to states of the world seen many times before.

This sets up our natural experiment. We have two different kinds of shocks corresponding to two different degrees of "surprise", to the same locked-in buyer from the same seller at the same time. The greater surprise corresponds to the unprecedented shock in the production cost *differential* between premium and regular grade gasoline, due to octane enhancers. The lesser surprise corresponds to the everyday shocks in the production cost of regular grade gasoline and the non-differential component of premium grade gasoline, generally due to crude oil price changes. If short run incentives dominate, one might expect sellers to exercise a greater degree of opportunistic pricing on their locked-in buyers exactly when the "surprise" in the realized state of the world is greater, holding the seller, the buyer, and their observed and unobserved characteristics fixed. If relational contracts are important, one might not. In contrast, there should be no difference in seller pricing on unrestricted buyers regardless of the type of shock, since these buyers are not locked-in at any time and free to shop. Unrestricted buyers thus serve as an additional layer of control.

We thus extend the data to premium grade gasoline and estimate Equations 1-6 using premium-regular cost *differentials* in addition to regular grade costs alone, for each buyer type. That is, we estimate the passthrough rate of sellers' premium-regular cost differential (as given by the spot price differential) into the premium-regular rack price differential faced by each buyer type. We already estimated the passthrough rate of sellers' regular grade gasoline cost (as given by the regular grade spot price) into the regular grade rack price for each buyer type. We can now calculate the difference in the two passthough rates for locked-in buyers, the treatment group, and for unrestricted buyers, the control group, and compare the difference in differences between the two. We are interested in the average treatment effect on the treated, i.e. the extent to which sellers price opportunistically on their actual locked-in buyers, and this is what we estimate directly.

Before turning to the main results, we perform a series of preliminary diagnostic tests to check if our data is well-behaved. We test for unit roots in each time series and for possible cointegration between each successive pair of upstream and downstream prices. Since time series that contain unit roots act as random walks, regressing one series on the other can lead to spurious regressions if unit roots are present but the two series are not cointegrated. We adopt the Levin-Lin-Chu (LLC) unit root test for panel data developed by Levin et al. (2002), and perform the following regression:

$$\Delta y_{it} = \phi y_{i,t-1} + z_{it}'\gamma_i + \sum_{j=1}^{P} \theta_{ij} \Delta y_{i,t-j} + u_{it} \tag{7}$$

for a variable y, where i denotes the panel and t denotes the time, $i = 1..N$, $t = 1..T$. The z_{it} contains the panel-specific mean and a linear time trend, and the number of lags P is chosen by the Bayesian Information Criterion (BIC).[14] The null hypothesis is that the panels contain a unit root, $\phi = 0$. Since the traditional t-statistic on ϕ would be biased if the null hypothesis were true, we calculate bias-adjusted t-statistics as described by Levin et al. (2002).

We report the bias-adjusted t-statistics for regular grade unit root tests in the top part of Table 2. Not surprisingly, we cannot reject unit roots in any price series expressed in levels (columns (1) through (3)), but do reject unit roots in each of the first differences (columns (4) through (6)). We report results for premium grade gasoline prices in the middle part of Table 2 and for premium-regular price differentials in the bottom part. We cannot reject unit roots in any premium grade price series (spot, rack, and retail) and in some of the premium-regular price differentials, but we do reject unit roots in the first differences in every case. We conclude that all series are I(1) stationary.

We also test for the cointegration of each pair of upstream and downstream variables using four sets of statistics as proposed by Westerlund (2007). The two group-mean statistics test the null hypothesis of no cointegration against the alternative hypothesis that cointegration is present for at least one panel i. The two panel statistics test the null of no cointegration against the alternative of cointegration in the panels as a whole. To construct the statistics, we regress:

$$\begin{aligned} \Delta y_{it} &= \delta_i' d_t + \alpha_i (y_{i,t-1} - \beta_i' x_{i,t-1}) \\ &\quad + \sum_{j=1}^{p_i} \alpha_{ij} \Delta y_{i,t-j} + \left[\sum_{j=-q_i}^{p_i} \gamma_{ij} \Delta x_{i,t-j} + e_{it} \right] \end{aligned} \tag{8}$$

[14] The median number of lags across the various time series is eight.

where y is our downstream variable and x is our upstream variable. The p_i and q_i are the number of lags and leads within a panel respectively. The d_t is a deterministic term that contains a constant and a trend. The group-mean statistics are given by:

$$G_\alpha = \frac{1}{N}\sum_{i=1}^{N}\frac{\widehat{\alpha}_i}{SE(\widehat{\alpha}_i)} \text{ and } G_\tau = \frac{1}{N}\sum_{i=1}^{N}\frac{T\widehat{\alpha}_i}{(\widehat{\alpha_i(1)})} \tag{9}$$

where SE denotes the usual standard error, and $\widehat{\alpha_i(1)}$ is the estimate of the term given in square brackets in Equation 8 including the residual. The panel statistics are given by:

$$P_\alpha = \frac{\widehat{\alpha}}{SE(\widehat{\alpha})} \text{ and } P_\tau = T\widehat{\alpha} \tag{10}$$

where

$$\widehat{\alpha} = \left(\sum_{i=1}^{N}\sum_{t=2}^{T}\widetilde{y}_{i,t-1}^2\right)^{-1}\sum_{i=1}^{N}\sum_{t=2}^{T}\frac{1}{\widehat{\alpha_i(1)}}\widetilde{y}_{i,t-1}\Delta\widetilde{y}_{it} \tag{11}$$

and $SE(\widehat{\alpha})$ is its standard error.

We calculate all four statistics for each transmission link in the vertical chain for regular grade gasoline and report the results in the top part of Table 3. We report results for premium grade gasoline in the middle part of the table and the premium-regular price differentials in the bottom part of the table. Columns (1) and (2) report the group-mean statistics for the spot-to-rack and rack-to-retail transmission links respectively. Columns (3) and (4) report the panel statistics for the spot-to-rack and rack-to-retail transmission links respectively. There are two statistics in each cell corresponding to either G_α and G_τ in the first two columns or P_α and P_τ in the last two. We find that all four statistics reject the null hypothesis of no cointegration at the 1% level in every case except one, and at the 5% level in that one. We conclude that each series is cointegrated, the data is well-behaved, and proceed.

5 Passthrough of Regular Grade Gasoline

We begin our main analysis by estimating the spot-price-to-rack price passthrough rate for regular grade gasoline, for a seller's locked-in branded buyers on one hand and for its unrestricted unbranded buyers on the other. We might expect sellers to pass through cost changes, increases in particular, more quickly on its locked-in branded buyers than unrestricted unbranded ones, unless reputational incentives are sufficiently strong. We report impulse response functions for the regular grade spot-to-rack transmission link in Figure 1, with separate plots for branded and unbranded buyers.

Turning to our first main result, the figure shows a markedly different passthrough rate for branded regular grade gasoline than for unbranded regular grade gasoline, and not in the direction one would expect if sellers were acting in a short run opportunistic way. Under the opportunistic pricing hypothesis, one would expect faster and more aggressive passthrough on locked-in branded buyers than on unrestricted unbranded buyers. But we find the opposite – slower and more cautious cost passthrough of regular grade cost shocks on locked-in buyers. The passthrough rate on branded regular grade gasoline reaches only 40% after the few first days, rising to about 80% after two and a half weeks. In contrast, the passthrough rate on unbranded regular grade gasoline reaches about 80% in the first few days and always remains above that of its branded counterpart. The maximum difference in rates is large, at 46 percentage points. This is an interesting result that recurs over and over again. Sellers are making price adjustments in a more cautious way on their locked-in branded buyers, inconsistent with opportunistic pricing and consistent with the alternative hypothesis that long run reputational considerations, and the value of their long run relationships, matter most. They smooth out short run cost fluctuations and provide a price volatility buffer on behalf of their locked-in branded buyers, a kind of insurance policy for locked-in buyers that comes with the open price contract but is not written into the contract or required by it. We interpret this as a relationship building effort which can increase the seller's attractiveness in the long run contracts market. The findings are consistent with lessons of the relational contracts literature and the asymmetric information models within that literature in particular (Levin (2003), Li and Matouschek (2013)). When buyers are less informed about sellers' costs, sellers have an incentive to act especially conservatively when the incentive for price opportunism is highest, even setting prices inefficiently low after cost increases to avoid the perception by their locked-in buyers of price opportunism.

We note that the results cannot be driven by the usual omitted variables concerns discussed earlier. Under the usual omitted variables hypothesis, systematic differences in the price elasticities of end-consumers that patronize branded gasoline stations vis-a-vis those that patronize unbranded stations can lead to different passthrough rates having nothing to do with contract type. As is well known, branded stations historically focused more on non-price factors, charge a slightly higher price for the same physical gasoline, and cater to a more inelastic group of end-consumers. But this higher inelasticity would imply a smaller demand response to branded price increases, a greater gain to opportunistic pricing, and a faster rate of cost passthrough by sellers on their locked-in branded consumers. We find exactly the opposite. We find that wholesale passthrough rates are slower and not faster, on branded gasoline vis-a-vis unbranded gasoline, meaning that the usual bias goes in the opposite direction of our results, and our conclusions are only stronger as a result.

Turning to the other results from the figure, we see that cost passthrough is still largely complete after 30 days for both types of buyers. The 30-day passthrough rate is 91% and 95% for branded locked-in buyers and unrestricted unbranded buyers respectively. This is in line with typical rates of passthrough estimated in the literature, noting that the literature does not distinguish by contract type as we do here.[15] The confidence intervals are also very tight, given our regional focus and separation of IRFs by contract type, and adds additional confidence to the result.

We present the asymmetric passthrough analysis in Figures 2 and 3. Figure 2 shows sellers' passthrough rates in response to cost increases and cost decreases for locked-in branded buyers, and Figure 3 shows the same for unrestricted unbranded buyers. We find little in the way of rockets and feathers at the spot-to-rack level in general. Figure 2 shows a slight rockets and feathers effect on branded gasoline in the first few days, which then actually reverses to a slight balloons and rocks effect after the tenth day. Figure 3 shows a similar and slight rockets and feathers effect on unbranded gasoline in the first few days, and then becomes statistically symmetric after the tenth

[15] An exception is Chesnes (2016), which estimates passthrough rates separately for branded and unbranded regular grade gasoline, in search of asymmetry. The author estimates the spot-to-branded-rack passthrough rate and plots an IRF (Figure 2 in that article) that is similar to our corresponding figure here. The author does not present the corresponding plot for the spot-to-unbranded-rack passthrough, however.

day. In short, the symmetric model presented earlier does not mask any opportunistic pricing behavior on the part of sellers, and all our conclusions carry through.

The reversal of branded gasoline to a balloons and rocks effect, even though small, is interesting in its own right. It means that sellers are actually passing through cost increases *less* quickly than cost decreases to its locked-in branded buyers after the tenth day, even if just by a slight amount. This especially favorable treatment of locked-in buyers is inconsistent with the hypothesis of opportunistic pricing, and in line with the lessons from the relational contracts literature.

We can also compare passthrough rates across the two figures. We compare the passthrough rates of cost increases on locked-in branded buyers versus unrestricted unbranded buyers on one hand and, separately, the passthrough rates of cost decreases between the two types of buyers on the other. Whether in reference to cost increases or cost decreases, we find that passthrough rates to locked-in branded buyers are always significantly lower than to unrestricted unbranded buyers. The market volatility insurance provided by the seller to its locked-in branded buyers, which we first saw in Figure 1, carries over to our asymmetric analysis.

6 Passthrough of Premium-Regular Differentials

We now turn to our natural experiment and estimate spot-to-rack passthrough rates of premium-regular grade cost differentials, in addition to spot-to-rack rates of regular grade costs. The types of endogeneity concerns that previously applied to our cross-sectional comparisons across buyer types no longer apply in this within-buyer analysis, given that all buyer unobservables are held fixed.

The shock to sellers' premium-regular production cost differentials resulted in a realization of the state of the world that was especially surprising given past history, while shocks to regular grade gasoline production costs resulted in states of the world that had been seen many times before. We test whether sellers priced more aggressively following the cost differential increase than for more typical regular grade cost shocks, on their locked-in branded buyers in particular. Unrestricted buyers serve as an additional control for the latent difference in these responses that would have occurred in the absence of open price contracts.

The shock to the premium-regular cost differential is the kind of unforeseen event imagined in the incomplete contracts literature. It was large - spot price differentials averaged 14.0 cents per gallon in 2011 and rose, in a bumpy way, to 27.4 cents per gallon in 2015. It was unanticipated - roughly two-thirds of the contracts (assuming a term of ten years) were signed prior to the unexpected run-up in the spot price differential and were still in force during our data period. And it was largely unprecedented - premium-regular cost differentials had not changed in any meaningful way for years. The shock pushed sellers and buyers into uncharted territory and, in contrast to regular grade gasoline cost shocks, there was not a long and established history for how sellers would respond.

This squares our analysis into the shape of a traditional natural experiment with two dimensions of treatment - the first being the unprecedentedness of the shock (the treatment "surprise") and the second being buyer type (with locked-in buyers being the more susceptible treatment group). Under the opportunistic pricing hypothesis, we would expect faster passthrough of premium-regular cost differential shocks than that of regular grade gasoline cost shocks for locked-in branded buyers, and that the difference would be greater than the corresponding difference for unrestricted unbranded buyers. For the relational contracts hypothesis, we would expect slower passthrough of premium-regular cost differential shocks vis-a-vis regular grade cost shocks for locked-in branded buyers, and that the difference between the two passthrough rates would be greater (in absolute value) than the corresponding difference for unrestricted unbranded buyers.

We report impulse response functions for the passthrough of premium-regular spot price differentials into premium-regular rack differentials in Figure 4. There are separate plots for branded and unbranded gasoline. We begin with locked-in branded buyers. The most striking result is that the passthrough rate on these buyers is extremely low and close to *zero*. In spite of a spot differential increase of 13.4 cents per gallon from 2011 to 2015 (a 96% increase), sellers chose to *not* pass that cost increase through to its locked-in branded buyers almost at all, even though these buyers would be contractually obligated to buy at the higher prices if they did. The passthrough rate on the differential reaches only 4% after 30 days, in sharp contrast to the 91% passthrough rate we found on regular grade gasoline cost shocks on these buyers back in Figure 1. This is just $1/23rd$ as much, or a difference of 87 percentage points (from 4% to 91% on a scale from 0% to 100%). Exactly when the surprise was the greatest and exactly where we expect the highest potential for short run price opportunism by sellers, we find sellers are passing through cost increases in the most restrained and buyer-friendly fashion. It is a striking result – passthrough to locked-in buyers is almost complete for common crude-based cost shocks, but almost entirely non-existent for the unprecedented octane-based cost shock.

To check the result, we contrast the experience of locked-in branded buyers to our benchmark case of unrestricted unbranded buyers. The latter group is useful because it allows us to control for any additional delay by sellers, specifically following the cost differential shock, that was common across all buyers. Given that the shock was largely unprecedented, it is possible that sellers needed a little more time to decide how to proceed, for example. The relevant question for us is – once sellers did begin passing the cost differential increase through to rack differentials, did they do it more quickly on locked-in branded buyers than on unrestricted ones?

We calculate the difference in the two passthrough rates for unrestricted unbranded buyers and compare it to the large twenty-three-fold decrease in passthrough rates we found for locked-in branded buyers. In short, we do not see the same large decrease. Figure 4 shows that the passthrough rate on spot differentials into unbranded rack prices rises quickly to 40% after a few days, reaching 71% after 30 days. While still less than the corresponding passthrough rate of regular grade cost shocks into unbranded rack prices from Figure 1 (95% after 30 days), the difference between the two 30-day rates is just 24 percentage points. This is substantially and statistically significantly smaller than the corresponding 87 percentage point difference for locked-in branded buyers. In other words, sellers shielded their locked-in buyers from the most unexpected cost increases in an especially significant way.

Comparing the two plots contained in Figure 4, from one buyer type to another, the results tell a similar story. The cost differential increase was largely passed through to unrestricted unbranded retailers by the end of 30 days (71%), while almost none of the cost differential was passed through to locked-in branded buyers (4%). The difference was 67 percentage points and is statistically significantly different from zero.

We perform an asymmetric version of the model as well and present it in Figures 5 and 6 for branded and unbranded gasoline respectively. Allowing for asymmetry has no meaningful impact on our results. There is a small rockets and feathers asymmetry in the first few days for both branded and unbranded gasoline, which then becomes statistically insignificant after the first week. The percentages are all similar to the symmetric case and all our conclusions carry through.

We conclude that sellers are not setting prices opportunistically to its locked-in buyers but doing quite the opposite – they are providing an unwritten form of market volatility insurance to insulate their locked-in buyers from excess market volatility. We interpret this as a relationship building effect, consistent with the relational contracts literature. Sellers avoid even the perception of opportunistic pricing to protect their long run relationships and build positive reputational effects in the long run contracts market. It shows that the long run value sellers place on their relationships not only exceeds any short run gains from pricing opportunistically now (and losing these buyers later), it is significant enough that sellers are willing to accept below-market prices and even losses in the short run to protect them.

The almost complete lack of passthrough of the spot price differential into the rack price differential on locked-in buyers is interesting for a second reason. It stands in sharp contrast to the gasoline literature which shows that costs tend to be passed through to output prices quickly. Many studies have examined cost passthrough on various parts of the vertical chain and generally find that cost passthrough is either complete or close to complete (Eckert (2013), Noel (2016)). The focus is usually on whether 100% passthrough can or cannot be rejected (Noel (2009), Alm et al. (2009), Marion and Muehlegger (2011), Noel and Roach (2016)). The possibility of a zero percent passthrough is not something that is mentioned or even imagined in these discussions. And to our knowledge, it has not been seen in the literature. Yet in this study, we find that a near-zero rate of passthrough is not only possible but has existed for many years on a very important gasoline product, premium gasoline, at the wholesale level.

The reason why the literature has missed this pricing friction all this time is actually straightforward. The vast majority of papers focus on regular grade gasoline only, and as we have shown, passthrough rates for regular grade gasoline from the spot to the rack level are high – over 90% after 30 days in our setting. There are very few studies that examine premium grade passthrough in its own right, and those that do generally do not take into account the formulaic nature of premium rack prices (Karrenbrock (1991), Remer (2015)). But understanding its formulaic nature is the key to understanding the near-zero passthrough rate. Of the two distinct components in the premium grade rack price - the regular grade rack price and the premium-regular differential - only the differential is unique to premium grade gasoline. When the two components are not distinguished, and premium grade cost passthrough is estimated in the usual way, it would appear to show that premium grade has a reasonably high passthrough rate, similar to, but somewhat lower than, that of regular grade. This is a spurious result in the sense that premium grade passthrough is largely being driven by common regular grade cost changes and not by the independent component - the differential - that sets premium pricing apart. We show that independent component barely moved for locked-in branded buyers even as the cost differential accelerated.

We were able to identify this near-zero passthrough rate by exploiting a natural experiment that shocked the cost of octane enhancers and created the exogenous right-hand-side variation needed to estimate the relevant rate. To our knowledge, ours is the first study to break down premium grade gasoline prices into its components and examine passthrough of the premium-regular differential to uncover this important and substantial price friction in the vertical supply chain for gasoline. This is a new contribution to the literature on gasoline pricing in its own right.

We call this the "Premium Paradox". It is the unintuitive result that cost passthrough of the premium-regular cost differential from sellers to branded buyers at the wholesale level has been close to zero for a long while. While the IRFs presented here are only 30 days in duration, in the next section, we show that passthrough of the cost differential was actually close to zero for *years* after the run-up in octane prices.

Our study both identifies the paradox and simultaneously offers an explanation for it. We find that sellers had been smoothing out small changes in the premium-regular cost differential for some time, and that when those differentials begin to soar, they insulated their contracted buyers from the increases. We argue that this kind of market protection is a form of unwritten insurance provided by a seller to its locked-in buyers only, consistent with the relational contracts literature and competitive motives in the long run contracts market.

7 Non-Parametric Analysis of Differentials

The IRFs above extend out only 30 days, but to fully understand the Premium Paradox, it is necessary to explore the pricing dynamics over the longer multi-year run-up in the cost differential. We thus take a non-parametric approach and examine a series of kernel density plots, by year and by buyer type, showing shock dynamics over five years.

We begin by showing the basic Premium Paradox in pictures. Figures 7 and 8 break down the premium grade gasoline rack price into its two components – the regular grade rack price on one hand and the premium-regular rack price differential on the other – and plot the distribution of daily changes of each. Figure 7 plots the distribution of daily regular grade rack price changes, and Figure 8 plots the distribution of daily premium-regular rack price differential changes. We plot branded and unbranded gasoline separately.

Figure 7 shows that unbranded regular grade rack price changes were almost twice as common as branded regular grade rack price changes (the peak in each plot being very near zero), consistent with our first set of results. Sellers insulate their locked-in branded buyers from market volatility to a significant degree, but not their unrestricted unbranded buyers. Branded regular grade rack prices change substantially less often, and the variance in the branded regular rack price is substantially lower than that of the unbranded regular rack price.

Figure 8, which shows the distribution of premium-regular rack price differentials, shows an even more extreme difference between locked-in branded buyers and unrestricted unbranded buyers. It shows that unbranded rack price differential changes were about *ten* times more common than branded rack price differential changes (the peak of the branded price again being at zero), instead of "just" twice. It is consistent with our second finding that sellers adjusted the rack price differential on their locked-in branded buyers especially rarely, in spite of the significant cost differential increases. The variance in the branded rack differential was low in spite of sellers' variance in the cost differential, whereas the variance in the unbranded rack differential was high and in line with the variance in the cost differential.

The tight and tall distribution for branded rack differential changes in Figure 8, with the pronounced peak, is particularly striking, and stands in contrast to the other three distributions in

Figures 7 and 8 (all plotted on the same scale). The difference in a) the different heights of the two peaks in Figure 8 and b) the different heights of the two peaks in Figure 7 is the Premium Paradox and it is what drives our main results.

Now we turn to long run dynamics. Figure 9 plots the distribution of the spot price differential for each year from 2011 to 2015. The average spot price differential begins relatively low at 14.0 cents per gallon in 2011 and 16.5 cents per gallon in 2012. It then spikes to 23.7 cents per gallon in 2013, before temporarily retracting to 20.0 cents per gallon in 2014, and then increasing again to 27.4 cents per gallon on average in 2015. The overall change in the spot price differential from 2011 to 2015 was 13.4 cents per gallon, or 96%.

Figures 10 and 11 show how these spot price differential changes were passed through - or not passed through - to rack price differentials over time. Figure 10 plots the distribution of the unbranded rack price differential for each year from 2011 to 2015. It shows variation from year to year, consistent with a meaningful degree of cost passthrough from unbranded spot price differentials into unbranded rack price differentials year after year. The overall change in the unbranded rack price differential from 2011 to 2015 was 14.2 cents per gallon, and is closely in line with the 13.4 cent per gallon change in the spot price differential overall during that same period. Sellers simply passed through their cost differential increases to their unrestricted unbranded buyers.

Figure 11 plots the distribution of the branded rack price differential instead, for each year from 2011 to 2015. It shows a very different outcome - sellers did not pass their spot price differential increases through to locked-in branded buyers as they did to unrestricted unbranded buyers. The distribution of branded rack price differentials is almost identical from 2011 to 2014, with peaks centered around 19.4 cents per gallon each year, in spite of the fact that locked-in buyers would have been contractually obligated to continue to purchase from sellers at the higher prices if so chosen. Only in 2015, after the increase in the spot price differential had almost doubled, was there finally some movement in the branded rack price differential. Even then, the movement was small compared to the spot price differential increase - the branded rack differential increased to only 21.3 cents per gallon, just 1.9 cents per gallon higher than in 2011, and far short of the 13.4 cent per gallon change in the spot price differential over that same period. It is also far short of the 14.2 cent per gallon change in the rack price differential charged to unrestricted unbranded buyers.

The evidence shows that sellers provided market protection to their locked-in branded buyers for a period of years rather than days, reinforcing our conclusion that reputational considerations and the long run value of sellers' current and expected future relationships are important to sellers in exercising residual price-setting rights under open price contracts.

8 Impacts on Downstream Competition

The very different passthrough rates on locked-in branded and unrestricted unbranded buyers leads to another interesting question - how do these different passthrough rates impact prices and competition further downstream?

We saw that sellers passed through cost increases to unrestricted unbranded buyers more quickly than to locked-in branded buyers. This applies additional pressure on unrestricted unbranded buyers to raise their own regular grade retail prices to cover costs, although doing so would make them relatively less competitive with branded buyers. It is even more extreme in the case of the premium-regular grade rack differential, where the difference in sellers' passthrough rates was especially large. So how did unbranded buyers respond to this? Did they pass through their now relatively higher costs into retail prices, or did they absorb the cost increase to remain competitive at retail? Did branded buyers raise retail prices in line with their unbranded counterparts, for a windfall profit, or did they keep their markups low?

The results are shown in Figures 12 through 15. Figure 12 shows buyers' rates of passthrough from rack prices (their cost) to retail prices (their output price) for regular grade gasoline, separately for branded and unbranded buyers. It shows that locked-in branded buyers, who were facing smaller and fewer changes in their own costs, simply passed through the few changes they did face quickly. In contrast, unbranded buyers reacted to relatively higher cost increases by absorbing the excess cost increases themselves and passing less of it through to retail prices. In essence, after sellers acted as a price volatility buffer for their locked-in branded buyers under contract, unrestricted unbranded buyers acted as their own buffer, accepting lower margins in order to remain competitive at retail. The difference in the branded and unbranded regular grade rack-to-retail passthrough rates is large and reaches a maximum of 27 percentage points on the $7th$ day after the shock. During this time, the margins of unrestricted unbranded buyers (i.e. gasoline stations) fall. By the end of 30 days, the shock is largely passed through to both types of buyers, 88% for branded buyers and 83% for unbranded buyers.

We can combine the two different stages of passthrough – the regular grade spot-to-rack passthrough and the regular grade rack-to-retail passthrough – to calculate the spot-to-retail passthrough rate that shows how an increase in sellers' cost of producing regular grade gasoline, after all adjustments, impacts the regular grade retail prices that consumers ultimately pay. Figure 13 shows that the combined passthrough rate for regular grade gasoline is similar for both branded and unbranded buyers, with only slightly faster passthrough of cost shocks into unbranded retail prices than branded retail prices.

The same dynamics play out in a more extreme way in the case of premium-regular rack price differentials. Recall that the passthrough rate on unbranded spot-to-rack differentials was 71% after 30 days, while the passthrough rate on branded spot-to-rack differentials was just 4%. Figure 14 plots the corresponding rack-to-retail passthough rate on the differential, and shows that unrestricted unbranded buyers absorbed almost the entire increase in the rack price differential internally, responding with a much lower and offsetting rack-to-retail passthrough rate. Unrestricted unbranded buyers passed just 5% of their rack price differential increases through to consumers after 30 days. In contrast, locked-in branded buyers, which faced almost no changes in their branded rack differential at all, passed through what little changes they did see more readily, 61% after 30 days. Similar to before but in a more extreme way, unrestricted unbranded buyers absorbed their substantially higher rack differential increases in order to remain competitive at the retail level.

Figure 15 shows how the shock to spot price differentials ultimately affected the retail price differentials that end-consumers pay overall. The short answer is that premium grade gasoline end-consumers paid essentially none of the cost increase. The reason is the same – locked-in branded buyers had little to pass through, while unrestricted unbranded buyers largely absorbed their excess cost increase. This is seen as a largely flat IRF very close to zero.

We can extend our earlier non-parametric analysis on the cost differential shock to downstream competition as well. Figure 16 shows the distribution of the premium-regular retail price differential for locked-in branded buyers from 2011 to 2015, and Figure 17 shows the corresponding distribution for unrestricted unbranded buyers. Recall that the increase in the premium-regular spot price differential was 13.4 cent per gallon over this time. Figure 16 shows that locked-in branded buyers, almost fully insulated from spot price differential increases from 2011 to 2014, increased retail prices exceptionally little. The average branded retail differential was 22.8 cents per gallon in 2011, 22.8 cents per gallon in 2012, 23.2 cents per gallon in 2013 and 23.2 cents per gallon in 2014. Only in 2015, when sellers began to pass some of their spot price differential increases through to branded rack price differentials, did retail prices begin to rise a little after a four year cushion. The average 2015 branded retail price differential was 26.4 cents per gallon, only 3.6 cents per gallon higher than the 2011 average, and much less than the corresponding 13.4 cent per gallon increase in the spot differential. Sellers absorbed the vast majority of the cost increase on behalf of their locked-in branded buyers, for years.

Figure 17 shows the dynamic process for unrestricted unbranded buyers instead. In spite of the disproportionately large rack price differential passthrough they faced, unrestricted unbranded buyers changed their own retail prices very little from 2011 to 2014. The average unbranded retail differential was 22.6 cents per gallon in 2011, 22.9 cents per gallon in 2012, 23.8 cents per gallon in 2013 and 23.5 cents per gallon in 2014. Only in 2015, when branded retail prices started to rise, did unbranded retail prices have a little room to rise as well. The average 2015 unbranded retail price differential was still just 25.2 cents per gallon, only 2.6 cents per gallon higher than its 2011 value. The increase is again dwarfed by the 13.4 cent per gallon spot price differential increase. The key difference between locked-in buyers and unrestricted unbranded buyers is that the former were insulated from cost increases, while the latter had to absorb those cost increases internally.

The incomplete contracts literature would suggest that the party with residual pricing rights (the seller) in open price contract would be able to extract all additional surplus from unexpected realizations in the state of the world, but the relational contracts literature would point to the possibility of the opposite – that such a party may refrain from (cost-based and efficient) price increases in order to avoid real or even perceived claims of price opportunism, protect the value contained in its relationships and protect its long run reputation in the market for new contracts (Levin (2003), Halac (2012), Li and Matouschek (2013)). Here we find that the latter effect dominates, and in an extreme way in the case of premium-regular price differentials. Sellers with residual pricing rights over locked-in buyers under open price contracts largely absorbed the cost of higher octane prices on behalf of its locked-in buyers, shifting all additional surplus to those buyers. In contrast, sellers selling to unrestricted buyers (with no open price contracts, no residual pricing rights, and no long-term relationships to build) simply passed those cost increases through (as would be expected in an efficient market), shifting no such surplus to unrestricted buyers directly. Because of subsequent downstream retail competition, unrestricted unbranded buyers lost significant surplus at the retail level having to compete with locked-in branded buyers who had substantially more favorable premium wholesale prices over this period.

9 Discussion and Conclusion

The literature of incomplete contracts is rooted in the idea that it is difficult to contract upon every possible realization of the world that might arise during the term of the contract. This leads to the potential for price opportunism under such a contract, and if severe enough, ex ante hold-up problems. Efficiency loss can be minimized by assigning residual decisionmaking rights to one of the parties, but exactly how this is done affects the distribution of surplus across the parties. The theory of incomplete contracts predicts that the party with residual rights will act in its own self-interest when contingencies arise and exercise those rights. On the other hand, the relational contracts literature suggests that the party with residual rights will exercise such power cautiously, because any ex-post opportunism, or even the illusion of ex-post opportunism, can damage its long run reputation among less informed buyers and harm its ability to sign future contracts. In essence, a seller must weigh the long run value of its current and expected relationships against any gains it would achieve from acting opportunistically in the short run, knowing such such opportunistic behavior will result in the long run loss of those relationships.

An open price contract is a specific type of incomplete contract in which one of the most crucial elements in the contract – the price – has not been agreed upon at the time of signing. In our application of the wholesale gasoline market, open price contracts are the norm between sellers and branded buyers, and contracts give the sellers residual price setting rights.

We tested whether sellers use these rights in an opportunistic way on their locked-in branded buyers when unexpected states of the world arise, and to what degree. One might have expected more aggressive pricing on locked-in buyers than on unrestricted unbranded buyers, but we actually found the opposite, less aggressive pricing on locked-in buyers. We attribute this to reputational incentives, as highlighted by the relational contracts literature, in which sellers resist opportunistic tendencies to protect their long run reputation and improve their competitiveness in the long run contracts market for new buyers. In other words, we find that the value a seller places on its long run relationships dominate any short run opportunistic incentives that may arise from time to time. We also found that the degree of pricing restraint was especially pronounced exactly when the incentive for opportunistic pricing was the highest, consistent with relational contracts models with less than perfectly informed buyers. We exploited a unique and historic shock to the cost of octane enhancers, which caused the premium-regular cost differential to increase substantially, and corresponded to a greater "surprise" in the realized state of the world. Absent any recent historical precedent for what to do in response to such a shock (in contrast to the everyday shocks caused by the ups and downs of crude oil prices where seller responses were well known and expected), sellers had a greater potential for price opportunism but we found that they acted in an especially conservative way.

Sellers' pricing practices are inconsistent with short run opportunistic pricing and consistent with the hypothesis that long run reputation and relationship building incentives matter even in short-run decision-making. By forging relationships and providing locked-in buyers with a degree of market protection, neither written nor required by the contract, sellers enhance their long run ability to sign new open price contracts. In essence, sellers appear concerned about violating or being perceived to be violating an "unwritten code of conduct" when it comes to setting prices, and respond in an especially conservative way when the potential for price opportunism is high.

Ours is one of the first studies, if not the first, to consider open price contracts and analyze them in the context of the incomplete and relational contracts literatures. We focused on the wholesale fuels industry as our application because of the methodological advantages the industry provided (though we ultimately found some interesting results for gasoline researchers in their own right, e.g. the Premium Paradox). It remains to be seen if our results on open price contracts are generalizable beyond wholesale fuels, but we note that there is nothing inherently different about open price contracts in the wholesale fuels industry. Franchise industries generally all have open price terms that govern the purchase of important inputs, all exhibit incentives for price opportunism on the part of sellers, and all are tempered by longer term reputational concerns. Extending the analysis to other industries, and other environments, would be a useful direction for future empirical research.

10 References

Aghion, P. and Holden, R. (2011). "Incomplete contracts and the theory of the firm: what have we learned over the past 25 years?" *Journal of Economic Perspectives* 25(2), 181-197.

Ahundjanov, B. and Noel, M.D. (2019) "What's in a name? The incidence of gasoline excise taxes and gasoline carbon levies." *International Journal of Industrial Organization* 76, 102733.

Ajwang, F. (2020). Relational contracts and smallholder farmers' entry, stay and exit, in Kenyan fresh fruits and vegetables export value chain." *Journal of Development Studies* 56(4), 782-797.

Alm, J., Sennoga, E., and Skidmore, M. (2009). "Perfect competition, urbanization, and tax incidence in the retail gasoline market." *Economic Inquiry*, 47(1), 118–134.

Antràs, P. and Staiger, R. (2012). "Offshoring and the Role of Trade Agreements." *American Economic Review* 102(7), 3140–3183.

Argyres, N., Bercovitz, J, and Zanarone, G. (2020). "The role of relationship scope in sustaining relational contracts in interfirm networks." *Strategic Management Journal* 41(2), 222-245.

Bachmeier, L. J. and Griffin, J. M. (2003). "New evidence on asymmetric gasoline price responses." *Review of Economics and Statistics*, 85(3), 772–776.

Bajari, P., Houghton, S. and Tadelis, S. (2014). "Bidding for incomplete contracts: an empirical analysis of adaptation costs." *American Economic Review* 104(4), 1288-1319.

Baker, G., Gibbons, R., and Murphy, K.J. (2002). "Relational contracts and the theory of the firm." *Quarterly Journal of Economics* 117(1), 39-84.

Baron, D.P. and Myerson, R.B. (1982). "Regulating a monopolist with unknown costs." *Econometrica* 50 (4), 911–930.

Barron, D. and Powell, M. (2019). "Policies in relational contracts." *American Economic Journal: Microeconomics* 11(2), 228-249.

Bhattacharyya, S. and Lafontaine, F. (1995). "Double-sided moral hazard and the nature of share contracts." *RAND Journal of Economics* 26(4), 761-781.

Blair, B.F., Campbell, R.C. and Mixon, P.A. (2017). "Price pass-through in US gasoline markets." *Energy Economics* 65, 42-49.

Board, S. (2011). "Relational contracts and the value of loyalty." *American Economic Review* 101(7), 3349-3367.

Borenstein, S., Cameron, A. C., and Gilbert, R. (1997). "Do gasoline prices respond asymmetrically to crude oil price changes?" *The Quarterly Journal of Economics*, 112(1), 305–339.

Brickley, J.A. and Dark, F.H. (1987). "The choice of organizational form: the case of franchising." *Journal of Financial Economics* 18(2), 401-420.

Brown, M., Falk, A. and Fehr, E. (2004). "Relational contracts and the nature of market interactions." *Econometrica* 72(3), 747-780.

Chassang, S. (2010). "Building routines: Learning, cooperation, and the dynamics of incomplete relational contracts." *American Economic Review* 100(1), 448-465.

Chesnes, M. (2016). "Asymmetric Pass-Through in U.S. Gasoline Prices." *Energy Journal* 37(1), 153-180.

Clougherty, J., Duso, T., and Muck, J. (2016). "Correcting for Self-Selection Based Endogeneity in Management Research: Review, Recommendations and Simulations.", *Organizational Research Methods* 19:2, 286-347.

Deltas, G. (2008). "Retail gasoline price dynamics and local market power." The *Journal of Industrial Economics*, 56(3), 613–628.

Eckert, A. (2013). "Empirical studies of gasoline retailing: a guide to the literature." *Journal of Economic Surveys* 27(1), 140-166.

Engle, R.F. and Granger, C. W. (1987). "Co-integration and error correction: representation, estimation, and testing." *Econometrica: Journal of the Econometric Society*, 251–276.

Fong, Y.F. and Li, J. (2017). "Relational contracts, limited availability, and employment dynamics." *Journal of Economic Theory* 169, 270-293.

Forbes, S.J. and Lederman, M. (2009). "Adaptation and Vertical Integration in the Airline Industry." *American Economic Review* 99(5), 1831-1849.

Gamage, K.V.P.I., and Priyanath, H.M.S. (2019). "Relational norms, opportunism and business performance: An empirical evidence of gem dealers in Sri Lanka." *Sri Lanka Journal of Economic Research* 6(2), 39-67.

Grossman, S.J. and Hart, O.D. (1983). "An analysis of the principal-agent problem." *Econometrica* 51(1), 7-46.

Grossman, S.J. and Hart, O.D. (1986), "The costs and benefits of ownership: a theory of vertical and lateral integration." *Journal of Political Economy* 94(4), 691-719.

Halac, M. (2012). "Relational contracts and the value of relationships." *American Economic Review* 102(2), 750-759.

Hart, O.D. (2017). "Incomplete contracts and control." *American Economic Review* 107(7), 1731-1752.

Hart, O.D. and Moore, J. (1988). "Incomplete contracts and renegotiation." *Econometrica* 56(4), 755-785.

Hart, O.D. and Moore, J. (1990). "Property rights and the nature of the firm." *Journal of Political Economy* 98(6), 1119-1158.

Hoppe, E. and Schmitz, P. (2010). "Public versus private ownership: Quantity contracts and the allocation of investment tasks." *Journal of Public Economics* 94(3), 258–268.

Karrenbrock, J.D. (1991). "The behavior of retail gasoline prices: symmetric or not?" *Federal Reserve Bank of St. Louis Review* 73(4), 19-29.

Klein, B. and Leffler, K. (1981). "The role of market forces in assuring contractual performance." *Journal of Political Economy* 89(4), 615-641.

Knittel, C.R., Meiselman, B.S., and Stock, J.H. (2017). "The pass-through of RIN prices to wholesale and retail fuels under the renewable fuel standard." *Journal of the Association of Environmental and Resource Economics* 4(4), 1081-1119.

Kosova, R. and Sertsios, G. (2018). "An empirical analysis of self-enforcement mechanisms: evidence from hotel franchising." *Management Science* 64(1), 43-63.

Lafontaine, F. and Shaw, K.L. (1999) "The dynamics of franchise contracting: Evidence from panel data." *Journal of Political Economy* 107(5), 1041-1080.

Lafontaine, F. (1992) "Agency theory and franchising: some empirical results." *RAND Journal of Economics* 23(2), 263-283.

Levin, J. (2003). "Relational incentive contracts." *American Economic Review* 93(3), 835-857.

Levin, A., Lin, C.-F., and Chu, C.-S. (2002). "Unit root tests in panel data: asymptotic and finite-sample properties." *Journal of Econometrics* 108(1), 1-24.

Lewis, M. S. (2011). "Asymmetric price adjustment and consumer search: An examination of the retail gasoline market." *Journal of Economics and Management Strategy*, 20(2), 409–449.

Lewis, M. and Noel, M. (2011). "The speed of gasoline price response in markets with and without Edgeworth cycles." *Review of Economics and Statistics*, 93(2), 672–682.

Li, J. and Matouschek, N. (2013). "Managing conflicts in relational contracts." *American Economic Review* 103(6), 2328-2351.

Macchiavello, R. and Morjaria, A. (2021). "Competition and relational contracts in the Rwanda coffee chain." *Quarterly Journal of Economics* 136(2), 1089-1143.

MacLeod, W.B. (2007). "Reputations, relationships, and contract enforcement." *Journal of Eco-*

nomic Literature 45(3), 595-628.

Maskin, E. and Riley, J. (1984). "Monopoly with incomplete information." *RAND Journal of Economics* 15(2), 171–196.

Marion, J. and Muehlegger, E. (2011). "Fuel tax incidence and supply conditions." *Journal of Public Economics*, 95(9-10), 1202–1212.

Mathis v. Exxon (2002). *Mathis v. Exxon Corp.*, 302 F. 3d 448 (5th Cir. 2002).

Noel, M. (2009). "Do retail gasoline prices respond asymmetrically to cost shocks? The influence of Edgeworth cycles." *The RAND Journal of Economics*, 40(3), 582–595.

Noel, M.D. and Roach, T.J. (2016) "Regulated and unregulated substitutes: Aversion effects from an ethanol mandate." *Economic Inquiry* 54(2), 1150-1166.

Noel, M.D. (2016). "Retail gasoline markets" in the Handbook on the Economics of Retail and Distribution, E. Basker (ed.), Edward Edgar Publishing.

Peltzman, S. (2000). "Prices rise faster than they fall." *Journal of Political Economy* 108(3), 466-502.

Remer, M. (2015). "An empirical investigation of the determinants of asymmetric pricing." *International Journal of Industrial Organization* 42, 46-56.

Shavell, S. (1979). "Risk sharing and incentives in the principal and agent relationship." *Bell Journal of Economics* 10(1), 55–73.

Shell v. HRN (2004). *Shell Oil Company, Motiva Enterprises LLC, Equilon Enterprises LLC, and Equiva Services LLC v. HRN, Inc. et al.* Case number: 03-0555 (Supreme Court of Texas 2004).

Vita, M.G. (2000). "Regulatory restrictions on vertical integration and control: the competitive impact of gasoline divorcement policies." *Journal of Regulatory Economics* 18(3), 217-233.

Westerlund, J. "Testing for error correction in panel data." *Oxford Bulletin of Economics and Statistics* 69(6), 709-748.

Yang, N., Song, Y., Zhang, Y. and Wang, J. (2020). "Dark side of joint R&D collaborations: dependence asymmetry and opportunism." *Journal of Business and Industrial Marketing* 35(4), 741-755.

Zanarone, G. (2013). "Contract adaptation under legal constraints." *Journal of Law, Economics, and Organization* 29(4), 799-834.

Zhou, Y., Yang, W. and Zhuang, G. (2020). "The dilemma of relational embeddedness: mediating roles of influence strategies in managing marketing channel." *Journal of Business and Industrial Marketing.*

Table 1. Summary Statistics

	Num. Obs.	Mean	Std. Dev.	Minimum	Maximum
Regular Grade Gasoline Prices					
Spot Price	5478	262.64	56.90	115.9	377.2
Rack Price - All	5478	265.06	54.64	122.6	371.1
Rack Price - Branded	5478	265.83	53.93	126.9	361.0
Rack Price - Unbranded	5478	264.06	55.95	115.8	384.4
Retail Price - All	5478	342.15	50.85	197.7	429.0
Retail Price - Branded	5478	346.70	49.99	204.2	432.6
Retail Price - Unbranded	5478	336.66	51.85	191.9	424.0
Premium Grade Gasoline Prices					
Spot Price	5478	282.98	55.03	136.7	398.2
Rack Price - All	5478	287.43	52.96	143.7	391.4
Rack Price - Branded	5478	285.69	53.35	146.1	380.5
Rack Price - Unbranded	5478	289.45	53.11	139.5	406.5
Retail Price - All	5478	365.87	49.62	225.4	451.5
Retail Price - Branded	5478	370.65	48.69	228.8	455.7
Retail Price - Unbranded	5478	360.50	50.77	221.6	445.9

All prices in U.S. cents per gallon.

Table 2. Unit Root Tests

	Levels			First Differences		
	Spot (1)	Rack (2)	Retail (3)	Spot (4)	Rack (5)	Retail (6)
Regular Grade Gasoline						
Branded		1.11	1.27		-54.15***	-28.9***
Unbranded		-1.17	1.65		-96.62***	-20.01***
Overall	-1.13	0.28	1.3	-110***	-74.28***	-21.93***
Premium Grade Gasoline						
Branded		1.11	1.25		-54.15***	-30.44***
Unbranded		-1.09	1.69		-94.19***	-24.16***
Overall	-0.85	0.23	1.33	-120***	-82.1***	-23.6***
Premium-Regular Differential						
Branded		-21.36***	-0.28		-140***	-130***
Unbranded		-5.08***	-5.7***		-100***	-110***
Overall	1.39	-6.26***	-0.97	-73.16***	-110***	-110***

Cells show t-statistics from unit root tests. ***Significant at the 1% level. ** Significant at the 5% level. * Significant at the 10% level.

Table 3. Panel Cointegration Tests

	Group-Mean Statistics		Panel Statistics	
	Spot-Rack (1)	Rack-Retail (2)	Spot-Rack (3)	Rack-Retail (4)
Regular Grade Gasoline				
Branded	-9.07***	-7.29***	-15.69***	-12.68***
	-128.77***	-67.93***	-128.68***	-68.14***
Unbranded	-7.94***	-8.51***	-14.24***	-14.52***
	-127.30***	-68.98***	-139.04***	-65.59***
Overall	-8.05***	-7.42***	-13.91***	-12.93***
	-112.82***	-69.25***	-117.27***	-68.95***
Premium Grade Gasoline				
Branded	-6.32***	-7.26***	-10.94***	-12.63***
	-61.31***	-68.84***	-61.30***	-68.52***
Unbranded	-7.47***	-7.89***	-13.35***	-13.58***
	-106.62***	-57.01***	-114.65***	-55.84***
Overall	-6.48***	-6.89***	-11.30***	-12.19***
	-72.89***	-57.67***	-75.81***	-58.70***
Premium-Regular Differential				
Branded	-3.69**	-5.80***	-6.16**	-11.07***
	-86.29***	-65.24***	-78.44***	-73.45***
Unbranded	-6.29***	-5.34***	-11.16***	-10.11***
	-91.62***	-63.68***	-93.37***	-77.44***
Overall	-6.17***	-3.91***	-10.85***	-7.12***
	-92.65***	-31.01***	-91.63***	-36.15***

Each cell contains two statistics (see text). Rejection of the group-mean statistics means cointegration is present in at least one of the cross-sectional units. Rejection of the panel statistics is that cointegration is present in the whole panel. *** Significant at the 1% level. ** Significant at the 5% level. * Significant at the 10% level.

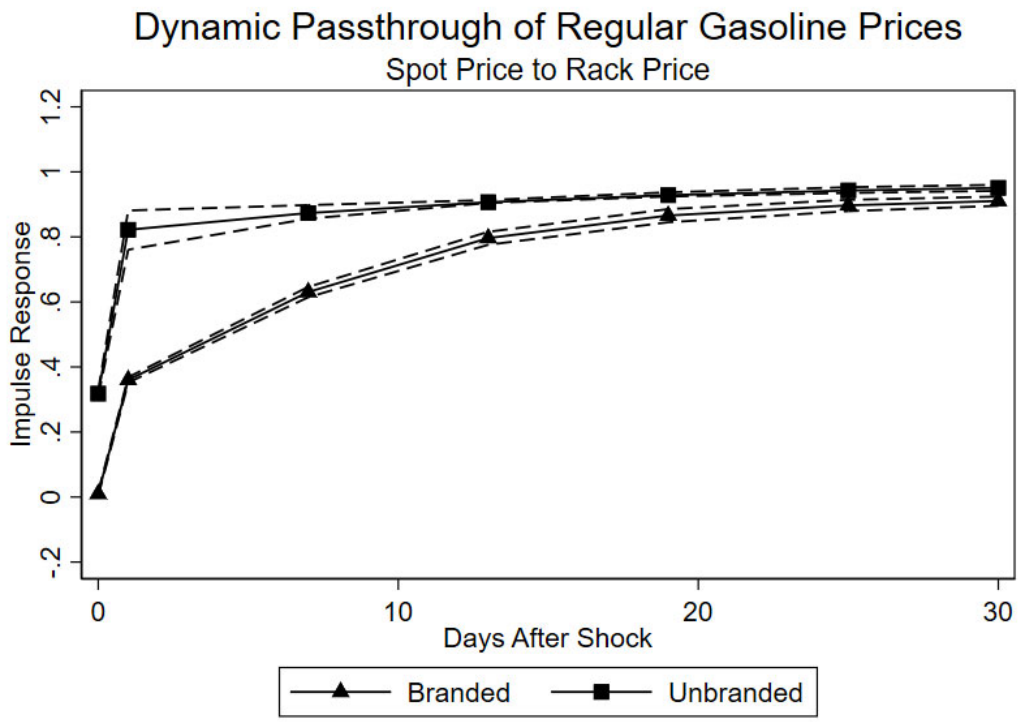

Figure 1. Dynamic Passthrough of Regular Gasoline: Spot Price to Rack Price

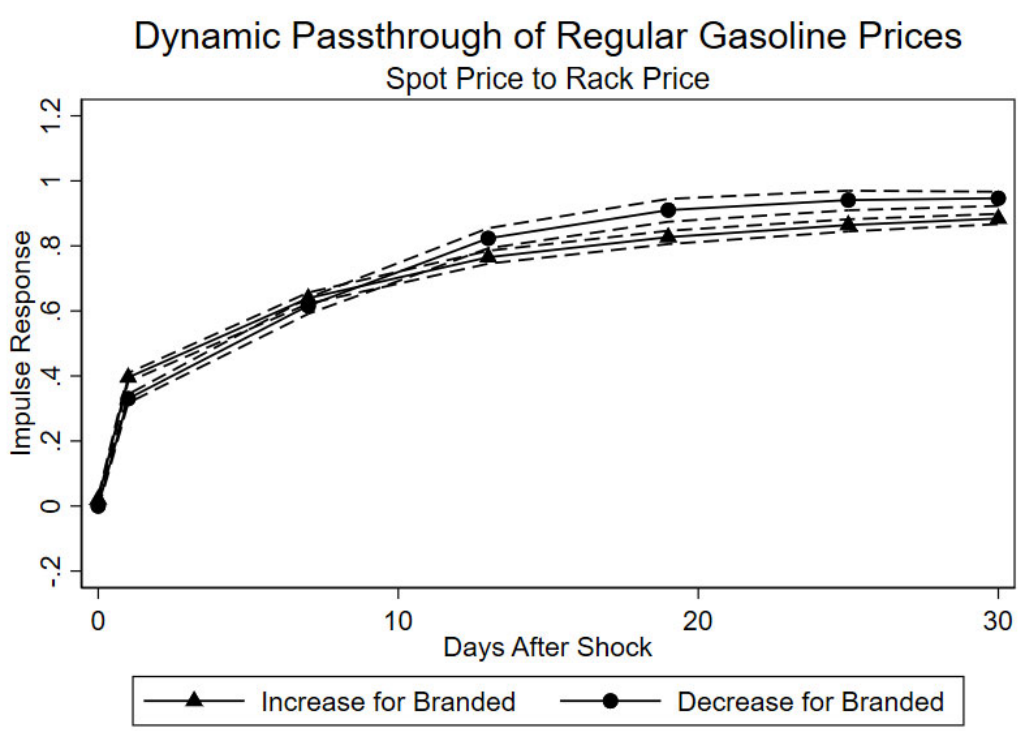

Figure 2. Dynamic Passthrough of Regular Gasoline: Branded Spot Price to Rack Price

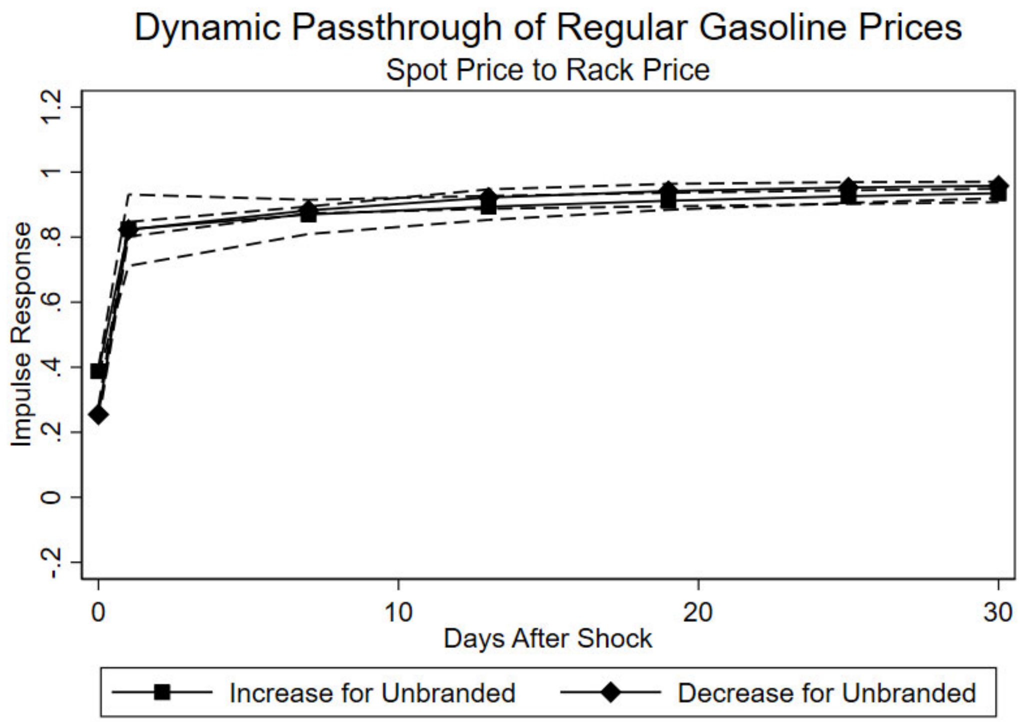

Figure 3. Dynamic Passthrough of Regular Gasoline: Unbranded Spot Price to Rack Price

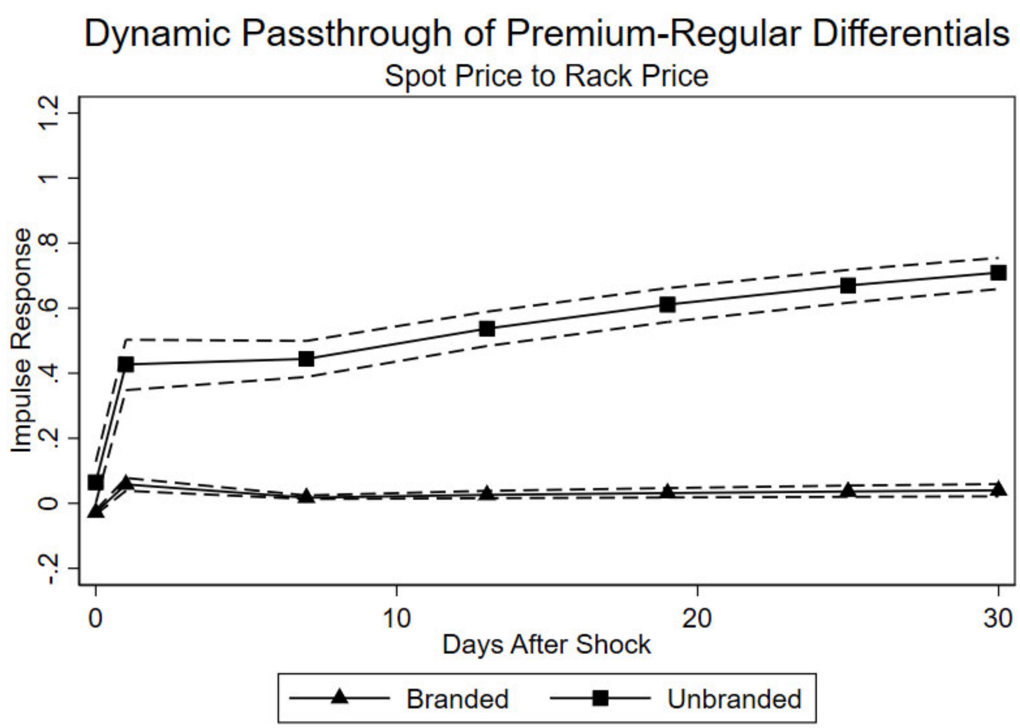

Figure 4. Dynamic Passthrough of Premium-Regular Differentials: Spot Price to Rack Price

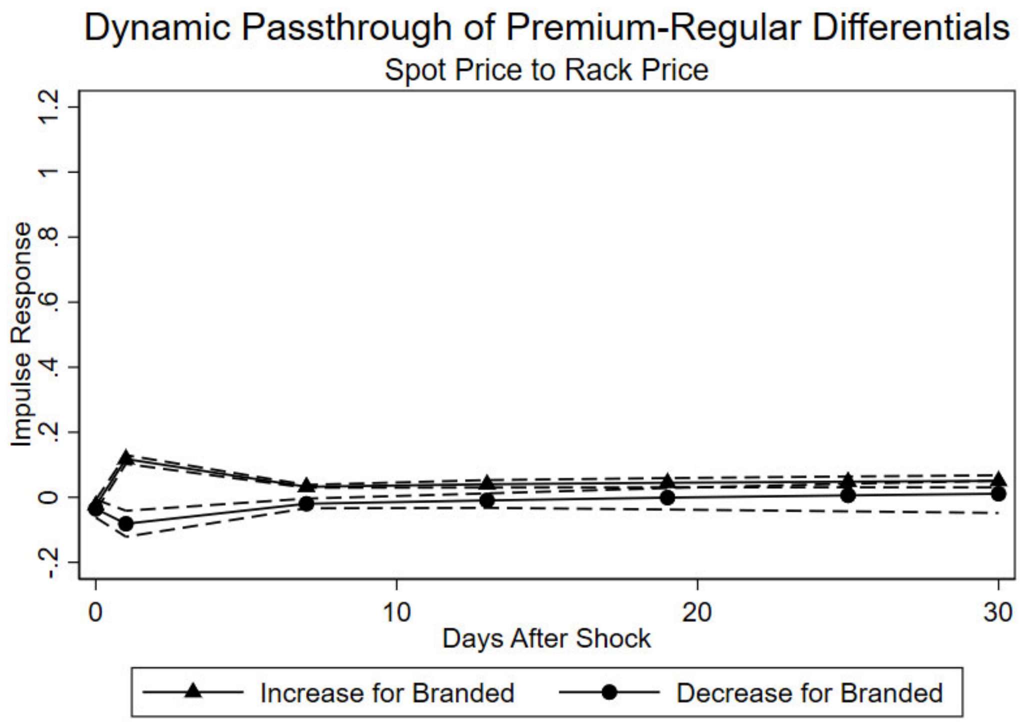

Figure 5. Dynamic Passthrough of Premium-Regular Differentials: Branded Spot Price to Rack Price

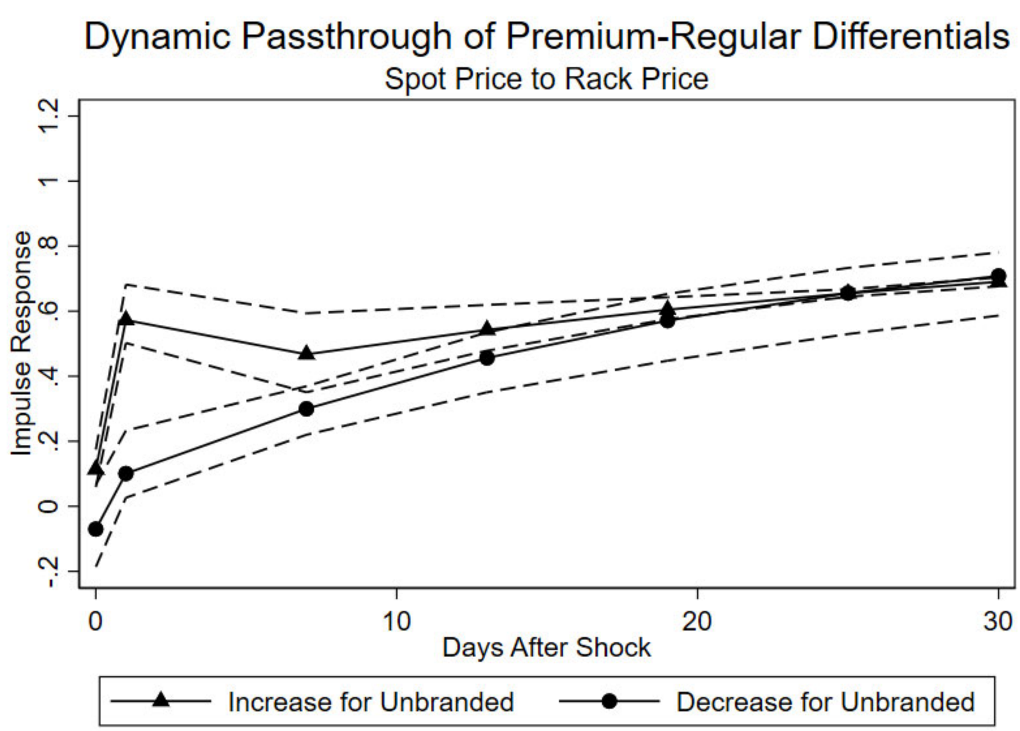

Figure 6. Dynamic Passthrough of Premium-Regular Differentials: Unbranded Spot Price to Rack Price

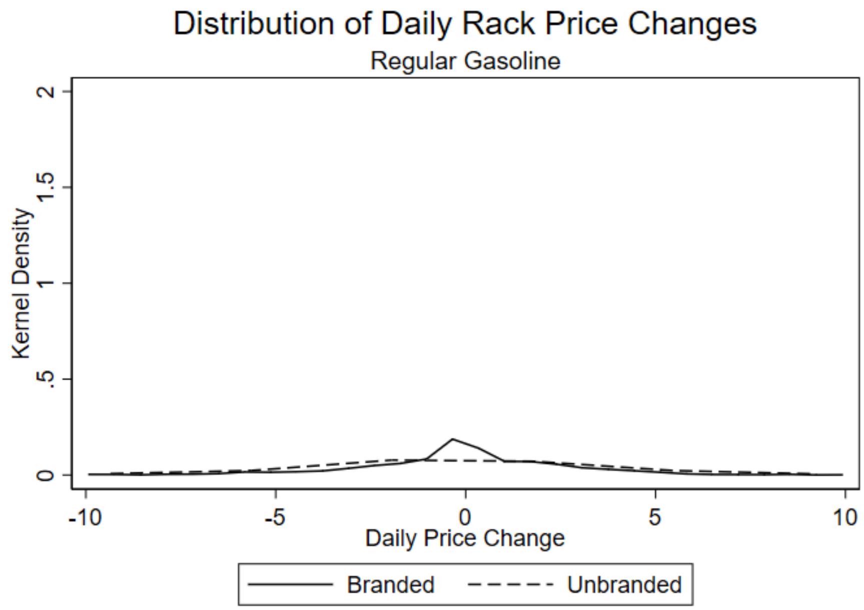

Figure 7. Kernel Density Plots of Daily Rack Price Changes

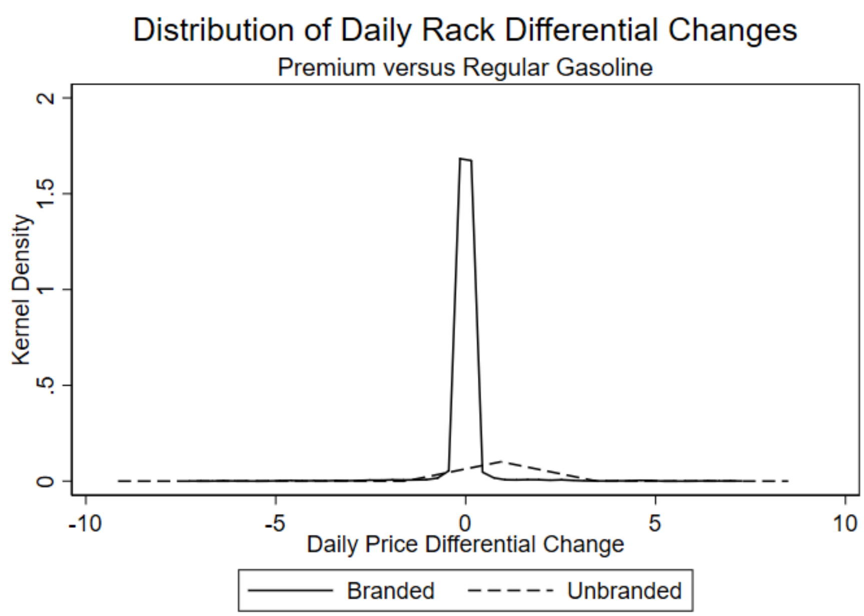

Figure 8. Kernel Density Plots of Daily Rack Differential Changes

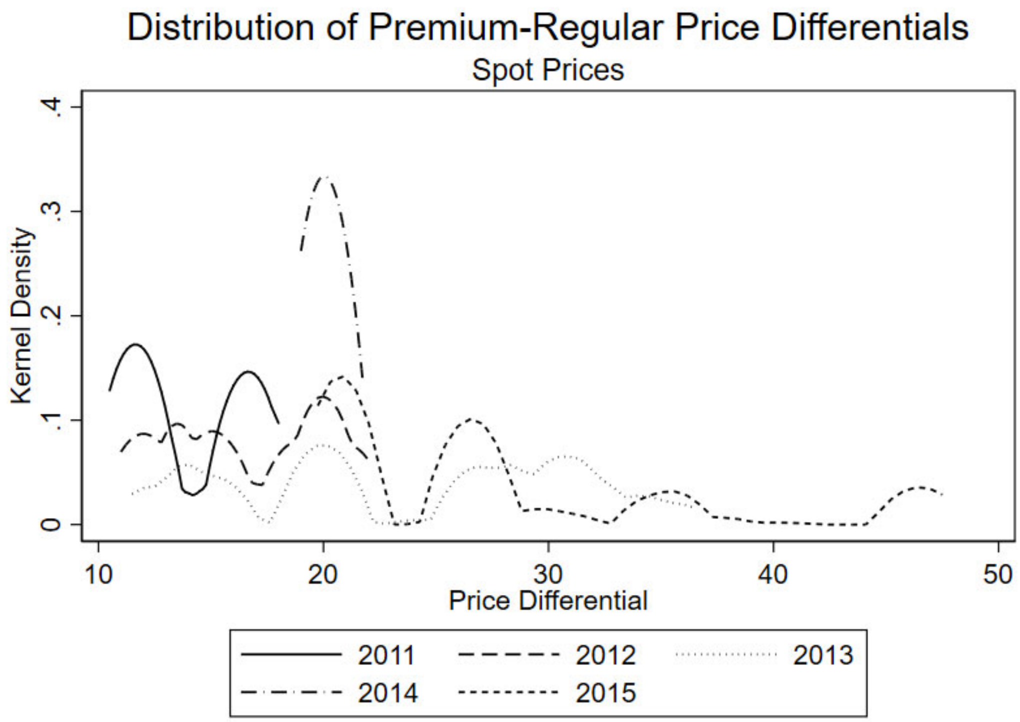

Figure 9. Kernel Density Plots of Premium-Regular Spot Differentials by Year

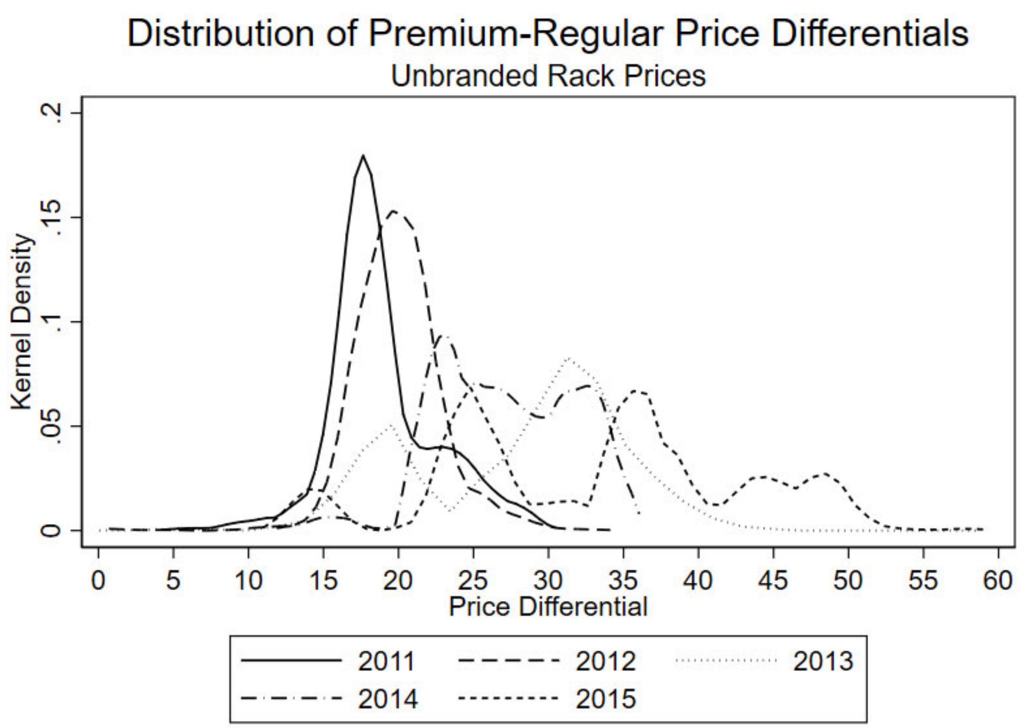

Figure 10. Kernel Density Plots of Premium-Regular Unbranded Rack Differentials by Year

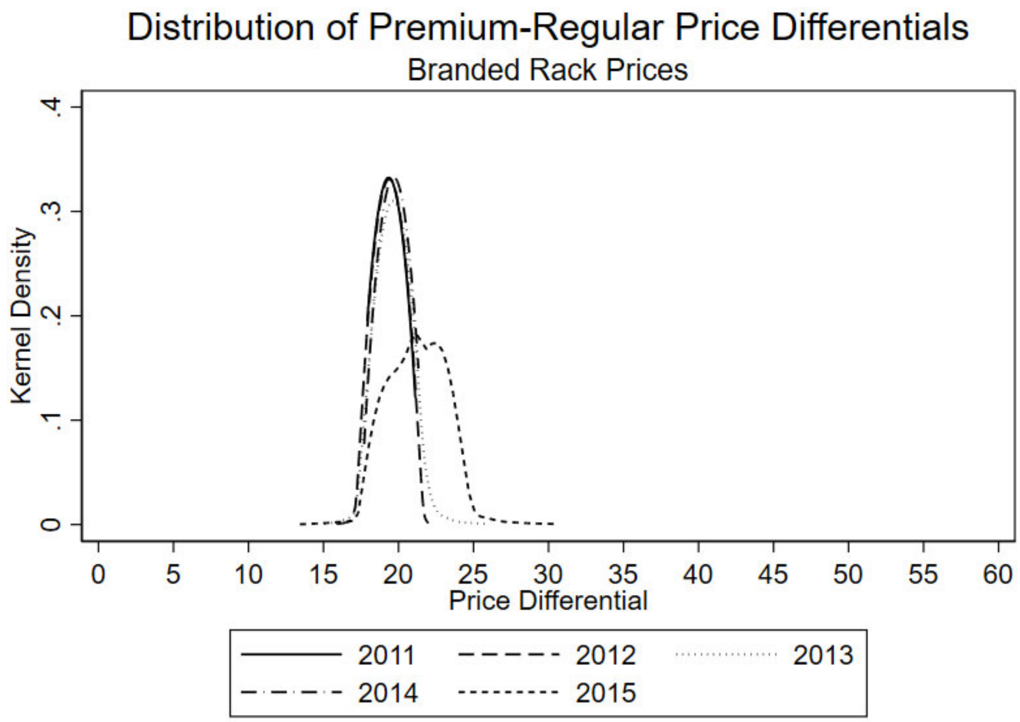

Figure 11. Kernel Density Plots of Premium-Regular Branded Rack Differentials by Year

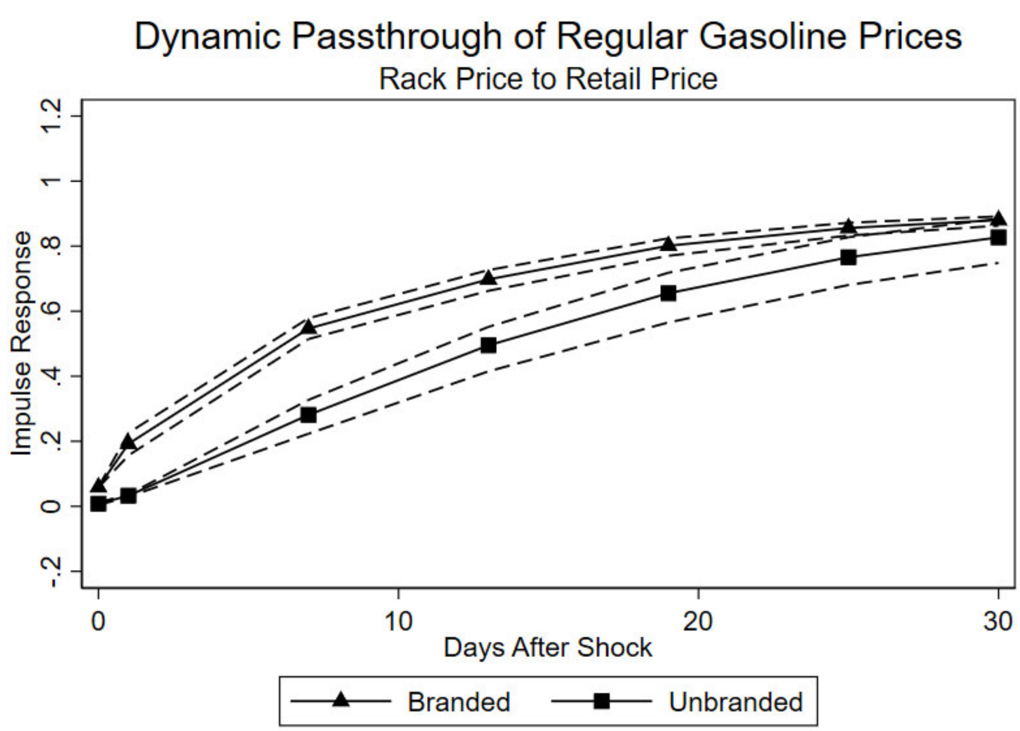

Figure 12. Dynamic Passthrough of Regular Gasoline: Rack Price to Retail Price

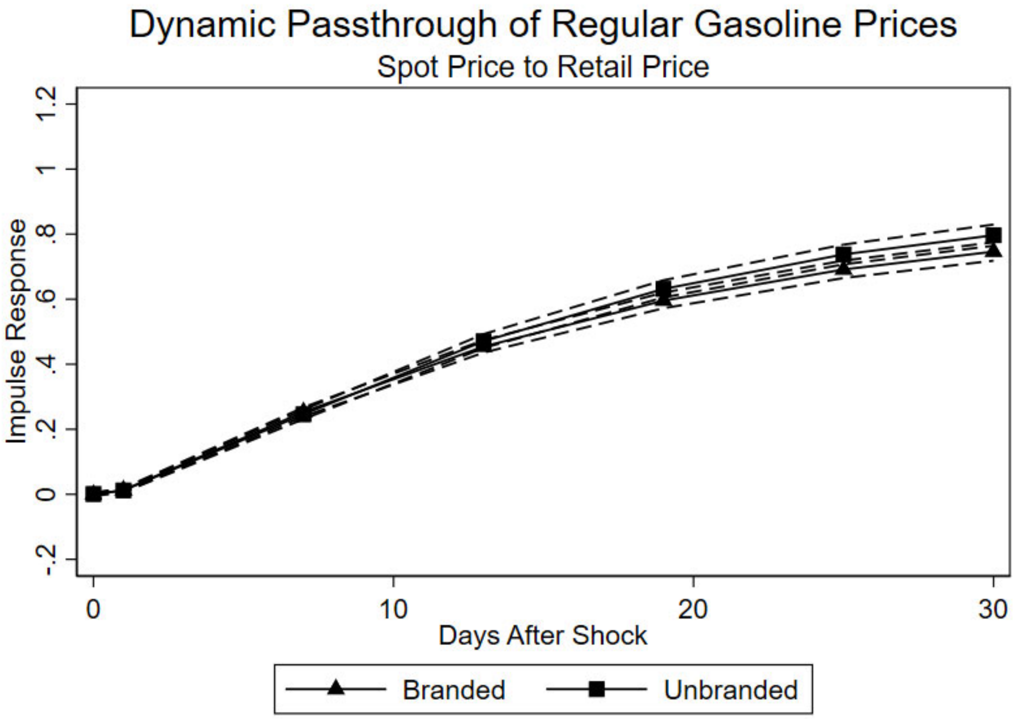

Figure 13. Dynamic Passthrough of Regular Gasoline: Spot Price to Retail Price

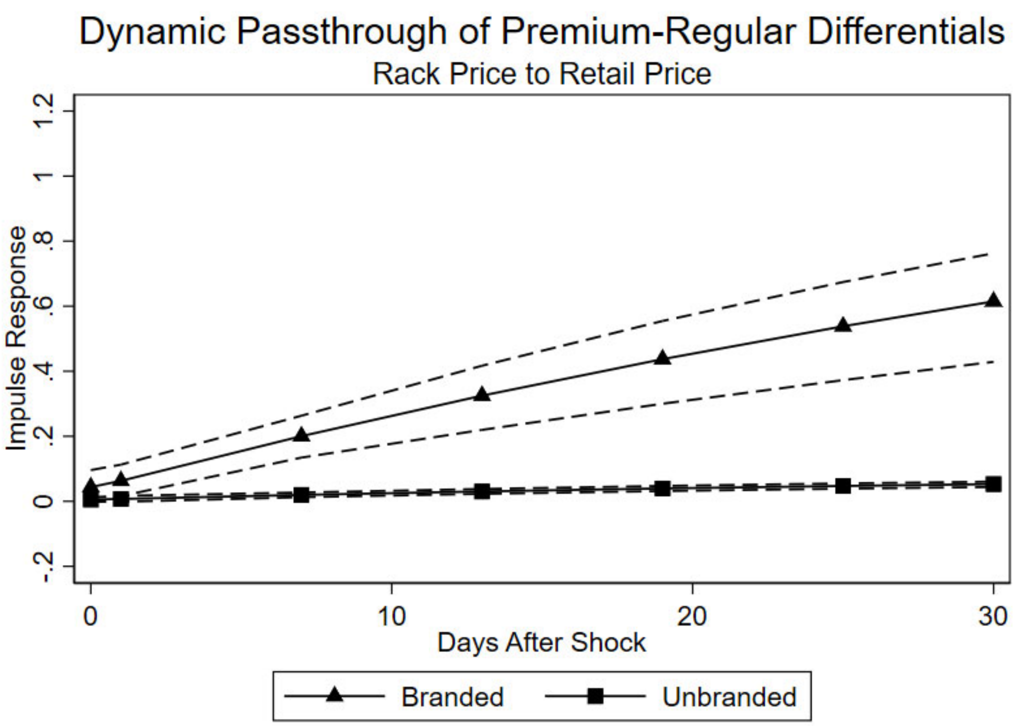

Figure 14. Dynamic Passthrough of Premium-Regular Differentials: Rack Price to Retail Price

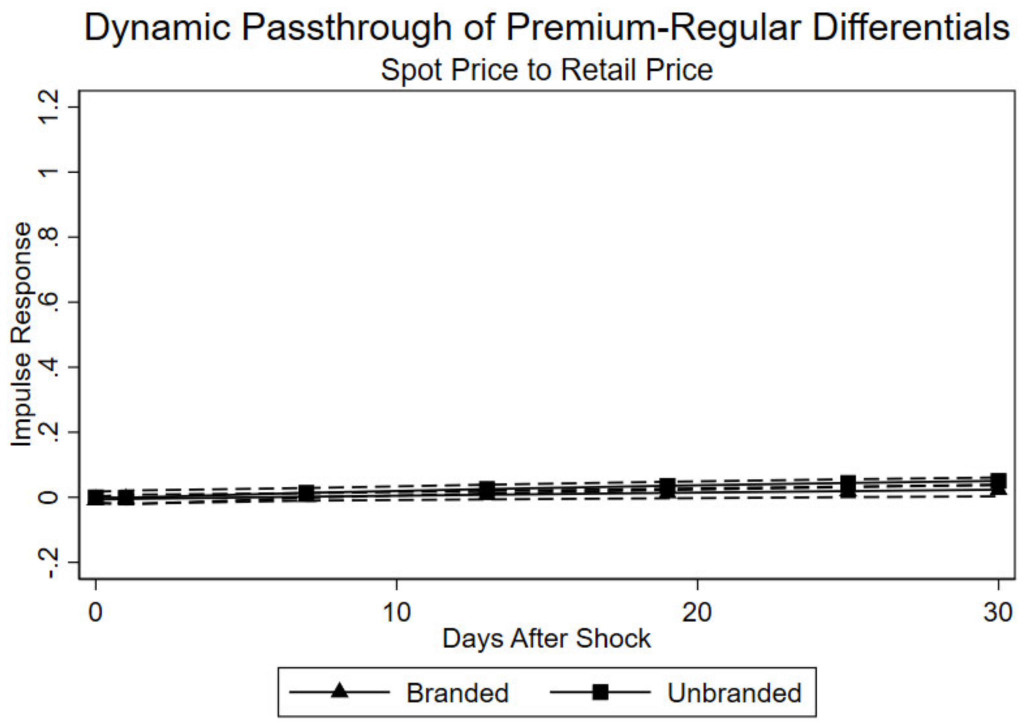

Figure 15. Dynamic Passthrough of Premium-Regular Differentials: Spot Price to Retail Price

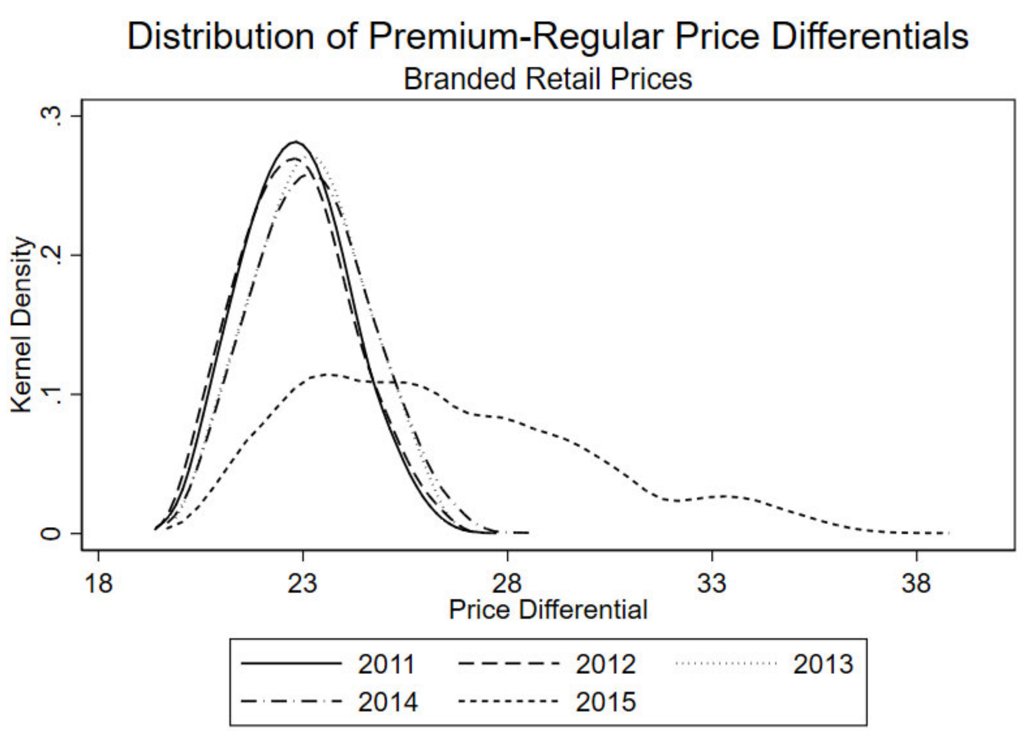

Figure 16. Kernel Density Plots of Premium-Regular Branded Retail Differentials by Year

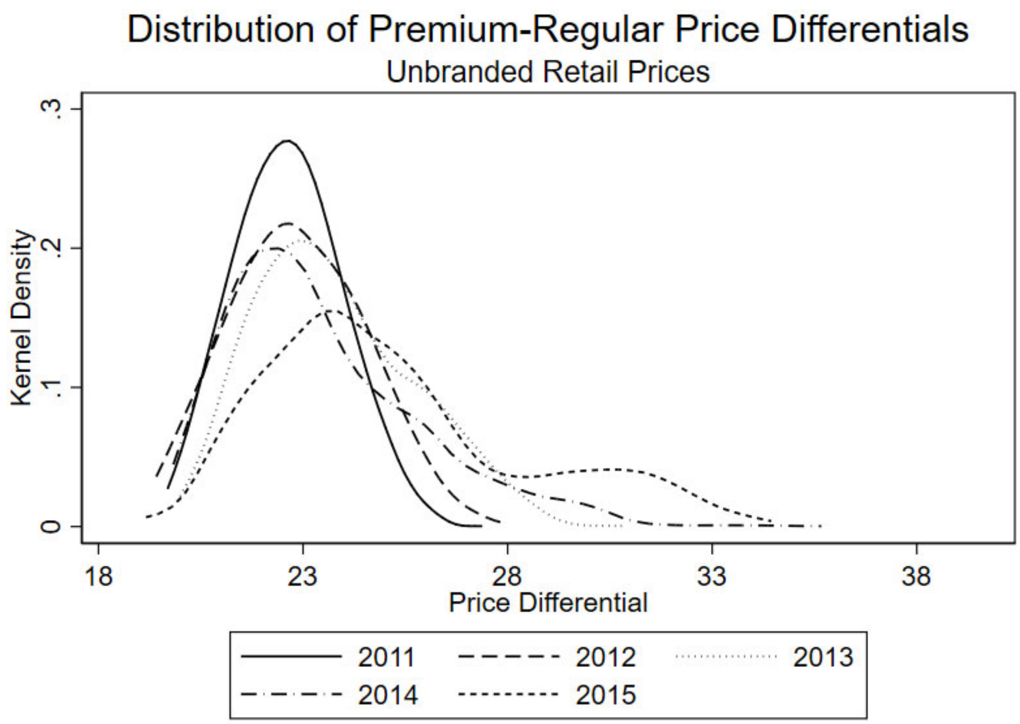

Figure 17. Kernel Density Plots of Premium-Regular Unbranded Retail Differentials by Year

Tables for Online Appendix

Table A1. Panel-VECM: Spot Price to Rack Prices, Symmetric Model

	Branded Regular	Unbranded Regular	Branded Differentials	Unbranded Differentials
$\Delta c_{t,0}$	0.010**	0.319***	-0.028**	0.062
	(0.001)	(0.004)	(0.003)	(0.035)
$\Delta c_{t,1}$	0.316***	0.485***	0.063**	0.335***
	(0.004)	(0.043)	(0.010)	(0.039)
$\Delta c_{t,2}$	0.017	0.060*		
	(0.009)	(0.015)		
$\Delta c_{t,3}$	0.003			
	(0.004)			
$\Delta c_{t,4}$	0.003*			
	(0.001)			
$\Delta c_{t,5}$	0.023***			
	(0.001)			
$\Delta p_{t,1}$	0.116**	-0.121**	-0.066**	-0.289**
	(0.018)	(0.024)	(0.074)	(0.043)
$\Delta p_{t,2}$	0.044**		-0.501**	-0.094***
	(0.006)		(0.080)	(0.006)
$\Delta p_{t,3}$	0.015***		-0.390**	
	(0.001)		(0.080)	
$\Delta p_{t,4}$	-0.027**		-0.331**	
	(0.003)		(0.061)	
$\Delta p_{t,5}$	0.044***		-0.241**	
	(0.002)		(0.056)	
$\Delta p_{t,6}$	0.055**		-0.148**	
	(0.006)		(0.022)	
$\Delta p_{t,7}$	0.114***			
	(0.003)			
$c_{i,t-1}$	0.931***	0.972***	0.089***	0.900***
	(0.002)	(0.010)	(0.006)	(0.032)
$z_{i,t-1}$	-0.037***	-0.074**	-0.048	-0.053**
	(0.002)	(0.014)	(0.019)	(0.007)

*** Significant at the 1% level. ** Significant at the 5% level. * Significant at the 10% level. Robust standard errors in parentheses.

Table A2. Panel-VECM: Spot Price to Rack Prices, Asymmetric Model

	Branded Regular	Unbranded Regular	Branded Differentials	Unbranded Differentials
$+\Delta c_{t,0}$	0.021***	0.388***	-0.025	0.119*
	(0.001)	(0.007)	(0.009)	(0.025)
$+\Delta c_{t,1}$	0.325***	0.451**	0.123***	0.470***
	(0.003)	(0.087)	(0.004)	(0.022)
$+\Delta c_{t,2}$	0.045**	0.067*		
	(0.007)	(0.019)		
$+\Delta c_{t,3}$	0.002			
	(0.007)			
$+\Delta c_{t,4}$	0.020**			
	(0.003)			
$+\Delta c_{t,5}$	0.020**			
	(0.003)			
$+\Delta p_{t,1}$	0.026**	-0.111	-0.693**	-0.454
	(0.006)	(0.073)	(0.074)	(0.149)
$+\Delta p_{t,2}$	0.027		-0.445**	-0.019
	(0.010)		(0.087)	(0.078)
$+\Delta p_{t,3}$	0.077***		-0.438*	
	(0.004)		(0.103)	
$+\Delta p_{t,4}$	-0.044**		-0.266**	
	(0.007)		(0.055)	
$+\Delta p_{t,5}$	0.063***		-0.338*	
	(0.001)		(0.081)	
$+\Delta p_{t,6}$	0.056**		-0.112*	
	(0.012)		(0.032)	
$+\Delta p_{t,7}$	0.069**			
	(0.008)			
$-\Delta c_{t,0}$	-0.000	0.254***	-0.036	-0.068
	(0.002)	(0.014)	(0.015)	(0.064)
$-\Delta c_{t,1}$	0.304***	0.517***	-0.078*	0.074
	(0,006)	(0.028)	(0.023)	(0.029)
$-\Delta c_{t,2}$	-0.006	0.048*		
	(0.014)	(0.016)		
$-\Delta c_{t,3}$	0.008*			
	(0.002)			
$-\Delta c_{t,4}$	-0.013**			
	(0.002)			
$-\Delta c_{t,5}$	0.027***			
	(0.001)			
$-\Delta p_{t,1}$	0.185**	-0.127*	-0.600**	-0.072
	(0.028)	(0.037)	(0.080)	(0.131)
$-\Delta p_{t,2}$	0.045***		-0.058**	-0.087
	(0.004)		(0.083)	(0.037)
$-\Delta p_{t,3}$	0.103***		-0.359**	
	(0.008)		(0.065)	
$-\Delta p_{t,4}$	-0.025**		-0.434**	
	(0.004)		(0.088)	
$-\Delta p_{t,5}$	0.013**		-0.173*	
	(0.003)		(0.043)	
$-\Delta p_{t,6}$	0.044***		-0.194***	
	(0.000)		(0.017)	
$-\Delta p_{t,7}$	0.148***			
	(0.002)			
$c_{i,t-1}$	0.931***	0.972***	0.089***	0.899***
	(0.002)	(0.010)	(0.006)	(0.032)
$+z_{i,t-1}$	-0.028***	-0.115	-0.052	-0.058**
	(0.001)	(0.051)	(0.041)	(0.012)
$-z_{i,t-1}$	-0.055***	-0.048***	-0.044	-0.046*
	(0.001)	(0.003)	(0.027)	(0.014)

*** Significant at the 1% level. ** Significant at the 5% level. * Significant at the 10% level. Robust standard errors in parentheses.

Table A3. Panel-VECM: Rack Prices to Retail Prices, Symmetric Model

	Branded Regular	Unbranded Regular	Branded Differentials	Unbranded Differentials
$\Delta c_{t,0}$	0.059***	0.008*	0.042	0.006
	(0.000)	(0.002)	(0.027)	(0.003)
$\Delta c_{t,1}$	0.112**	0.012***	-0.006	-0.000
	(0.157)	(0.001)	(0.006)	(0.001)
$\Delta c_{t,2}$	0.062**	0.024*		
	(0.007)	(0.007)		
$\Delta c_{t,3}$	-0.000	0.016***		
	(0.004)	(0.000)		
$\Delta c_{t,4}$	0.020**	0.012		
	(0.004)	(0.005)		
$\Delta c_{t,5}$	-0.007	-0.002		
	(0.004)	(0.001)		
$\Delta c_{t,6}$	0.045**	0.019*		
	(0.008)	(0.005)		
$\Delta c_{t,7}$	0.053**	0.022		
	(0.011)	(0.008)		
$\Delta c_{t,8}$	-0.041**			
	(0.005)			
$\Delta p_{t,1}$	0.176**	0.138**	-0.274**	-0.249**
	(0.018)	(0.030)	(0.038)	(0.028)
$\Delta p_{t,2}$	0.038	0.214***	-0.209***	-0.119**
	(0.035)	(0.017)	(0.016)	(0.022)
$\Delta p_{t,3}$	0.059**	0.148***		
	(0.008)	(0.010)		
$\Delta p_{t,4}$	0.037*	0.037		
	(0.010)	(0.018)		
$\Delta p_{t,5}$	0.028	0.055**		
	(0.012)	(0.008)		
$\Delta p_{t,6}$	-0.000	-0.025		
	(0.033)	(0.014)		
$\Delta p_{t,7}$	0.226**	0.265**		
	(0.028)	(0.032)		
$\Delta p_{t,8}$		-0.112*		
		(0.036)		
$c_{i,t-1}$	0.897***	0.872***	1.494*	0.093*
	(0.022)	(0.008)	(0.444)	(0.026)
$z_{i,t-1}$	-0.013***	-0.013**	-0.025**	-0.035***
	(0.001)	(0.002)	(0.005)	(0.003)

*** Significant at the 1% level. ** Significant at the 5% level. * Significant at the 10% level. Robust standard errors in parentheses.

Table A4. Panel-VECM: Spot Price to Retail Prices, Symmetric Model

	Branded Regular	Unbranded Regular	Branded Differentials	Unbranded Differentials
$\Delta c_{t,0}$	-0.001	0.001	-0.007	-0.000
	(0.004)	(0,002)	(0.005)	(0.005)
$\Delta c_{t,1}$	0.004*	0.000	-0.001	-0.004
	(0.001)	(0.004)	(0.003)	(0.002)
$\Delta c_{t,2}$	0.044***	0.024***		
	(0.004)	(0.002)		
$\Delta c_{t,3}$	0.023***	0.020***		
	(0.001)	(0.001)		
$\Delta c_{t,4}$	0.014**	0.014**		
	(0.001)	(0.002)		
$\Delta c_{t,5}$	0.013***	0.013***		
	(0.001)	(0.001)		
$\Delta c_{t,6}$	0.008***	0.006**		
	(0.000)	(0.001)		
$\Delta c_{t,7}$	0.020**	0.025***		
	(0.002)	(0.001)		
$\Delta c_{t,8}$	0.022***	0.019***		
	(0.001)	(0.001)		
$\Delta p_{t,1}$	0.219***	0.115***	-0.283**	-0.250**
	(0.014)	(0.001)	(0.038)	(0.028)
$\Delta p_{t,2}$	0.043	0.202***	-0.216***	-0.119**
	(0.038)	(0.011)	(0.016)	(0.022)
$\Delta p_{t,3}$	0.048**	0.141***		
	(0.005)	(0.005)		
$\Delta p_{t,4}$	0.032*	0.038		
	(0.008)	(0.016)		
$\Delta p_{t,5}$	0.055**	0.050**		
	(0.010)	(0.008)		
$\Delta p_{t,6}$	0.026	-0.027		
	(0.041)	(0.013)		
$\Delta p_{t,7}$	0.241**	0.275**		
	(0.031)	(0.031)		
$\Delta p_{t,8}$		-0.097*		
		(0.023)		
$c_{i,t-1}$	0.817***	0.850***	0.156*	0.099
	(0.018)	(0.006)	(0.046)	(0.046)
$z_{i,t-1}$	-0.012***	-0.013**	-0.010*	-0.033**
	(0.001)	(0.001)	(0.003)	(0.004)

*** Significant at the 1% level. ** Significant at the 5% level. * Significant at the 10% level. Robust standard errors in parentheses.