Open Price Contracts, Locked-In Buyers, and Opportunism

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Abstract

While there is a large literature on incomplete contracts, one prominent type of incomplete contract has received little attention. An "open price contract" is one in which a buyer commits to purchasing goods from a seller even though the price is not yet set. They generally give the seller the right to set prices later, and the buyer is then obligated to purchase at those prices. This gives rise to obvious incentives for short-run opportunistic pricing by sellers, but with obvious reputational consequences as well. In this article, we test for opportunistic pricing on locked-in buyers in a specific application.

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1 Introduction

The theory of contracts has attracted much attention from economic researchers 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. Economic theorists have studied optimal contract design in a variety of situations, including in the presence of 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), Hart (2017)). This last field of research is known as incomplete contracting, and seminal theoretical works in the field highlight the potential for opportunistic behavior on the part of the parties when unexpected events require extensive contract renegotiations.

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An empirical literature on incomplete contracts has followed (e.g. Hoppe and Schmitz (2010), Antras and Staiger (2012), and Bajari et al. (2014)), but one very prominent type of incomplete contract has received little attention. "Open price contracts" or "open price term" contracts are ones in which a buyer commits to purchasing products from a seller even though the price is not set or agreed upon at the time of signing. While it may seem unwise for a party to commit to buying or selling products without agreeing to a price in advance, these types of contracts are actually commonplace 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 contracts. These contracts generally give the seller the right to set and change prices from time to time and the buyer is then obligated by contract to purchase from the seller at the prices so set and so changed from time to time.

Open price contracts create a set of interesting incentives, most notably the incentive for sellers to raise prices on its locked-in buyers in an opportunistic way ex post. This makes the gap in the empirical literature all the more surprising and it is a gap that we attempt to begin to fill in here.[1] We examine the potential for opportunistic pricing behavior on the part of the party that has ex post control over prices at the potential expense of the party that is locked-in and captive to the first party's pricing choices.

We do so in the context of a specific application, the wholesale fuels industry. Long term open price contracts between wholesale fuel sellers (refiners) and wholesale fuel buyers (retailers) are common and generally contain an open price term that gives sellers the authority to set and from time to time change wholesale prices over the life of the contract. Buyers are then obligated to purchase at the wholesale prices so chosen and from time to time so changed by the seller.

As background, open price contracts are a subset of what economists called "incomplete contracts". The theory of incomplete contracts dates back to seminal works by Grossman and Hart (1986), Hart and Moore (1988), and Hart and Moore (1990), and stems from 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 is realized, contract renegotiations may become necessary and these can lead

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

to hold-up problems and productive inefficiency. An interesting result from the literature is that assigning residual decisionmaking rights to one party or the other for when an unforeseen state of the world arises can improve this outcome, especially when the rights are given to the party whose investment is most important at the margin (Aghion and Holden (2011), Hart (2017)).

Open price contracts are incomplete contracts in which a very fundamental component on the contract - namely the price - is not set in advance. They are useful in situations where many individual transactions are expected to take place over the life of the contract, and where prices are difficult to set in advance because they depend on unknown costs and other uncertainties.

Franchise contracts typically have open price terms that surround the price of inputs. As it would be difficult to negotiate a price for each input for each period of time for each potential realization of the world over the term of the contract, these contracts are inherently incomplete and contain an open price term. In the case of restaurants and hotels, franchisees are often required to purchase major inputs from the franchisor or from a limited list of approved vendors provided by the franchisor, at prices either set by the franchisor or the vendor and changed from time to time.[2] In the case of clothing retail outlets, mobile telephone store outlets, gasoline stations, and car dealerships, franchisees are generally required to purchase most major inputs directly from the franchisor at prices set by the franchisor and changed by the franchisor from time to time.[3]

There is a large literature on franchising contracts, but most studies focus on other aspects 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 effects of the open price terms contained in these contracts.

We postulate that the open price term could lead to ex post price opportunism on the part of the seller (i.e. the franchisor) with respect to its contractually-obligated and locked-in buyers (i.e. its franchisees). A seller could, for example, include a low initial price for a product under the

[2] Franchised restaurants are often required to purchase their food, packaging, and signage from the franchisor or an approved vendor, and franchised hotels are often required to purchase bedding, furnishings, and signage from the same. Labor inputs are an obvious exception, few franchisors restrict a franchisee's labor choices except to specify minimum quality standards for certain positions.

[3] An Apple Store franchisee is often required to purchase its inventory from Apple and a Ford dealership franchisee is generally required to purchase its inventory from Ford.

terms of the contract but then raise it after the contract is signed and the buyer is locked-in. It could also pass through cost increases especially aggressively to its locked-in buyers vis-a-vis other buyers. The theory of incomplete contracts predicts that the holder of residual rights - in this case the seller that has the authority to set and change prices as new states of the world are realized - would set ex post prices in a way that maximizes its own gain under the contract. It would be interesting to test this in a real world setting.

There is one reason, however, why a seller with residual price setting rights might not engage in short run price opportunism after all. It is out of concern for their long run reputation and competitive positioning in the market for future contract signings. While incomplete contract theory often focuses on incentives under a single contract, in practice, sellers enter into contracts with many buyers at the same time and engage in long run competition for new contracts with new buyers and contract renewals with existing buyers. A buyer's decision to enter into an open price contract will depend on the seller's history and reputation, including its propensity to price opportunistically on its already locked-in buyers. These long-run competitive considerations could offset or even eliminate any short run opportunistic pricing incentives presented to sellers by the open price contract.

A second reason worth mentioning 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.[4] 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 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)).

So do open price contracts lead to short run opportunistic pricing behavior on the part of the seller, as suggested by incomplete contract theory? Or do long-run competitive considerations effectively limit the incentive in real world practice?

Our application to the wholesale motor fuels industry should be insightful for several reasons.

[4] Each state has adopted the UCC in some form into state law.

First, contracts in the industry tend to be long, for reasons discussed below, which means compounding uncertainty over possible realizations of the state of the world and a greater ex ante potential for opportunistic pricing. Second, there have been several lawsuits claiming unfair or unreasonable pricing on the part of sellers which would suggest the industry might be a good place to look. Third, since wholesale prices make up the vast majority of the retail price of fuel, the stakes are high and the manner in which sellers exercise price-setting rights carries clear short run and long run consequences for all parties.

There is one more important and practical reason for focusing on our application. Unlike most other franchise industries, we can observe both types of buying arrangements in this industry at the same time - one in which wholesale fuel is sold under open price contracts (in which buyers are obligated to buy at prices set by sellers) - and one in which the identical wholesale fuel is sold on the open, unrestricted market (without contract and without obligation to buy). This unique situation allows us to compare and contrast seller pricing practices in the presence and in the absence of open price contracts (i.e. under different contract types) and examine potential opportunistic pricing behavior in the former.

The obvious concern is that a buyer entering into an open price contract versus operating without a contract is a choice, and there can be selection or reverse causality concerns. We will argue that, conditional on entering the industry, a buyer's contract type is largely pre-determined, based on the financial position of the buyer and prior investment decisions made by it. In our first set of analyses, we take contract type to be pre-determined and compare across contract types. In our later set of analyses, we control for possible self-selection and reverse causality (to the extent there is scope for choice by buyers at the margin) by exploiting a unique natural experiment in which we compare seller pricing *within* contract type. Specifically, we compare seller pricing, within contract type and, in fact, within the same contract, to different degrees of "surprise" in the realization of the state of the world. The greater the "surprise" in the state of the world, the less precedent there is on how sellers with residual price control will respond, and the greater the chance for opportunistic pricing under the theory of incomplete contracts. This type of natural experiment is new to the literature.

The remainder of this study is organized as follows. Section 2 begins with background on the wholesale fuels industry that is the subject of our application. Section 3 describes the data. Section 4 identifies three forms of potential price opportunism and outlines our methodology for detecting them. Sections 4 through 8 contain our main empirical results. Section 4 tests for opportunistic pricing across contract types in the context of regular grade gasoline. Section 5 adds data on premium grade gasoline and tests for opportunistic pricing across and within contract types by exploiting a natural experiment involving an especially unexpected and surprising shock to sellers' production cost differentials across grades. Section 6 analyzes opportunistic pricing using an alternate dynamic and non-parametric approach. Motivated by our findings, Section 7 presents an additional ancillary investigation of how sellers' wholesale pricing practices impact competition further downstream. Section 9 concludes.

2 Contracts, Branding, and Wholesale Pricing

We first review the basics of the wholesale fuels industry. Wholesale gasoline is generally sold by a seller (the refiner) to a buyer (the retailer) either directly or through a middleman. Sales can be 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 Travel Centers.

Regardless of whether a station is branded or unbranded, the physical gasoline sold at each station is generally exactly the same. It is the same gasoline stock that travels from the same refineries through the same common pipelines to the same common storage tanks at a city's terminal facilities. The distinction between branded and unbranded gasoline occurs only at the end of the process - once gasoline is loaded into a tanker truck and delivered to either a branded or unbranded station.[5] There is also little relationship between the name on a retail gasoline station and the

[5] 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. The one rare exception where the quality of gasoline can meaningfully differ from one station to another is if the gasoline at a station becomes stale (i.e. oxygenates) or phase-separates (when water vapor attaches to the ethanol in the gasoline blend over time and separates it from the pure gasoline) due to poorly maintained

refiner that actually refined the gasoline. Spot market contracts among refiners dictate how much each refiner transports to each city and how much each refiner owns and is able to sell to buyers in each city.

Branded stations, although displaying a banner of a major refiner, are rarely owned or operated by the refiner anymore.[6] They are generally owned by independent retailers that range from small one-station operations to chains of hundred stations apiece. Similarly, unbranded retailers are independently owned and operated and range from small one-station operations to chains of hundreds or even thousands of stations. The larger ones, like Costco, Quiktrip or Love's, have substantial brand recognition of their own. They are called unbranded only because they do not carry a refiner's brand name and buy through the unbranded channel.

Whereas thirty years ago it could be argued that branded stations were of a higher quality than unbranded stations on average, this is a more difficult case to make today. Some of the largest and most successful chains are unbranded chains, and 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).

The primary distinction between branded and unbranded gasoline is a contractual one. Branded gasoline is generally sold under a long term contract between the seller (the refiner) and the buyer (the retailer) that includes an open price term. The seller has the authority to set and change its wholesale prices at any time, and the buyer is contractually obligated to purchase from that seller at those prices so set and so changed. A buyer cannot switch to a different seller during the term of the contract even if it feels its prices are too high.[7] The contracts are generally for five to fifteen year terms, and the branded buyer is locked-in to the pricing decisions of the seller during that time.

Unbranded gasoline, in contrast, is generally sold in the unrestricted market without an open

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equipment and extremely low gasoline turnover.

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

[7] Buyers commit to buying a pre-specified minimum quantity of gasoline each month for resale at its stations branded with that refiner's name. Buyers may simultaneously have stations branded with other refiners' names, and supplied under separate contracts with each seller.

price contract or any contract at all. Unbranded buyers without a contract are free to price-shop and buy from any seller on any given day, switching between sellers as often as desired.

A buyer entering into an open price contract is obviously a choice, and this leads to possible selection concerns. After all, why would a buyer choose to enter into an open price contract if it expects to be subject to price opportunism? As we will argue, contract choice is largely predetermined for the vast majority of buyers. An open price contract for branded sales is often the only feasible choice for certain types of buyers while the unbranded channel is the only feasible or sensible choice for other types of buyers.

The branded open price contract 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 several key add-ons. First, it comes with the license to use the seller's brand name, which provides instant brand recognition and can increase traffic and sales. Second, it is the seller, and not the buyer, that generally pays the substantial up-front cost to rebrand and renovate the buyer's station to the brand's standard. The cost to renovate can reach a hundred thousand dollars in some cases and is especially prohibitive for smaller buyers. For these reasons, it can make sense for buyers to enter into a branded open price contract, even if some degree of ex-post price opportunism on the part of sellers were expected. In exchange for the benefits, sellers charge a small per gallon premium on branded sales over unbranded sales.[8]

The reason why sellers require a long term open price contract on branded relationships is straightforward. The long term contract protects sellers' large up-front investments into the buyer's station and the open price term is needed because it is difficult to predict seller production costs (which in turn depend on crude prices) over a long period. The open price term allows the seller to make adjustments to wholesale prices as cost and demand conditions warrant, or as environmental regulations, competition, and production infrastructures evolve. It removes uncertainty for the seller and buyer compared to a fixed price contract, but creates a different uncertainty in that it opens up the buyer to the possibility of ex post price opportunism.

The unbranded sales channel is more suited to different types of buyers. These buyers either

[8] We do not consider the premium for branded gasoline to be an example of opportunism, since it simply reflects the additional economic value of the branded contract and because it is well known to all at the time of signing, i.e. it is not "incomplete" contracting.

do not need, or cannot profitable incorporate, the add-ons that come with the branded contract. For example, large unbranded buyers with brand name recognition of their own have little need to pay a premium to use the seller's brand name and little need for capital assistance when building or renovating stations. On the other end of the scale, smaller, older, or poorly located stations are sometimes too expensive to feasibly retrofit making the unbranded channel the only efficient choice for these kinds of stations. Unbranded stations cannot display or advertise the seller's brand name and receive no capital support from the seller. There is thus no need for an open price contract and unbranded buyers can just purchase unbranded gasoline in the unrestricted market, at a discount to branded gasoline.

So while the two contract types (open price contracts versus no contract) are options in theory, in practice, it is uncommon for individual buyers to switch from the branded channel to the unbranded channel and vice versa, even at contract expiry. This is consistent with our claim that contract type is to a large degree pre-determined for buyers in the industry.

The different contractual arrangements nonetheless affect the incentives for seller pricing. In the branded case, a change in pricing policy by a seller has no short run wholesale consequences and only retail consequences, because wholesale buyers are locked-in by contract to purchase gasoline from the seller. In the unbranded case, the change has wholesale consequences as well as retail consequences because wholesale buyers can switch to other sellers at any time without notice. Sellers thus face no short run competitive pressures from locked-in branded buyers but do face long run competitive pressures from them since short run pricing decisions affect their ability to compete for new branded contracts. There is less distinction between short run and long run competition in the case of unbranded buyers in the absence of open price contracts.

This leads to the question that is at the heart of this study - do sellers act more opportunistically in pricing toward locked-in buyers that are obligated to buy under open price contracts, than to unrestricted buyers that buy on the open market? Or do long run competitive considerations limit or even eliminate it? We discuss manifestations of price opportunism shortly, but first we outline the data used in our application.

3 Data

Our data consists 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 represent actual and opportunity costs of sellers (refiners) for refined wholesale gasoline. Spot prices 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.[9] They are commonly used as a measure of opportunity costs since when sellers sell at spot, they forego the need to ship refined product to individual city terminals and sell to branded and unbranded buyers. They are also actual costs - when a seller is short on supply to meet its contractual obligations, it can buy at spot, and when it has a surplus, it can sell. Accordingly, we 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, but 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 refiner 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.

The third set of prices are the familiar "retail prices" charged by wholesale buyers (retailers) to consumers for each gallon of gasoline. These will be used in our ancillary analysis of downstream competitive effects. We have separate 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

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

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 three potential manifestations of price opportunism by sellers on their locked-in branded buyers.

The first and most obvious would be if a seller, after signing a contract with a branded buyer, suddenly and unexpectedly increased its margins on that buyer while still keeping it low for new and similar branded sign-ups. However, we can easily dismiss this potential manifestation by construction of open price contracts in the industry.

The wholesale price paid by branded rack buyers is based on the posted branded rack price, which is the same for each buyer, less a set of discounts that are specific to the buyer. The discounts are set out in the contract and are therefore not examples of incomplete contracting. When branded rack prices rise and fall, the rack price structure means that final prices necessarily rise and fall similarly for all buyers buying from the same seller at the branded rack. Final prices may differ due to different negotiated discounts, but final prices cannot systematically diverge in unexpected ways for branded rack contracts.[10] We thus rule out this potential manifestation and focus instead on other, more subtle potential manifestations of price opportunism.

In particular, we examine how sellers respond to sudden and unexpected shocks in their own costs of production, i.e. shocks to spot prices, and how quickly they pass them through to locked-in buyers under open price contracts on one hand, and to unrestricted unbranded buyers on the other. We do this in two distinct exercises, the first being a straightforward comparison of passthrough rates across contract types (open price contracts versus no contracts) and the second taking advantage of a unique natural experiment that allows us to compare different potentials of price opportunism even within the same contract type.

The first exercise focuses on regular grade gasoline, the product at the center of the vast majority of studies on gasoline pricing. We test if sellers pass their regular grade gasoline production costs,

[10] The type and amount of discounts may vary over the term of the contract but, since this is also known in advance, it is not an example of an incomplete contracting.

particularly increases, through to their locked-in branded buyers more aggressively than to their unrestricted unbranded buyers.

It is well known that cost increases for regular grade gasoline tend to be passed though to output prices with a lag and that the lag can often be multiple weeks, depending on the geography and time period studied (Lewis and Noel (2011), Marion and Muehlegger (2011), Knittel et al. (2017), Blair et al. (2017), Ahundjanov and Noel (2019)). This is normal and of no surprise. It is also well known that regular grade gasoline cost increases are sometimes passed through more quickly than cost decreases, again depending on the geography and time period studied. Again, this is normal and of no surprise. Asymmetry in response based on the direction of the cost change is known as the "rockets and feathers" effect and has been well studied (Borenstein et al. (1997), Bachmeier and Griffin (2003), Deltas (2008), Noel (2009), Lewis (2011), and many others).

In this article, we are not interested in the speed or asymmetry of cost passthrough per se, but we are interested in the $difference$ in cost passthrough rates on a seller's locked-in branded buyers versus its unrestricted unbranded buyers. We interpret especially fast and aggressive passthrough of a seller's regular grade gasoline cost shocks on its locked-in branded buyers compared to its unrestricted unbranded buyers, , cost increases in particular, as an example of price opportunism. We interpret especially slow and cautious passthrough of a seller's regular grade gasoline cost shocks on its locked-in branded buyers compared to unrestricted unbranded buyers as the opposite of price opportunism - an example of price volatility smoothing by sellers. Price volatility smoothing by sellers on behalf of their locked-in buyers would be consistent with long run incentives to forge buyer relationships and compete more aggressively in the long run market for new contracts.

Sellers' pricing on unrestricted, unbranded buyers serves as the benchmark case. These buyers are not locked-in and are free to switch to other sellers in the unrestricted wholesale market at any time. Without an open price contract, there is less scope for price opportunism, and there is no long run competition for new open price contracts.

We discussed the concern that different buyers may, to some degree, self-select into different contract types, and it is a problem if the reasons for selection also matter for passthrough rates. This could bias the interpretation of the results, since we are interpreting faster passthrough rates under open price contracts as manifestations of opportunistic pricing. A related concern is that consumers of branded and unbranded gasoline may also be different in ways that matter for passthrough rates. Earlier, we noted that branded and unbranded gasoline were the same physical product and we argued that the open price contract was the primary difference between the two sales channels. We are comfortable with this interpretation in today's world (that a consumer at a Stop and Shop, Circle K, or Love's Travel Stop is not systematically different than a consumer at a ConocoPhillips, Valero, or Chevron), but we recognize that perceptual differences at the consumer level can potentially matter for pricing and passthrough.

To address these concerns, we adopt a second approach that allows us to make comparisons *within* each contract type, i.e. within the set of locked-in branded buyers and within the set of unrestricted unbranded buyers, instead of just across. It is a natural experiment involving an especially large and unanticipated shock to the costs of producing premium grade gasoline. The shock was a historic increase in the cost of high octane blendstocks in the early 2010s which in turn substantially increased sellers' relative costs of producing premium grade gasoline relative over regular grade gasoline.

The shock is important not just because there was a relative cost increase but because the increase forced a fundamental seller reevaluation of how premium grade gasoline prices were set. It is the quintessential kind of shock to the state of the world imagined in the incomplete contracts literature - large, unanticipated, and unprecedented. In contrast to regular grade gasoline cost shocks for which there was a fairly long history of how sellers would respond and what was expected of them, there was little precedent for how sellers would change their approach when the old premium pricing algorithm no longer worked. The potential for opportunistic pricing was high.

As background, premium grade gasoline is priced fundamentally differently from how regular grade gasoline is priced. Regular grade rack prices are set freely each day by each seller each day according to market conditions, but premium grade gasoline rack prices are generally built up according to a pricing formula. Premium rack prices are calculated as the sum of the regular grade rack price plus a per gallon premium-regular rack price differential. While it varied by seller, the differential would often be in the neighborhood of twenty cents per gallon. The relative cost of producing premium grade gasoline over regular grade gasoline was relatively more stable for many years, and as a result the regular grade spot differentials were relatively stable as well.

This all changed in the early 2010s when the cost of higher octane blendstocks began to soar to record levels. How would sellers pass through these especially large and unprecedented increases in their own relative production costs? Would they do so more quickly than for more typical regular grade gasoline cost changes, at least in the case of locked-in branded buyers? How about for unrestricted unbranded buyers? Unlike regular grade cost shocks, there was little precedent for how sellers would deal with the historic run-up in the premium-regular grade cost differential and the scope for opportunistic pricing was high.

We thus extend the data to premium grade gasoline as well and estimate the rate of passthrough of sellers' cost *differential* between regular and premium gasoline into the rack price differential. We compare these rates to the corresponding passthrough rates for regular grade gasoline passthrough, separately for each type of buyer. The two different kinds of shocks correspond to different degrees of surprise, or unprecedentedness, but importantly both occur within the same contract type. For locked-in branded buyers, the incomplete contracts theory would suggest a higher potential for price opportunism in the case of the premium-regular grade cost change, a shock that was unusual and unprecedented in recent times. For unrestricted unbranded buyers operating without open price contracts, there is less difference between short run and long run incentives, and one would expect less a difference in responses.

In this way, our analysis takes the shape of a traditional natural experiment, with two dimensions of treatment - the first being buyer type (high-treatment locked-in buyers versus low-treatment unrestricted buyers) and the second being the unprecedentedness of the shock (higher-treatment premium-regular grade gasoline differential cost shocks and lower-treatment regular grade gasoline cost shocks). The results are interesting and highlight the importance of competitive dynamics in the context of incomplete contracting models.

We ultimately find that seller responses differed enormously in these situations, and this leads to our final ancillary question. How do these different seller passthrough rates at the wholesale level impact prices and competition further downstream? We explore this question by examining passthrough rates from rack prices to retail prices, first for regular grade gasoline retail prices and then for premium-regular grade retail price differentials, and separately for branded and unbranded gasoline. We find that differences in the seller-buyer relationship at the wholesale level have important implications for downstream competition.

5 The Case of Regular Grade Gasoline

We begin by examining the rate of passthrough of regular grade gasoline from spot prices to rack prices, distinguishing between a seller's locked-in branded buyers and its unrestricted unbranded buyers.

5.1 Preliminary Diagnostics

We first perform a series of preliminary diagnostic tests. We test for unit roots in each time series and for possible cointegration between each successive pair 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 and the two series are not also 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:

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

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).[11] 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 conclude that each series is I(1) stationary.

We 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

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

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:

$$\begin{aligned} \Delta y_{it} &= \delta_i' d_t + \alpha_i (y_{i,t-1} - \beta_i' x_{i,t-1}) \\ &\quad + \sum_{j=1}^{p_i} \alpha_{ij} \Delta y_{i,t-j} + \left[\sum_{j=-q_i}^{p_i} \gamma_{ij} \Delta x_{i,t-j} + e_{it} \right] \end{aligned} \tag{2}$$

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:

$$G_\alpha = \frac{1}{N} \sum_{i=1}^{N} \frac{\widehat{\alpha}_i}{SE(\widehat{\alpha}_i)} \text{ and } G_\tau = \frac{1}{N} \sum_{i=1}^{N} \frac{T\widehat{\alpha}_i}{(\widehat{\alpha_i(1)})} \tag{3}$$

where SE denotes the usual standard error, and $\widehat{\alpha_i(1)}$ is the estimate of the term given in square brackets in Equation 2 including the residual. The panel statistics are given by:

$$P_\alpha = \frac{\widehat{\alpha}}{SE(\widehat{\alpha})} \text{ and } P_\tau = T\widehat{\alpha} \tag{4}$$

where

$$\widehat{\alpha} = \left(\sum_{i=1}^{N} \sum_{t=2}^{T} \widetilde{y}_{i,t-1}^2 \right)^{-1} \sum_{i=1}^{N} \sum_{t=2}^{T} \frac{1}{\widehat{\alpha_i(1)}} \widetilde{y}_{i,t-1} \Delta \widetilde{y}_{it} \tag{5}$$

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. 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. In every case, we find that all four statistics reject the null hypothesis of no cointegration at the 1% level. Hence we proceed under the assumption of cointegration.

5.2 Passthrough of Regular Grade Gasoline

We begin our main wholesale pricing analysis with a series of vector autoregressive error-correction model regressions (VAR-ECM) in the spirit of Engle and Granger (1987). We estimate the rate of passthrough of sellers' regular grade gasoline costs, i.e. spot prices, into its regular grade gasoline output prices, i.e. rack prices. As we are interested in the effects of potential price opportunism on locked-in branded buyers governed by open price contracts, we compare passthrough rates on locked-in branded buyers to the benchmark group of unrestricted unbranded buyers not subject to open price contracts.

Since raw regression results in VAR-ECM models are difficult to interpret, we follow the standard practice in the literature of reporting the impulse response functions generated from these models.[12]

We estimate:

$$\Delta p_{it} = \sum_{j=0}^{s} \beta_j \Delta c_{i,t-j} + \sum_{j=1}^{r} \gamma_j \Delta p_{i,t-j} + \theta z_{i,t-1} + \varepsilon_{it} \tag{6}$$

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.[13] The z_{it} represents the current deviation from the long run equilibrium, or error correction term, and is given by:

$$z_{it} = p_{it} - \alpha_0 - \alpha_1 c_{it} - X_{it}\Phi \tag{7}$$

where the X_{it} contain a set of city-specific indicator variables.

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 $t = 0$:

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

[13] In a few cases, we find slightly higher standard errors without the clustering adjustment than with the adjustment. When this happens, we report the wider confidence intervals associated with the larger standard errors to be more conservative.

$$IRF_{it} = \widehat{p_{it}} - \widehat{p_{i,t-1}} + IRF_{i,t-1} \tag{8}$$

or

$$\begin{aligned} IRF_{it} &= \widehat{\beta}_t + \sum_{j=1}^{t} \widehat{\gamma}_j (IRF_{i,t-j} - IRF_{i,t-j-1}) \\ &\quad + \theta(IRF_{i,t-1} - \widehat{\alpha_1}) + IRF_{i,t-1} \end{aligned} \tag{9}$$

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

We report impulse response functions for the regular grade spot-to-rack transmission link in Figure 1. There are separate plots for branded and unbranded buyers.

Turning to our first main result, the figure shows a markedly different passthrough rate for branded gasoline than unbranded gasoline, and not in the direction one would expect if sellers were acting in a short run opportunistic way. Rather than faster and more aggressive cost passthrough on branded gasoline, we find slower cost passthrough on locked-in branded buyers than on unrestricted unbranded 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 46 percentage points.

Under the opportunistic pricing hypothesis, one would have expected relatively fast and more aggressive passthrough on those buyers obligated to keep purchasing gasoline at the new prices. We find the opposite, that sellers are making price adjustments in a more cautious way on their locked-in branded buyers than their unrestricted unbranded buyers. The finding is inconsistent with opportunistic pricing and consistent with the alternate hypothesis that long run competitive considerations play an important role. Sellers appear to be smoothing out short run cost fluctuations and providing essentially a price volatility buffer on behalf of their contracted buyers, something not done to the same degree for their unrestricted uncontracted buyers. Providing a degree of market buffer protection for branded retailers would presumably be beneficial to the seller in the long run competitive market for new contract signings.

Even prior to performing our natural experiment exercise, we see that our results are inconsistent with a consumer heterogeneity story. Under this hypothesis, systematic differences in the price elasticities of consumers that patronize branded gasoline stations and those that patronize unbranded stations can lead to different passthrough rates having nothing to do with contract type per se. It is well known after all that branded stations historically focused more on non-price factors and charged a small premium for the same physical gasoline. If consumers that patronize branded stations are indeed less price elastic in general, it would imply a smaller demand response to price increases and thus a faster rate of cost passthrough for these consumers. However, we find the opposite here. Passthrough rates are slower, not faster, on branded gasoline. We thus rule out the consumer heterogeneity hypothesis as the source of the difference we find in regular grade passthrough rates.

Similarly, we can rule out our main selection concern - why would branded buyers lock into an open price contract if they expect to be subject to short run opportunistic pricing from sellers? Our results show that they are not subject to opportunistic pricing from sellers after all, so there is no adverse selection away from branded contracts in this regard. Branded contracts remain the purview of buyers that both need and qualify for the more expensive branded contract, while unbranded contracts go to those buyers (from large chains to small independents) that either do not need or do not qualify for it.

Turning to 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 and unbranded buyers respectively. The results are in line with typical rate of passthrough estimates in the literature, noting that the literature does not distinguish by contract type as we do here. The confidence intervals are also relatively tight compared to most in the literature, which is expected with our regional focus and our new separation of IRFs by contract type.

The above analysis is based on a symmetric VAR-ECM model, but we recognize that it is possible that price opportunism manifest itself in a more asymmetric form instead. For example, it is possible that sellers pass costs through to its 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. The concern is that the symmetric model may be masking price opportunism by averaging a very high passthrough rate on cost increases with a very low passthrough rate on cost decreases for locked-in branded buyers. To test for this, we estimate an asymmetric version of Equations 6 and 7 given by:

$$\begin{aligned} \Delta p_{it} &= \sum_{j=0}^{s} \beta_j^{+} \Delta c_{i,t-j}^{+} + \sum_{j=0}^{s} \beta_j^{-} \Delta c_{i,t-j}^{-} + \sum_{j=1}^{r} \gamma_j^{+} \Delta p_{i,t-j}^{+} + \sum_{j=1}^{r} \gamma_j^{-} \Delta p_{i,t-j}^{-} \\ &\quad + \theta^{+} z_{i,t-1}^{+} + \theta^{-} z_{i,t-1}^{-} + \varepsilon_{it} \end{aligned} \tag{10}$$

where

$$z_{it} = p_{it} - \alpha_0 - \alpha_1 c_{it} - X_{it}\Phi \tag{11}$$

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.

The relevant question is not whether rockets and feathers is present in our setting, which would not be an uncommon finding, but whether any rockets and feathers effect is stronger on locked-in branded buyers than on unrestricted unbranded buyers. We are specifically asking whether cost increases are passed through to locked-in buyers more quickly than to unrestricted buyers and whether cost decreases are passed through more slowly.

We present our asymmetric 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. In short, we find that the earlier symmetric model does not mask any opportunistic pricing behavior on the part of sellers and all our conclusions carry through.

We find little in the way of rockets and feathers in general at the spot-to-rack level. Figure 2 shows a slight rockets and feathers effect in the early days on branded gasoline which then actually reverses to a slight balloons and rocks effect after the tenth day. While the asymmetries are always small, the reversal itself is interesting and inconsistent with opportunistic pricing. 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. There is no reason for sellers to do this if they were pricing opportunistically, and it shows that sellers are setting prices in an especially cautious way with respect to these buyers. In contrast, Figure 3 for unbranded gasoline shows that sellers pass through cost increases and cost decreases similarly. After a slight and similar rockets and feathers effect in the first few days, passthrough rates become indistinguishably symmetric after ten days. There is no asymmetry reversal on unbranded gasoline as we found for branded gasoline.

We can also compare directly across the two figures. We compare the rate of passthrough of cost increases on branded versus unbranded buyers and, separately, the rate of passthrough of cost decreases between the two types of buyers. 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 price smoothing function provided by the seller to its locked-in branded buyers, which we first saw in Figure 1, carries over to our asymmetric analysis. We conclude that the symmetric model is not masking any manifestations of price opportunism in the form of very fast passthrough on cost increases for locked-in branded buyers.

6 The Case of Premium-Regular Differentials

We now turn to an analysis of passthrough of premium-regular grade cost differentials. Earlier we noted that premium grade gasoline is generally set by a formula equal to the regular grade rack price plus a premium-regular differential. Relative production costs between premium and regular had been relatively stable in the past and rack price differentials were in turn relatively stable, until a historically large increase in the cost of high octane blendstocks in the early 2010s put pressure on sellers to increase rack price differentials. How would sellers exercise their residual right to set prices following this shock?

The shock 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 typical term of ten years) were signed prior to the unexpected run-up in the spot price differential and were still in force. And it was largely unprecedented - premium-regular rack differentials had not changed in any meaningful way for many years. In essence, it was new ground. In contrast to regular grade gasoline cost shocks for which there was a long and established history for how sellers would react (a history presumably taken into consideration by buyers prior to contract signing), there was not a similar history for how sellers would react to the historic change in spot price differentials. We would presumably expect them to pass the cost increases through to buyers, but the question is when and how.

It sets up a convenient natural experiment in which we can compare the effects of an open price contract on short run price opportunism not only across contract type (open price contract versus no open price contract) but also within contract type. In short, we test for short run opportunistic pricing on locked-in branded buyers by comparing seller pricing responses under two different degrees of surprise and two different degrees of short run opportunistic pricing "potential". The shock to sellers' own production cost differentials represents a realization of the world that was especially surprising, compared to regular grade cost shocks which were more commonplace. The theory of incomplete contracts suggests that the potential for short run opportunistic pricing on locked-in branded buyers under open price contracts would be greater for this more unexpected realization of the world, because it deviates more radically from typical experience and history. Sellers' pricing towards its unrestricted unbranded buyers can still serve as a competitive benchmark and a second dimension of control.

This squares our analysis into the shape of a traditional natural experiment, with two dimensions of treatment - the first being buyer type and the second being the unprecedentedness of the shock. We compare the $difference$ between the two types of cost passthrough (passthrough of regular grade cost shocks and passthrough of premium-regular grade cost differential shocks), and then compare the differences between locked-in buyers and unrestricted buyers on these differentials. Under the opportunistic pricing hypothesis, we would expect faster passthrough of premium-regular cost differential shocks than regular grade cost shocks for locked-in branded buyers, and that the differerence would be greater than the corresponding difference for unrestricted unbranded buyers. For the long term contract competition hypothesis, we would expect especially slower passthrough of premium-regular grade cost differentials on locked-in branded buyers in particular.

6.1 Preliminary Diagnostics

We begin with preliminary diagnostics. We report results from our LLC unit root tests 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. We do reject unit roots in the first differences in every case. We conclude that each series is I(1) stationary.

We test for cointegration of upstream and downstream premium gasoline prices, and upstream and downstream premium-regular price differentials. We report results for the former in the middle part of Table 3 and the latter in the bottom part of the table. Columns (1) and (2) report group-mean statistics for the spot-to-rack transmission link and the rack-to-retail transmission link respectively, and Columns (3) and (4) report panel statistics for the same. 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, and proceed.

6.2 Passthrough of Premium-Regular Differentials

We report impulse response functions for the passthrough of premium-regular grade spot differentials into premium-regular rack differentials in Figure 4. There are separate plots for branded and unbranded gasoline. The results of this exercise are particularly striking. Figure 4 shows a markedly different passthrough rate of premium-regular cost differentials across passthrough type and across buyer type, and again not in the direction one would expect if sellers were acting in a short run opportunistic way.

We begin with an analysis of 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 elected to *not* pass that cost increase through to its locked-in branded buyers almost at all, even though these buyers would be obligated to buy at the higher prices. The passthrough rate on the differential reaches only 4% after 30 days, in contrast to the 91% 30-day passthrough rate we found on regular grade gasoline cost shocks for these buyers back in Figure 1. That is just $1/23rd$ as much, and the rate is always substantially and statistically significantly lower at each point in time. In other words, 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 fashion.

To check this result, we contrast the experience of locked-in branded buyers to our benchmark case of unrestricted unbranded buyers. We calculate the difference in the two passthrough rates for unrestricted unbranded buyers and compare it to the twenty-three-fold decrease in passthrough rates we found for locked-in branded buyers. In short, we do not see the same massive 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%, substantially and statistically significantly smaller than the corresponding 87% difference for locked-in branded buyers.

Comparing the two plots contained in Figure 4, across buyer type, the results are just as striking. The cost differential increase was largely passed through to unrestricted unbranded retailers by the end of 30 days (71%), while very little of the cost differential was passed through to locked-in branded buyers (4%). The difference was 67 percentage points. Exactly where sellers had the greatest opportunity to price in a short run opportunistic way, we find that sellers were in fact the most restrained. Later, when we explore the dynamics of the shock in more detail, we will show that sellers in fact insulated their locked-in buyers to a substantial degree for a significant span of time.

The opposite of short run price opportunism, our results are consistent with the hypothesis that long run competitive considerations are most important. The premium-regular cost differential run-up carries a greater potential for short run price opportunism than for regular grade cost shocks, but it also carries a greater potential for negative long run contract ramifications. Buyers are generally unhappy with price increases and presumably especially so with new and unexpected forms of price increases, even if a seller is just passing through costs. They are likely to be unhappier still if a seller its raises prices more quickly than other sellers, which can lead to an extended war of attrition, which in turn is what we find here. We conclude that long run incentives in terms of competing for new contracts and contract renewals dominate the obvious short run incentives to price opportunistically in our application.

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.

6.3 The Premium Paradox

The almost complete lack of passthrough of the spot price differential into the rack price differential is independently interesting for a second reason. It stands in sharp contrast to the conventional wisdom in the gasoline literature that costs tend to be passed through to output prices relatively 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 tends to come up in these discussions. In this study, we have found that a near-zero rate of passthrough is not only possible but has existed for many years on a very important gasoline product, that of premium gasoline, at the wholesale level.

The reason the literature has been silent on this significant pricing friction is relatively straightforward. The vast majority of papers focus on regular grade gasoline and, as we have shown, passthrough rates from spot to rack 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, do not take into account the formulaic nature of premium rack prices (Karrenbrock (1991), Remer (2015)). We show that one needs to take into account the formulaic nature of premium grade rack pricing to see the friction. 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 passthrough is estimated, it naturally appears that premium grade has a relatively high passthrough rate, similar to, but a bit lower than, that of regular grade. The result is spurious in the sense that premium grade passthrough is being driven largely by regular grade cost changes and not by the independent component that sets premium apart. To our knowledge, ours is the first study to examine passthrough of the premium-regular differential and uncover this important and substantial price friction in the vertical supply chain.

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 many years. Our study simultaneously offers an explanation for the paradox. 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 these increases. We argued that this kind of price volatility protection is consistent with long run competitive motives, namely the ability of sellers to compete for new branded contracts in the long run.

7 Non-Parametric Analysis of Differentials

We think it would be interesting to explore the dynamics of the Premium Paradox in more detail and examine how the cost differential shock played out over its multi-year run-up. We take a non-parametric approach and examine a series of kernel density plots, by year, by buyer type, and based on the raw data, showing the shock dynamics over five years.

We begin by demonstrating 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. It shows the distribution of daily changes of each component. Figure 7 shows the distribution of daily regular grade rack price changes, and Figure 8 shows the distribution of daily 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 right at zero), consistent with our first set of results that sellers insulated their locked-in branded buyers from excess market volatility by changing branded regular grade rack prices substantially less often. Figure 8 is more extreme - it shows that unbranded rack price differential changes were about *ten* times more common than branded rack price differential changes (the peak again being at zero), consistent with our second finding that sellers especially rarely changed the rack price differential on branded buyers. The tight and tall distribution for branded rack differential changes is particularly striking, and stands in contrast to the other three distributions in Figures 7 and 8 (which are 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 shows the Premium Paradox and is what drives our main results.

The long run dynamics are interesting. 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.

Figures 10 and 11 show how these spot price differential changes were passed through - or not passed through - to rack price differentials. 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 over time. The overall change in the unbranded rack price differential from 2011 to 2015 was 14.2 cents per gallon, in line with the 13.4 cent per gallon change in the spot price differential over that period.

Figure 11 shows how the same spot price differentials changes were passed through to locked-in branded buyers instead. We see that, for the most part, they were not. The distribution of branded rack price differentials is almost identical from 2011 to 2014, with peaks centered around 19.4 cents per gallon. Only in 2015, after the increase in the spot price differential had almost doubled, was there finally a bit of movement in the branded rack price differential. The movement was still small - the differential increased to only 21.3 cents per gallon, a few cents per gallon above its previous value. Overall, the change in the branded rack price differential from 2011 to 2015 was just 1.9 cents per gallon 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 unbranded rack price differential. The results are consistent with our finding of an exceptionally small and delayed response to sellers' spot price differential changes on their locked-in branded buyers. It is consistent with our conclusion that long run competitive considerations are important when exercising residual price-setting rights under open price contracts and inconsistent with short run opportunistic pricing behavior on the part of sellers.

8 Impacts on Downstream Competition

The different rates of passthrough on branded and unbranded buyers of wholesale gasoline leads to one last ancillary question - how do these different passthrough rates impact prices and competition further downstream?

Imagine an increase in the cost of producing regular grade gasoline, which wholesale sellers pass through to unrestricted unbranded buyers more quickly than to locked-in branded buyers. This applies additional pressure to unbranded buyers to raise their own regular grade retail prices, but doing so would make them relatively less competitive at retail vis-a-vis their branded counterparts. The pressure is even greater for increases in the premium-regular grade rack differential, which wholesale sellers largely pass through to unbranded buyers but almost not at all to branded buyers. So how do unbranded buyers respond to the different passthrough rates? How about branded buyers?

Figures 12 through 15 reveal the answer. Figure 12 shows wholesale buyers' rates of passthrough from rack prices to retail prices for regular grade gasoline, separately for branded and unbranded buyers. It shows that branded buyers, which face smaller and fewer changes in their own costs, i.e. branded regular grade rack prices, pass through what changes they do face more readily. In contrast, unbranded buyers react to relatively higher increases in their own costs, i.e. unbranded regular grade rack prices, by absorbing much of the cost increase themselves and passing relatively less of it through to retail prices. In essence, after wholesale sellers act as a price volatility buffer for their locked-in branded buyers under contract, unbranded buyers respond by acting as their own market buffer in order to remain competitive at the retail level. The difference in the branded and unbranded regular grade rack-to-retail passthrough rates reaches a maximum of 27 percentage points on the $7th$ day after the shock. 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 regular grade spot-to-rack and rack-to-retail passthrough rates into a single figure to see how an increase in the cost of producing regular grade gasoline, after all adjustments, impacts regular grade retail prices. Figure 13 shows that the overall passthrough rate is now similar for branded and unbranded buyers, with only slightly faster passthrough of cost shocks into unbranded retail prices than branded retail prices. Unbranded buyers largely, but not quite completely, offset their higher spot-to-rack passthrough rate with a lower rack-to-retail passthrough rate.

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% in 30 days, while the passthrough rate on branded spot-to-rack differentials was just 4%. Figure 14 now shows that unbranded buyers almost entirely undo this difference with a slower and offsetting rack-to-retail passthrough rate. Unbranded buyers pass just 5% of their rack price differential increases through to consumers after 30 days. In contrast, branded buyers, which face almost no changes in their branded rack differential at all, pass through what little changes they do see more readily, 61% passthrough after 30 days. As before, but in a more extreme way, unbranded buyers absorb their substantially higher rack differential increases in order to remain competitive at the retail level.

Figure 15 shows the combined spot-to-rack and rack-to-retail passthrough rate for premium-regular price differentials. The overall passthrough rates are now very similar for branded and unbranded buyers, again with only slightly faster passthrough into unbranded retail prices than branded retail prices. Unbranded buyers largely, but not quite completely, offset their now substantially higher unbranded spot-to-rack differential passthrough rate with a now substantially lower unbranded rack-to-retail differential passthrough rate.

We can extend our non-parametric analysis to downstream competition as well. Figure 16 shows the distribution of the premium-regular retail price differential for branded buyers from 2011 to 2015, and Figure 17 shows the same for unbranded buyers. Figure 16 shows that 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 after a four year cushion. The average branded retail price differential was 26.4 cents per gallon in 2015, only 3.6 cents per gallon higher than the 2011 average. The increase is substantially less than the corresponding 13.4 cent per gallon spot price differential increase.

Figure 17 shows the dynamic process for unbranded buyers instead. In spite of relatively large rack price differential passthrough, 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 begin to rise a little as well. The average unbranded retail price differential was 25.2 cents per gallon in 2015, just 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.

In short, the spot price differential increase was not passed through to retail prices virtually at all from 2011 and 2014, and only to a small degree in 2015. While sellers insulated their branded buyers from it, unbranded buyers faced it and essentially absorbed it themselves to remain competitive at the retail level. Little trickled down to premium grade consumers, and hence the Premium Paradox.

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 hold-up and inefficiencies when an unexpected realization of the state of the world leads to contract renegotiations after initial investments into the relationship have been made. Efficiency loss can be minimized by assigning residual decisionmaking rights to one of the parties but how this is done substantially affects ex post surplus. The theory of incomplete contracts predicts that the party with residual rights will act opportunistically in its own self-interest when contingencies arise as it exercises those rights.

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. These are common in franchisor-franchisee contracts where many transactions take place over the life of the contract and the price of those transactions depend on future, unknown, costs. Open price contracts generally give the franchisor the right to set prices and change them from time to time. In our application of the wholesale gasoline market, open price contracts are common between sellers and branded buyers and it is the sellers that hold the right to set and change wholesale prices.

We test whether sellers set prices in an opportunistic way on these locked-in branded buyers when shocks to the state of the world occur, as predicted by the standard theory. We find the opposite, however, that sellers pass through cost changes more cautiously on its locked-in branded buyers than on its unrestricted unbranded buyers. The degree of caution was especially pronounced in the case of premium-regular cost differentials which underwent a substantial and unexpected shock. We found that sellers largely insulated their locked-in branded buyers from cost increases in the differentials for years. Sellers' pricing practices on their locked-in buyers are inconsistent with short run price opportunism and consistent with the hypothesis that long run contract competition matters in short run decision-making. Forging buyer relationships and providing a degree of market volatility protection would presumably help sellers win new contracts and contract renewals and improve its sales in the long run.

In spite of the interest in the economics of contracts, there has been surprisingly little empirical research on open price contracts specifically. Our study is a first step in filling that gap. While it may seem strange that a buyer would sign a long term purchase contract without agreeing to the price it would be charged, open price contracts are ubiquitous in our economy. Practically, up-front investments made by a seller into a buyer's business can necessitate the use of a long term contract and volatility in input prices and other future uncertainties can necessitate that it contain an open price term. But no buyer would wisely enter into such a contract without some degree of assurance that the seller will not price in an opportunistic way after signing. We argue that this assurance comes in large part from sellers' long run incentives to compete for contracts, an effort that would be harmed by short run opportunistic pricing on current locked-in buyers. Although the potential for opportunism would seem high in our application ex ante, we find that long run competitive considerations dominate short run temptations and make open price contracts both feasible and agreeable.

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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.

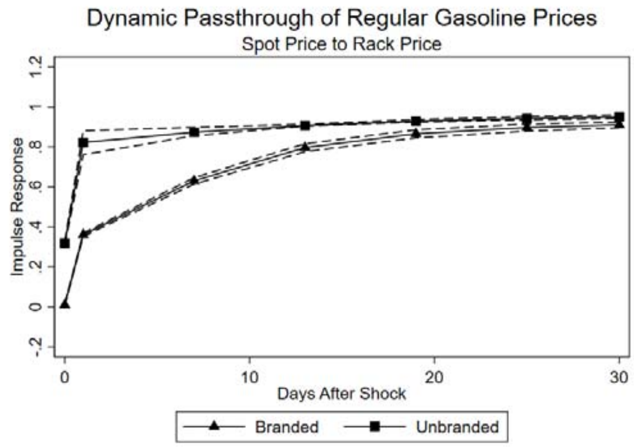

Figure 1. Dynamic Passthrough of Regular Gasoline: Spot Price to Rack Price

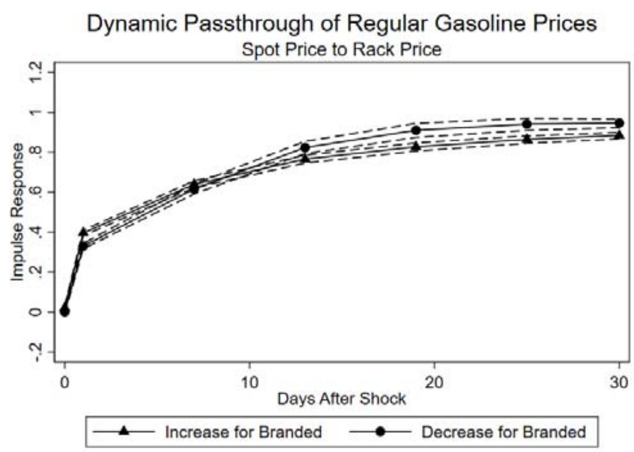

Figure 2. Dynamic Passthrough of Regular Gasoline: Branded Spot Price to Rack Price

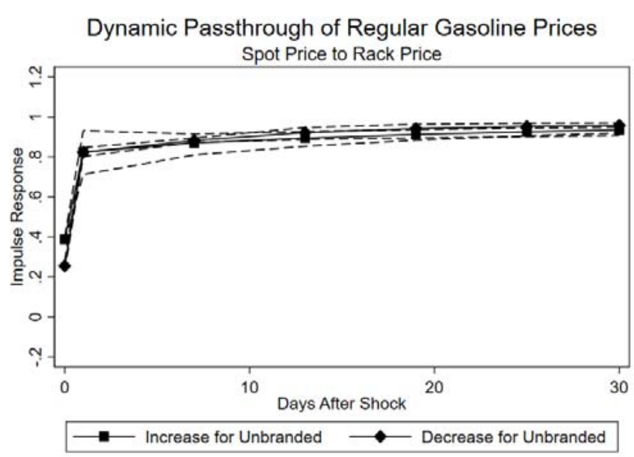

Figure 3. Dynamic Passthrough of Regular Gasoline: Unbranded Spot Price to Rack Price

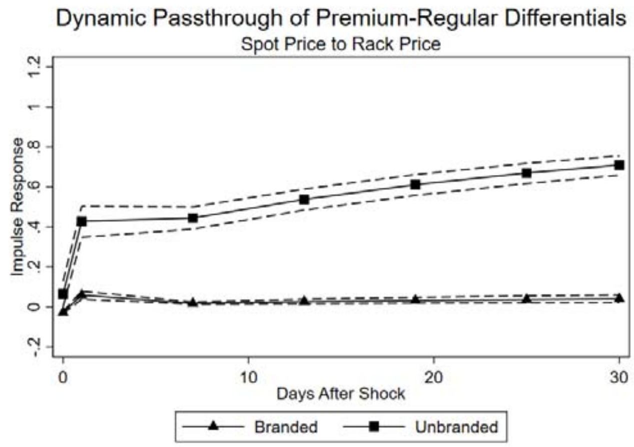

Figure 4. Dynamic Passthrough of Premium-Regular Differentials: Spot Price to Rack Price

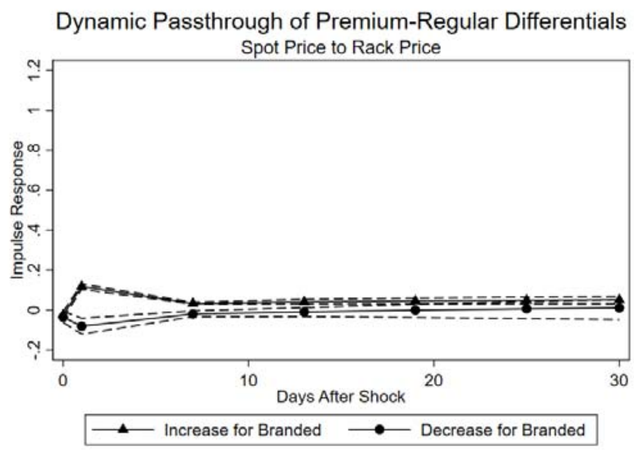

Figure 5. Dynamic Passthrough of Premium-Regular Differentials: Branded Spot Price to Rack Price

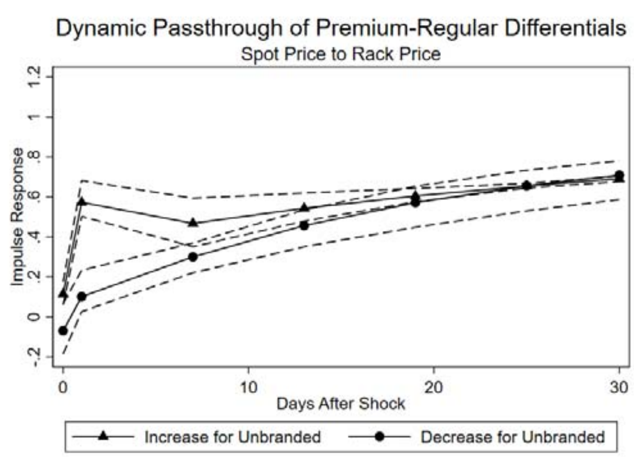

Figure 6. Dynamic Passthrough of Premium-Regular Differentials: Unbranded Spot Price to Rack Price

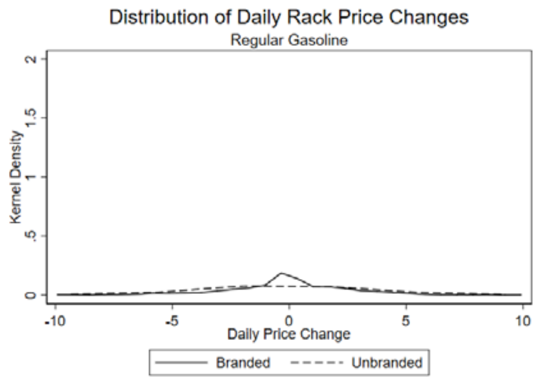

Figure 7. Kernel Density Plots of Daily Rack Price Changes

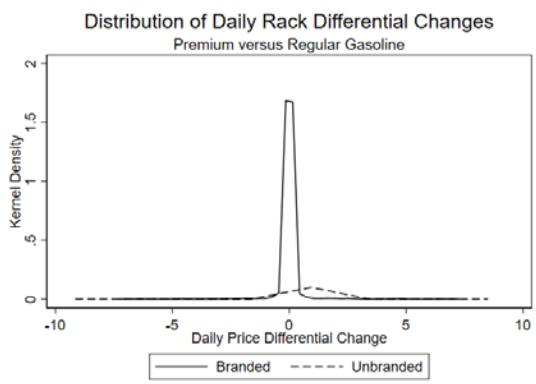

Figure 8. Kernel Density Plots of Daily Rack Differential Changes

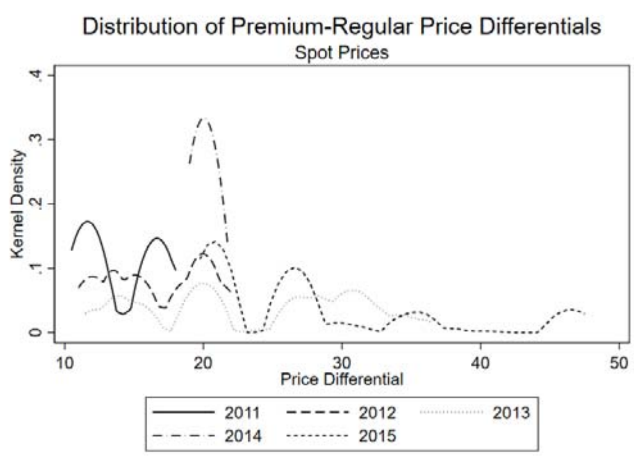

Figure 9. Kernel Density Plots of Premium-Regular Spot Differentials by Year

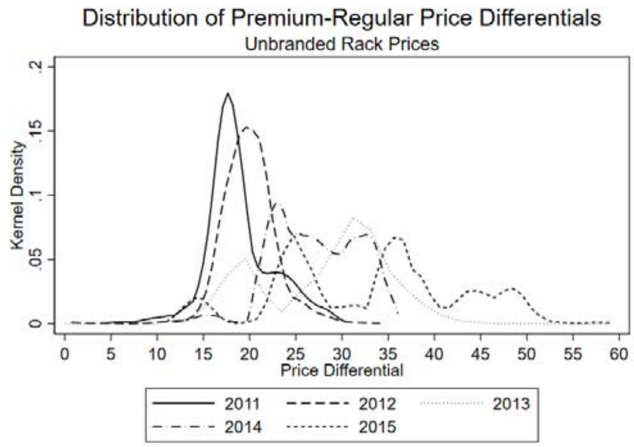

Figure 10. Kernel Density Plots of Premium-Regular Unbranded Rack Differentials by Year

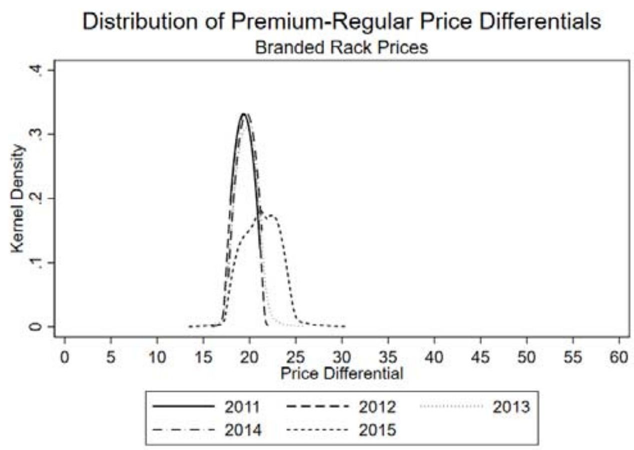

Figure 11. Kernel Density Plots of Premium-Regular Branded Rack Differentials by Year

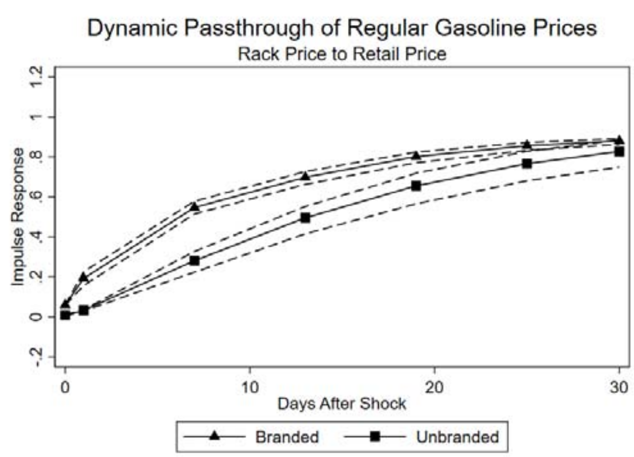

Figure 12. Dynamic Passthrough of Regular Gasoline: Rack Price to Retail Price

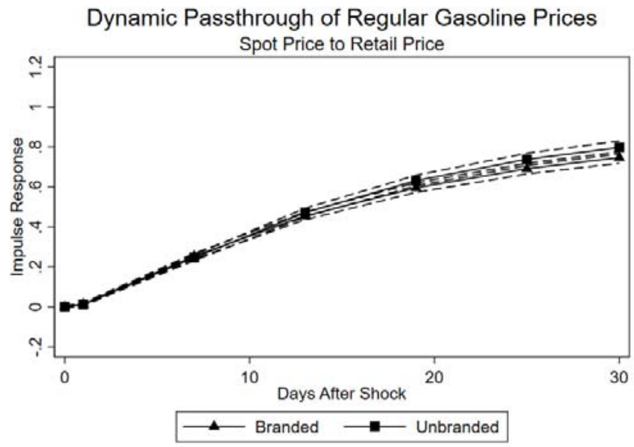

Figure 13. Dynamic Passthrough of Regular Gasoline: Spot Price to Retail Price

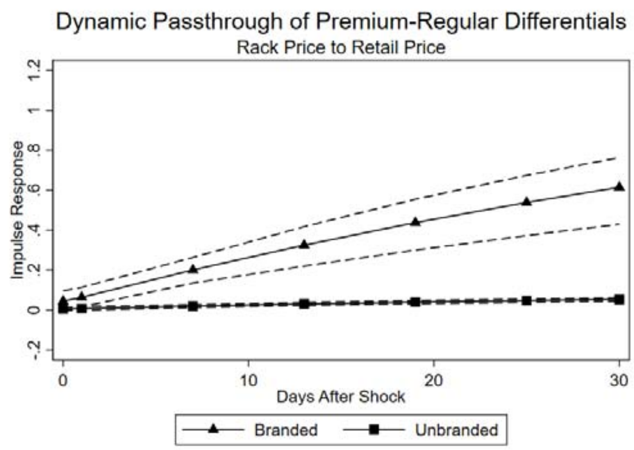

Figure 14. Dynamic Passthrough of Premium-Regular Differentials: Rack Price to Retail Price

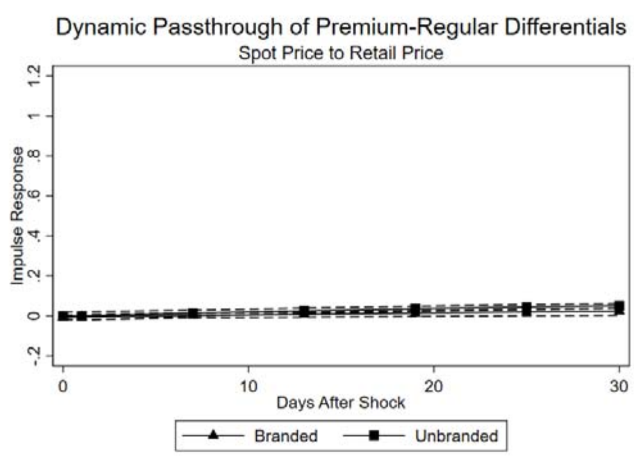

Figure 15. Dynamic Passthrough of Premium-Regular Differentials: Spot Price to Retail Price

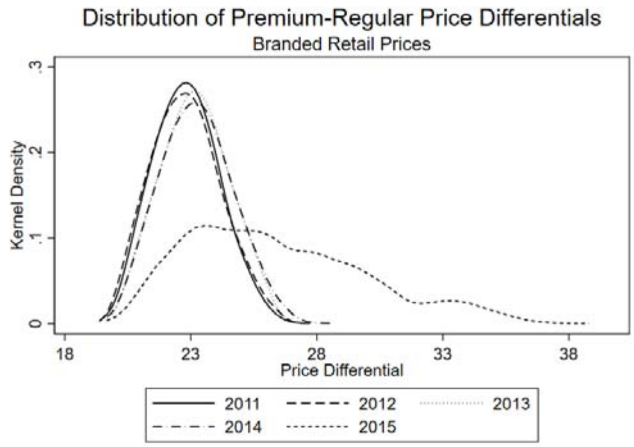

Figure 16. Kernel Density Plots of Premium-Regular Branded Retail Differentials by Year

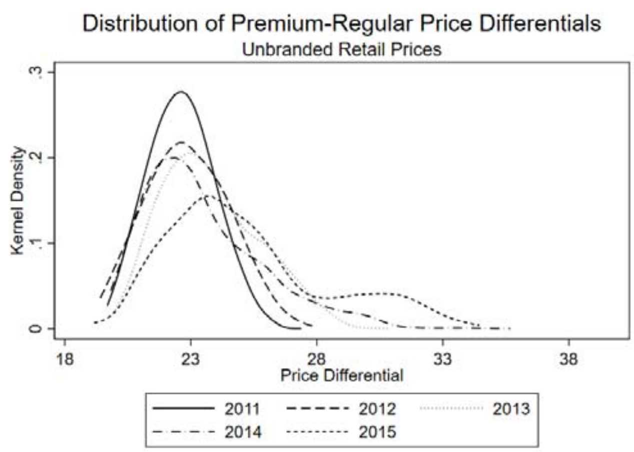

Figure 17. Kernel Density Plots of Premium-Regular Unbranded Retail Differentials by Year