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Vertical Market Structure and Tax Pass-through:

Evidence from the Spanish Gasoline Market

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Abstract

Many papers have explored the relationship between the horizontal market structure and consumers' tax incidence. However, the extent to which the vertical market structure affects tax incidence is an unexplored question. In this study we examine whether—and to what extent—the vertical market structure explains differences in the pass-through of a tax change onto consumers. First, we characterize the optimal pricing rule for a price-setting retailer; we embed this optimal pricing problem in the classical “successive monopolies” framework. Then, using a unique confidential dataset on gas stations' vertical contracts, in combination with prices at the pump and gas stations' characteristics in Spain, we show that—consistent with the theoretical predictions—the pass-through of the gas tax is higher in vertically-integrated gas stations than in non-vertically integrated one.

JEL Classification Numbers: D40, H22, H32, L11, L42.

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1 Introduction

Taxes are widely and repeatedly used to modify agents' decisions by affecting market prices. Indeed, by implementing taxes, governments do not only raise revenue to fund public expenditures, but they also (aim to) reduce the consumption of some particular goods, especially those that exert negative externalities on third parties —environmental damages, pollution, additional healthcare costs, etc. Given this fundamental role of taxes as behavior-modifying tools with notorious economic and policy implications —as discussed by [Muehlegger and Sweeney \(2017\)](#)—, it is not surprising to see a growing concern about the extent to which taxes are passed-through into final prices. This concern has resulted in an active policy discussion and a growing technical literature on the estimation of the incidence of consumption taxes in different contexts —see [Weyl and Fabinger \(2013\)](#).

Up to now, a fairly large portion of the literature has studied this matter with a focus on the role of market competition (or the lack thereof) and, more generally, on the existence of market power. This question is particularly relevant for policymakers, since the impact of their fiscal policy proposals may largely depend on the number of firms (and their relative size) operating in the market. Thus, many theoretical and empirical papers have previously analyzed the relationship between the pass-through of taxes onto prices and (horizontal) market concentration —see [Myles \(1989\)](#) and [Fullerton and Metcalf \(2002\)](#). The general consensus for the case of imperfectly competitive markets¹ is that the more (horizontally) concentrated the market is, the greater the pass-through of taxes to consumer prices is —see [Myles \(1989\)](#) and [Fullerton and Metcalf \(2002\)](#)².

This large literature on the role of horizontal market structure on tax incidence stands in stark contrast to the absent one on the role of the vertical market structure on tax incidence, which have been greatly overlooked by previous authors.³ Despite this lack of attention of previous literature, this question is of particular relevance these days, given the increasing number of markets all around the world that are dominated by relatively big, global firms (wholesalers and/or brands) —see [De Loecker and Eeckhout \(2018\)](#) and [Bajgar et al. \(2019\)](#). These global firms enter (retail) local markets using different vertical contracts, ranging from full vertical integration to complete vertical

¹As explained by [Hanson and Sullivan \(2009\)](#), for the case of perfectly competitive markets, economic theory predicts that taxes are fully passed to consumers.

²This general result has been tested in a wide array of markets and industries, including the alcohol industry —see [Shrestha and Markowitz \(2016\)](#)— the transportation fuel industry —see [Doyle and Samphantharak \(2008\)](#) and [Kopczuk et al. \(2016\)](#)—, and the cigarette industry —see [Delipalla and O'Donnell \(2001\)](#)—, among many others.

³One of the very few exceptions is the paper by [Rozema \(2018\)](#).

independence. Thus, understanding how different vertical relationships may potentially affect the pass-through of taxes is crucial for policymakers to assess the potential effects of some popular policies implemented at the local level, such as the so-called “fast fashion tax” (which was recently proposed in the UK), taxes on plastic cups that affect local coffee stores, or sugary soft drinks taxes, among many others.

The long-standing literature on vertical relationships has documented both theoretically and empirically the notorious consequences of the vertical market structure on consumer (final) prices, firms’ profits, and market efficiency (welfare). These consequences are driven by a cornerstone result, called the “double marginalization” problem: if there is market power upstream —e.g. a single firm produces an intermediate good— and downstream —e.g. a single firm transforms the intermediate good and/or distributes the final good—, firms in each of these vertical stages charge their own markup. This, in turn, results in a different market outcome (less quantity served to final consumers at a higher price, and greater deadweight loss) in comparison to the case in which the upstream firm and the downstream firm vertically integrate —which eliminates the markup charged by the upstream firm to the downstream firm; see [Spengler \(1950\)](#) and [Williamson \(1971\)](#). Therefore, the existence of different pricing strategies, due to differences in the vertical market structure, suggests that the impact of taxes will also have a heterogeneous impact on consumer prices depending on the degree of the vertical integration of their supply chains.

Bearing this information in mind, this paper aims at filling the aforementioned gap in the literature by exploring the novel question of the impact of vertical relationships on the pass-through of taxes to consumer prices. To do so, we use a confidential dataset on the vertical relationships between a major oil refinery (wholesaler) and all the gasoline retailers (gas stations) that operate under the brand of such a wholesaler in eight provinces in Spain. We combine this data with information on weekly posted prices and gas stations’ characteristics. Using this unique dataset, we study how changes in the regional (state) fuel excise duty⁴ differentially affected gas stations’ prices that are under different vertical relationships; namely, gas stations that are owned and controlled by the wholesaler (fully vertically-integrated) and gas stations that are independent of it (vertically-separated).⁵

⁴Over the time period comprised by our sample, four (out of the eight) provinces in our sample experienced an increase of the excise gas tax. Additional details are provided in Section 3.

⁵As we explain below, in Spain —as in many other countries, including the US; see [Hastings \(2004\)](#)— the relationship

To motivate our empirical analysis, we provide a simple, general model of a price-setting retailer—which builds on the classical models introduced by [Chamberlin et al. \(1933\)](#) and [Robinson \(1933\)](#), and the more recently developed by [Friedman \(1977\)](#) and [Vives \(2001\)](#)—in the presence of a per-unit specific tax.⁶ We combine this simple model with the analysis of different vertical structures, as done by [Spengler \(1950\)](#). In particular, we study both the case in which a retailer is independent of the wholesaler (“successive monopoly”), and the case in which the retailer is vertically integrated with the wholesaler. This framework is combined with a theoretical analysis on tax incidence—that closely follows [Anderson et al. \(2001\)](#)—to see the differential effect of a change in the tax on retail prices in both cases. The model predicts that, if the retailer and the wholesaler are vertically-integrated, taxes are passed-through to consumer to a greater extent (*ceteris paribus*) than in the case in which the retailer and the wholesaler are (vertically) separated entities. As we discuss latter, this result is directly connected to the existence of the “double marginalization problem”, since the tax negatively affects both the “margin” of the wholesaler and the “margin” of the retailer under vertical separation, while it affects only the “margin” of the retailer under vertical integration.

In line with this theoretical result, we show that an increase in the state fuel excise duty had a greater impact on prices in gas stations that are vertically-integrated than in those that are independent. In particular, we find that the vertically-integrated ones passed-through about 97% of the tax onto final prices, while non-vertically integrated ones just about 72% of the tax.⁷ These results are stable, significant and similar in magnitude across different model specifications, types of fuels, and wide variety of robustness checks, including propensity score matching techniques—in which we match vertically-integrated and vertically-separated gas stations that have similar characteristics.

As mentioned above, very little attention has been paid to the heterogeneous pass-through effect of taxes in the presence of differences in the vertical market structures. The only exception that (to the best of our knowledge) exists in the literature is the paper by [Rozema \(2018\)](#). In this study, the author focuses on the supply-side of the market to check how the burden of a tax is

between a wholesaler and a gas station falls under two clearly differentiated categories. First, there are some gas stations that are fully vertically-integrated (owned and controlled by the wholesaler). Second, there are gas stations that operate under the brand of a wholesaler, but that are independent of it (owned and controlled by a third party).

⁶As we explain latter, this theoretical setup is particularly common in the literature of retail gasoline markets. See [Slade \(1998\)](#), [Noel \(2007b\)](#), and [Clark and Houde \(2013\)](#), among many others.

⁷Consistently with this number, [Rozema \(2018\)](#) finds that 72% of the tax is passed onto consumers for the case of vertically-separated firms.

shared between upstream and downstream firms. By contrast, we focus on tax incidence on the consumer-side, differentiating between the case of a vertically-integrated supply chain and a non-vertically-integrated one. Some other previous papers have studied the transmission of different kind of shocks from the top of (and along) the supply chain to consumer prices in markets with different vertical structures. For instance, [Bonnet et al. \(2013\)](#) and [Hong and Li \(2017\)](#) focus on commodity price shocks, while [Yoshida et al. \(1999\)](#) study exchange-rate shocks. As in our case, these authors find that the double-marginalization problem plays a key role in explaining the differential effect on the transmission of these shocks across different vertical market structures.

The rest of the paper proceeds as follows. In Section 2 we present a simple model of successive monopolies, and discuss some theoretical predictions regarding consumers' tax incidence. Section 3 provides some background of the Spanish gasoline market. Section 4 presents the empirical strategy and describes the data. In Section 5 we include the main empirical results. Finally, Section 6 concludes.

2 Theoretical background

In this section, we borrow the classical framework of successive monopolies from [Spengler \(1950\)](#) and [Tirole \(1988\)](#) [pp. 174–176]. This framework is embedded in a standard model of a price-setting retailer in the presence of a per-unit specific tax.⁸ Then, we present some results on the incidence of consumers given a change in the per-unit tax considering separately the case in which a retailer is vertically integrated with a wholesaler and the case in which it is not.

2.1 Vertical relationships and the double marginalization problem

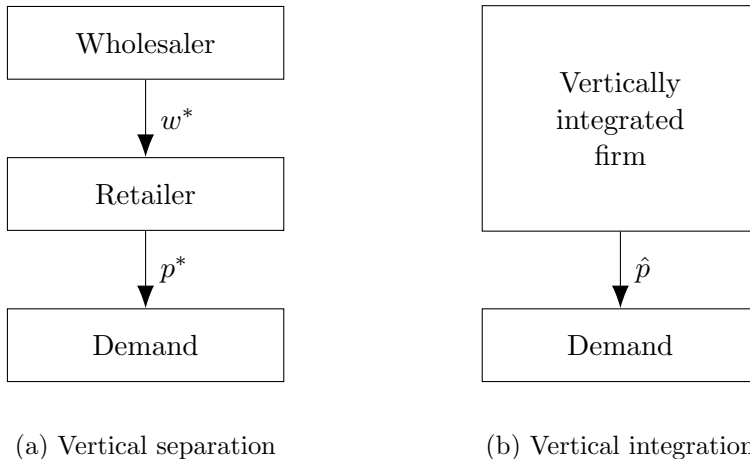
The successive monopolies problem

Let us assume that a firm —called the wholesaler or the upstream firm— produces an intermediate good at a (strictly positive) marginal cost c . This firm, which is the only producer of this intermediate good, sells it to another firm —called the retailer or the downstream firm— at a price w . The retailer

⁸This theoretical model is particularly common in the literature of retail gasoline markets. For instance, [Slade \(1998\)](#) uses the same model in a paper on the gasoline retail market, while [Noel \(2007b\)](#), [Noel \(2008\)](#) and [Clark and Houde \(2013\)](#) use a dynamic version of this model to explain dynamic patterns in gasoline markets. Similar models of price competition with an emphasis on issues related to spatial differentiation were employed by [Pinkse et al. \(2002\)](#) and [Firgo et al. \(2015\)](#) to study also retail gasoline markets.

transforms one unit of the intermediate good into one unit of the final good, and sells it to consumers at a price p .⁹ Subfigure 1a provides a graphical representation of this initial setup.

Figure 1: Diagram of the vertical relationships considered



Let us denote q the total quantity that the retailer serves to consumers (which is also equal to the production of the intermediate good). The total quantity served matches market demand, which is given by $D(p)$. As done by Vives (2001), we assume that $D(p)$ is a continuously differentiable, iso-elastic demand function, strictly decreasing and strictly concave in p ; that is, $\frac{\partial D}{\partial p} < 0$ and $\frac{\partial^2 D}{\partial p^2} < 0$.¹⁰ Finally, we assume that there is a per-unit tax levied on the retailer, denoted $\tau > 0$.¹¹

Given this setup, we solve the “successive monopolies” problem backwards. That is, first we solve the retailer’s problem, which seeks to maximize its own profit (denoted π^R) by choosing $p \in \mathbb{R}_{++}$. The profit function for the retailer is as follows:

$$\pi^R(p) = (p - w - \tau)D(p) \tag{1}$$

At an interior solution, firm’s optimal price, denoted p^* , is characterized by the following (well-

⁹For the sake of simplicity, we assume that the downstream division does not have additional costs (our theoretical predictions do not change if we assume instead that the downstream firm’s marginal cost is strictly positive).

¹⁰Strict concavity of the demand function is a necessary condition to guarantee the existence of an equilibrium. Alternative weaker conditions that imply concavity of the demand function in the own-price are discussed by Vives (2001) —see Chapter 6.

¹¹Throughout the rest of the paper, we study the particular case of a per-unit (or specific) tax. We do so because, in our empirical exercise, we focus on the impact of an excise gas tax, which falls into this category.

known) first-order condition:

$$D(p^*) + (p^* - w - \tau) \frac{\partial D(p^*)}{\partial p^*} = 0 \quad (2)$$

while we assume that the corresponding second-order condition is satisfied.

Notice that equation (2) characterizes the retailer's optimal price choice, given w and τ . Thus, by the implicit function theorem, we know that p^* can be expressed as a function of these two variables; that is, $p^*(w, \tau)$. Moreover, by applying implicit differentiation, it can be easily shown that the optimal retailer's price increases both in w (the unit price charge by the upstream firm) and τ (the per-unit tax).

Lemma 1. $\frac{dp^*}{dw} > 0$ and $\frac{dp^*}{d\tau} > 0$.

Next, we deal with the wholesaler's profit maximization problem. The wholesaler anticipates that the retailer's demand for the intermediate good is given by $D(p^*(w, \tau))$. Applying the chain rule, and using Lemma 1, it is straightforward to see that the retailer's demand function for the intermediate good served by the wholesaler is decreasing both in w and τ .

Lemma 2. $\frac{\partial D(p^*(w, \tau))}{\partial w} < 0$ and $\frac{\partial D(p^*(w, \tau))}{\partial \tau} < 0$.

The second result of Lemma 2 is rather a central point of the theoretical analysis. In particular, it indicates that an increase in the tax rate not only reduces the retailer's demand for the final good (due to the increase in the optimal retail price, as shown in the second part of Lemma 1), but it also reduces the wholesaler's demand for the intermediate good. This reduction on the demand for the intermediate good will also impact the wholesaler's profit-maximizing price choice; obviously, this re-adjustment in the optimal price charged by the wholesaler would not take place if it were vertically-integrated with the downstream firm.

Bearing the previous information in mind, we solve the wholesaler's problem, which seeks to maximize its own profit (denoted π^W) by choosing $w \in \mathbb{R}_{++}$. That is, this firm maximizes:

$$\pi^W(w) = (w - c)D(p^*(w, \tau)) \quad (3)$$

At an interior solution, the wholesaler's optimal price, denoted w^* , is characterized by the following

first-order condition:

$$D(p^*) + (w^* - c) \frac{\partial D(p^*)}{\partial p^*} \frac{dp^*}{dw^*} = 0 \quad (4)$$

while, again, we assume again that the corresponding second-order condition is satisfied.

Notice that equation (4) characterizes the wholesaler’s optimal price choice, given c and τ . Thus, once again, by the implicit function theorem, we know that w^* can be expressed as a function of these two variables. In particular, we can easily show that the optimal retailer’s price decreases in the tax rate (τ).

Lemma 3. $\frac{dw^*}{d\tau} < 0$.

Therefore, Lemma 1 and 3 indicate that an increase in the tax rate has an positive impact on the optimal retail price, and (more importantly) a negative impact on the optimal price charged by the wholesaler (which reduces the retailer’s price). In other words, the tax has both a direct, positive effect, and an indirect, negative one (due to the decrease in the demand for the intermediate good) on the retailer’s optimal price.

The vertically-integrated monopoly problem

Next, we consider a similar market environment as in the previous case, but we assume instead that the wholesaler and the retailer vertically integrate. That is, instead of solving the “successive monopolies” problem, we set up and solve the profit-maximization problem just for a vertically-integrated firm that produces the intermediate good (in the upstream division) and then sells it to the consumers in the retail market (through the downstream division).¹² Subfigure 1b provides a graphical representation of this alternative setup.

Again, the goal of the vertically-integrated firm is to choose the retail price, $p \in \mathbb{R}_{++}$, to maximize its profit —denoted π^{VI} . Thus, the vertically-integrated firm solves:

$$\pi^{VI}(p) = (p - c - \tau)D(p) \quad (5)$$

At an interior solution, firm’s optimal price, denoted \hat{p} , is characterized by the following first-

¹²We abstract away from potential issues related to transfer prices, which is a matter that lies beyond the scope of this paper.

order condition:

$$D(\hat{p}) + (\hat{p} - c - \tau) \frac{\partial D(\hat{p})}{\partial \hat{p}} = 0 \tag{6}$$

while again we assume that the corresponding second-order condition is satisfied.

As explained by [Spengler \(1950\)](#) and [Buehler and Gärtner \(2013\)](#), the classical “double-marginalization problem” implies that $w^* = c + \eta > c$, where η is the wholesaler’s markup. Therefore, *ceteris paribus*, the vertically-integrated monopoly charges lower prices and sells a greater quantity in comparison to a market controlled by two vertically-separated (successive) monopolies. As a consequence, $\pi^R + \pi^W < \pi^{VI}$ at the optimal prices. However, as mentioned by [Hong and Li \(2017\)](#), while the implications of vertical integration for pricing (and profits) are unambiguous and well-understood, the implications for cost or tax pass-through to consumers are not; this is precisely the task that we accomplish in the following Subsection.

2.2 Tax incidence and vertical relationships

We now study the effect of a change in the per-unit tax rate (τ) on optimal retail prices. In particular, we focus on the differences that exist between the impact on consumer prices both in a market served by two successive (vertically separated) monopolies (p^*) —Subfigure [1a](#)— and the case in which the market is served by a vertically-integrated monopoly (\hat{p}) —Subfigure [1b](#).

The main theoretical result of this paper is that, *ceteris paribus*, the pass-through rate of an increase in the per-unit tax to retail (consumer) prices is greater in the vertically-integrated-firm case than in the vertically-separated-firms one. For that is sufficient to assume that the second derivative of the demand function with respect to the price is fairly stable (i.e. it does not increase or decrease “too much” around p^* and \hat{p}).^{[13](#)}

Proposition 1. *Assume that $\frac{\partial^3 D}{\partial p^3}$ is zero (or very close to zero). Then, an increase in the per-unit tax τ increases retail prices to a greater extent in a market controlled by a vertically-integrated firm than in a market controlled by two “successive” (vertically-separated) firms (*ceteris paribus*). That is, $\frac{d\hat{p}}{d\tau} > \frac{dp^*}{d\tau}$.*

The intuition behind [Proposition 1](#) can be easily explained in the light of the previous theoretical

¹³This assumption —which simply implies that the curvature of the demand function does not “dramatically” change in a neighborhood around p^* and \hat{p} — is fulfilled if, for instance, we assume that $\frac{\partial^3 D}{\partial p^3} = 0$.

results. For the “successive monopolies” case (vertical separation), we document that there exist both a (direct) positive effect and an (indirect) negative one —due to the decrease in the demand for the intermediate good— of the tax on the retailer’s optimal price. However, this second indirect effect does not show up if the firms are vertically integrated. This is because, within the vertically-integrated firm, the upstream division does not modify (“re-optimize”) the price charged to the downstream division (as it happens with wholesaler if it is vertically separated from the retailer).

3 Industry background

3.1 Vertical relationships in the Spanish gasoline market

Despite the various particularities that we may observe in different countries regarding the organization of gasoline markets, there are two features that are commonly observed across most of them. First, wholesale gasoline markets are usually dominated by one or a few brands. That is, market power (and market concentration) in the upstream segment of gasoline markets (i.e. oil refineries) is usually relatively high —as documented by [Borenstein and Shepard \(2002\)](#), [Hastings and Gilbert \(2005\)](#) and [Oladunjoye \(2008\)](#) for the particular case of the US.¹⁴ Second, there typically exist differences in the relationship between the gasoline wholesalers (refiners) and the retailers (gas stations), both within and across brands. These differences arise depending on the degree of business and managerial control that the refiner exert on the retailer, ranging from full control (vertically-integrated gas stations) to none (vertically-separated gas stations).¹⁵

These two commonly observed features of gasoline markets are also observed in the Spanish case. To begin with, the petroleum refining industry in Spain is usually acknowledged as highly imperfectly competitive. As explained by [Stolper \(2016\)](#), only three companies (namely Repsol, Cepsa, and British Petroleum or BP) own the nine oil refineries operating in Spain, and together they own a majority stake in the national pipeline distribution network. Moreover, the gas stations

¹⁴Some other authors have documented the existence of substantial market power in the oil refining industry in many other countries, such as Hungary —see [Farkas and Yontcheva \(2019\)](#)—, Chile —see [Balmaceda and Soruco \(2008\)](#)—, the Netherlands —see [Bettendorf et al. \(2003\)](#)—, and Canada —see [Noel \(2007a\)](#)—, to name a few. The dominant position of refineries is even more evident in countries whose market is exclusively catered by a National Oil Company (NOC) —see [Hartley and Medlock III \(2013\)](#).

¹⁵As explained by [Hastings \(2004\)](#), there are also gas stations that are called “unbranded”. As follows, these type of gas stations (that do not sell gasoline under the brand of a major refiner) are always (by definition) vertically-separated from the wholesaler.

that operate under the brand of one of these major companies¹⁶ may have different contractual arrangements that define the vertical relationship between a refiner and the gas stations itself.¹⁷

In the Spanish gasoline market, there are two major types of contracts that define the relationship between a refiner and a gas station that operates under the brand of a major oil refiner. First, there are some gas stations that are fully owned and operated by the oil refiner; these are the “vertically integrated” ones. For these ones, the refiner takes full responsibility of making all the relevant managerial decisions, including the pricing of refined petroleum products (“prices at the pump”) as well as the purchasing and stockpiling of inventories. Second, there are some gas stations that bear the brand of a retailer but that are operated by a third party (an entrepreneur or a firm other than wholesaler); these are the “vertically separated” ones. In this other case, the refiner sells gasoline to the “third party” at a spot price, while such a “third party” controls all the relevant operational and managerial decisions (pricing, inventories, etc.), except for some basic merchandising decisions (for instance, the third party cannot unilaterally change the company’s logo).¹⁸

3.2 Gasoline taxes in Spain

Refined petroleum products used for transportation purposes (i.e. gasoline and diesel) are heavily taxed across Europe (in general), and in Spain (in particular). According to the information provided by the Spanish Association of Petroleum Products Operators—in Spanish, *Asociación Española de Operadores de Productos Petrolíferos*, or simply AOP—, on average, over 50% of the retail price of gasoline and diesel in Spain is tax.¹⁹ In fact, this 50% is the result not just of a single tax, but of different taxes that are applied both at the national level and at the regional level.

In particular, there are two specific fuel duties that affect refined petroleum products in Spain, namely, the national excise fuel tax (imposed by the central government), and regional excise fuel

¹⁶More than 60% of retail gas stations in Spain bear the brand of one of these refiners, that is, Repsol, Cepsa, or BP.

¹⁷As in the US, there are also gas stations that are “unbranded” (i.e. that do not operate under the brand of a major refiner). Since there is no heterogeneity in the contractual arrangement between them and the refiner (in the sense that all of them are “vertically-separated”), we do not include them in our study.

¹⁸There is also a third (major) type of contractual arrangement between gas stations and refiners, which lies sort of “in between” the these two ones. In particular, in this third type of contract, the gas stations are operated by a third party, but the wholesaler has the right to provide a (semi-biding) price retail price recommendation (RPR)—semi-binding in the sense that the retailer is allowed to set a price lower or equal to the RPR, but not higher than it. Due to the hybrid (undefined) nature of these contracts, and given the lack of data on these RPRs, we do not consider them in our empirical analysis.

¹⁹This percentage is smaller in Spanish overseas territories (e.g. the Canary Islands).

taxes (imposed by each of the 17 States in Spain).²⁰ While the national excise fuel tax has not changed over the past ten years, several States has introduces some changed in the regional tranche of the excise fuel duties.

Given the span of our dataset, which comprises four States (and a total of eight provinces) for a whole year, we focus our empirical study on the tax change implemented by the Northern States of Navarra (which contains only one province) and Aragón (which contains three provinces). In particular, in these two States, the regional excise fuel tax increased from 0 to 2.4 cents per liter in January 1, 2016.²¹ These changes in the regional tax rate were publicly announced (by surprise) the first week of November. Thus, we consider these changes as an exogenous shock that —after considering the potential anticipation effect that may exist between the first week of November and the last week of December 2015— allow us to study the differential effect of taxation on retail prices according to the vertical structure of the firms. This is the main task that we carry out in the following Sections.

4 Empirical strategy and data description

In this Section, we present our empirical strategy and discuss the data that we use to identify the heterogeneous effect of tax increases on prices according to the differences that exist in the vertical chain of the firms considered.

4.1 Methodology

A linear regression of an outcome Y on a dummy VI_i equal to 1 if a gas station is vertically-integrated and 0 otherwise leads to spurious estimates as to whether the unobservable characteristics of gas stations correlate with their being vertically-integrated or not. We can, instead, identify the causal effect of being vertically-integrated on fuel prices in Spanish gas stations by adopting a Difference-in-Differences strategy, *DiD* hereafter. In particular, we exploit two key features described in Section 2. First, the structure of the fuel market that defines the treatment effect of being vertically-integrated. Second, the time effect of the increase in the regional fuel tax in two Spanish regions. Specifically,

²⁰In addition, gasoline and diesel are subject to the Value Added Tax (VAT). The VAT has not changed in Spain since 2011.

²¹The regional tranche of the fuel duty in the other two States considered in our study —namely País Vasco and La Rioja— were equal to 0.

we estimate the following model:

$$\begin{aligned} \ln(\text{price}_{it}) = & \beta_1 VI_i + \beta_2 Treated_t + \beta_3 VI_i * Treated_t + \\ & + X'_{it} \delta + \gamma_t + \alpha_i + \epsilon_{it} \end{aligned} \quad (7)$$

where price_{it} is the fuel price for gas station i in week t and ϵ_{it} is clustered at the gas station level to reflect the variation in gas station prices. VI_i is the treatment variable, which takes the value 1 for those Spanish gas stations that are vertically-integrated and zero otherwise. Similarly, $Treated_t$ is another dummy equal to 1 for all observations from the first week of 2016 onwards in the two Spanish regions changing the fuel tax rate at that time, namely Aragón and Navarra. We use this increase in the regional fuel tax as an exogenous event that allows us to study how an increase in the tax differently impacts price decisions depending on whether this firm is vertically-integrated or not.

Estimating equation (7) using only these three dummies would give us the basic *DiD* estimator. To this standard specification, we first include in all specifications a weekly fixed effect γ_t , controlling for the growth of fuel prices common to all gas stations. In addition, we estimate our preferred specification augmenting the basic model by successively including: *i*) a vector of time-varying control variables X_{it} (Brent crude oil price, a dummy indicating the period between the tax change announcement and the time the new tax takes effect, and the interaction between this dummy and the treatment dummy), controlling for possible anticipation effects; *ii*) a gas station fixed effect α_i , controlling for any time-invariant characteristic that may have an influence both on outcomes and stations' locations; and *iii*) a province * Brent crude oil price fixed effect, controlling for province-specific costs.

In this setting, β_2 and β_3 are our parameters of interest: while β_2 measures the causal effect on prices of gas stations located in provinces that increased the tax after the fuel tax was increased, β_3 captures the additional effect of the tax specifically on vertically-integrated gas stations located on provinces that increased the excise fuel tax.

4.2 Data

To study the differential response of prices to the changes in regional taxes across different firms' vertical relationships, we use data from different sources. First, we use a unique dataset that specifies the contractual relationship between the gas stations that bear the brand of one of the major refiner and that refiner. We had access to the contract of all the gas stations of that brand in eight provinces in Spain. These contracts describe, for all the gas stations in these provinces, the degree of vertical integration between both parties. In particular, it is specified if a gas station is owned and operated by the refiner or not. Once we eliminate a few gas stations from our dataset for which the contractual arrangement present some problems, our dataset includes data for 183 gas stations.

Then, we add fuel price data from *Geoportal*, a website of the Spanish Ministry of Industry and Energy, which monitors and publishes daily information of all the gas stations in Spain. The Ministry posts every day a file with gas stations' prices and some other information items (location, brand, opening hours, etc.), and the file is erased and replaced with an updated file at midnight. We obtain daily price data for regular (unleaded) gasoline –the most popular fuel transportation fuels in Spain among non-professional drivers,²² six months before and after the tax reform that we study in this paper, that is, from June 2015 until July 2016.²³

We focus on all the gas stations located in the eight provinces for which we have information about the gas stations' degree of vertical integration.²⁴ These eight provinces belong to four different states, with different retail state fuel tax rates.

To this station-level data, we add information on the wholesale cost of fuel for the retailer. In particular, we have daily data on the Europe Brent Spot Price (FOB), which is a reference price for petroleum products in retail markets in Western Europe in general and in Spain in particular. The data was obtained from U.S. Energy Information Administration (EIA), and is given in dollars per barrel. We use data on the euro/dollar exchange rate provided by the Federal Reserve Bank of St. Louis to express Brent crude oil prices in euros per barrel.

Retail fuel prices and the characteristics of the gas stations in our sample are summarized in Table 1. We include summary statistics for both the treated (vertically-integrated) and the control

²²Our result prove robust when using data on prices for other commonly used fuels in Spain, such as diesel fuel.

²³Data is missing for a couple of days: January 3, 2016 and June 18, 2016. However, the impact of these two missing days is negligible given that our unit of observation is gas station-week.

²⁴The provinces and their states (in parentheses) are Huesca (Aragón), Zaragoza (Aragón), Teruel (Aragón), Navarra (Navarra), Álava (País Vasco), Guipúzcoa (País Vasco), Vizcaya (País Vasco) and La Rioja (La Rioja).

Table 1: Summary statistics by distance to the border

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	<i>Panel A1: Before tax</i>				<i>Panel A2: After tax</i>			
	All	Vertically-integrated		P-val	All	Vertically-integrated		P-val
		Yes	No			Yes	No	
	<i>Outcome variables</i>							
Diesel (price)	1.049	1.054	1.043	0.000	1.009	1.022	0.997	0.000
Gasoline (price)	1.176	1.177	1.174	0.018	1.151	1.161	1.143	0.000
	<i>Baseline characteristics</i>							
=1 if located in highway	0.107	0.091	0.129	0.000	0.172	0.204	0.143	0.000
=1 if located in highway (toll)	0.150	0.261	0.000	0.000	0.064	0.134	0.000	0.000
Brent (Euro)	40.257	40.046	40.546	0.001	35.601	35.640	35.566	0.749
	<i>% provinces</i>							
Huesca	0.092	0.042	0.160	0.000	0.272	0.167	0.367	0.000
Zaragoza	0.098	0.098	0.098	0.989	0.279	0.340	0.224	0.000
Teruel	0.039	0.020	0.067	0.000	0.118	0.067	0.165	0.000
Navarra	0.116	0.124	0.106	0.026	0.331	0.426	0.244	0.000
Álava	0.083	0.117	0.036	0.000	-	-	-	
Guipúzcoa	0.241	0.209	0.284	0.000	-	-	-	
Vizcaya	0.188	0.274	0.071	0.000	-	-	-	
La Rioja	0.143	0.117	0.178	0.000	-	-	-	
N. Observations	6,913	3,990	2,923		2,435	1,160	1,275	

Note: Summary statistics for all gas stations included in the sample. Panel A1: Before the tax change. Panel A2: After the tax change. Columns (1) and (5): Means for all gas-stations. Columns (2-3) and (6-7): Means for the subgroups of vertically-integrated and not-vertically-integrated gas stations. Columns (4) and (8): P-value of the null hypothesis that the difference in means between both subgroups is equal to zero.

(non-vertically-integrated) gas stations before and after the the regional tax change. Notice that the difference in average gasoline prices is practically the same for treated gas stations before the tax change. This difference increases after the tax reform. Conversely, the difference in average diesel prices is always positive for treated gas stations, regardless of the time period considered, although it also increases after the tax change.

5 Results

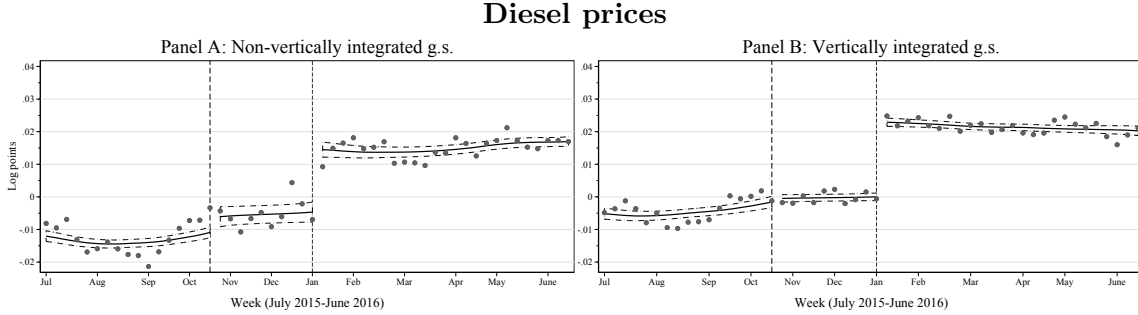
5.1 Main results: vertically-integrated vs. non-vertically integrated

We start by providing graphical evidence of the effect of being vertically-integrated on diesel prices. Figure 2 shows the difference in average log retail fuel prices between treated and control gas stations plotted against time. The solid lines represent local linear regressions separately estimated before and after the tax change announcement and before and after the tax change, while the dashed ones represent 95% confidence intervals.²⁵ Thus, the size of the discontinuity at the time of the tax change provides a “raw” *DiD* estimate of the effect of the regional tax change on diesel prices in Spanish

²⁵Notice that the estimation is normalized to zero just before the tax change in order to have a clearer notion of the jump.

gas stations, separately for those which are vertically-separated (Panel A) and vertically-integrated (Panel B) –see [Doyle and Samphantharak \(2008\)](#).

Figure 2: Local linear regressions of the difference in $\log(\text{price})$ against time



Note: Solid lines represent local linear regressions separately estimated before and after the tax change. Dashed lines represent 95% confident intervals. Mean values by week shown as circles.

Panel B reports the results for vertically-integrated gas stations. For this type, price differences are leveled off before and after the reform, with a significant estimated jump in the average price differentials between gas stations located in provinces affected and not affected by the tax change of about 2.2 log point following the increase in the regional fuel tax. In addition, we find in panel A a positive albeit smaller price jump around the tax change for the case of non-vertically integrated gas stations located in provinces affected by the tax reform, relative to non-vertically integrated gas stations in provinces not affected by the tax reform. This result suggests that diesel prices reacted immediately to the regional tax change, but consistently with Proposition [1](#) they reacted more for vertically-integrated gas stations.^{[26](#)}

The previous “raw” comparisons do not take into account gas station characteristics nor other controls. Thus, we now present the results from equation [\(7\)](#). Table [2](#) shows the estimates of the effect of being vertically-integrated on diesel prices, modifying the number of controls as we move from columns (1) to (5). The mean value of the dependent variables (in levels, before the tax change) for the subset of gas stations forming the control group is also reported at the bottom of the table.

Column (1) results are based on the basic *DiD* estimator, in which we only include the treatment variable, the time variable, their interaction and time fixed effects. The second row shows that gasoline prices for non-vertically-integrated gas stations significantly rose by 1.1% around the time

²⁶We also observe a small jump at the time of the tax announcement for non-vertically integrated gas stations. This is the reason why we also include a dummy indicating this period and the interaction with the treatment variable, as explained in Section [4.1](#)

Table 2: The effect of being VI on diesel prices

	(1)	(2)	(3)	(4)	(5)
<i>Treated * VI</i>	0.008** (0.003)	0.008** (0.004)	0.008*** (0.002)	0.006*** (0.002)	0.007*** (0.002)
<i>Treated</i>	0.011*** (0.003)	0.011*** (0.003)	0.019*** (0.002)	0.022*** (0.002)	0.020*** (0.002)
<i>VI</i>	0.015*** (0.002)	0.015*** (0.003)			
Mean dep. var. non-treated	1.043				
γ_t	✓	✓	✓	✓	✓
α_i			✓	✓	✓
Control vars.		✓		✓	✓
<i>Prov_i * Brent</i>					✓
N. Gas Stations	183	183	183	183	183
N. Observations	9,348	9,348	9,348	9,348	9,348

Note: Column (1): Basic DiD with week fixed effects. Column (2): DiD with week fixed effects and control variables. Column (3): DiD with gas station and week fixed effects. Column (4): DiD with both fixed effects and control variables. Column (5): DiD with week and gas station fixed effects, control variables, and also province*brent fixed effects. The significance levels are as follows: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Standard errors are clustered at the gas station level.

of the tax change, while there is an addition increase for vertically-integrated ones of 0.8%. Column (2) includes the vector of control variables. Column (3) includes gas station fixed effects, while the specification with gas station, week fixed effects and control variables is presented in Columns (4). The same row shows that the main result is practically unchanged. Finally, Columns (5) reports the most complete specification, including also *province * brent* fixed effects. After the inclusion of all controls, estimates for gasoline prices increase for non-vertically-integrated gas stations to 2%, while they slightly decrease to 0.7% for vertically-integrated ones. These estimates represent a 71.93% cross-border pass-through rate for non-vertically-integrated gasoline prices. For vertically-integrated gas stations, there is an additional pass-through of 25.18%, thus reaching a 97.11% final pass-through²⁷ Hence, consistent with the theoretical predictions summarized in Proposition 1 Table 2 shows that being located in those provinces with a tax change had a positive and significant impact on gasoline prices after this regional tax change –particularly for vertically-integrated gas stations.

²⁷Full “cross-border pass-through” would imply a 2.9 cents increase in fuel prices for gas stations located in provinces affected by the regional tax change. The estimates imply an increase of about 2.0 cents for non-vertically-integrated gasoline prices. In addition, they imply an addition increase of about 0.7 cents for vertically-integrated gas stations.

5.2 Robustness and research design validity

In this section, we first perform a battery of robustness checks and then we provide evidence in favour of the validity of our identifying strategy.

5.2.1 Robustness checks

We start by comparing pairs of vertically-integrated and non-vertically-integrated firms to check if there are significant differences between their prices after the introduction of the tax (January 2016). For that purpose, we continue to use differences in the vertical structure of firms (gas stations) as a source of a potential heterogeneous effect, but we restrict our analysis only to those ones that are located in provinces that implemented a tax change. In particular, following a similar strategy as the one used by [Nunn \(2007\)](#), we estimate the following equation:

$$\ln \left(\frac{price_{it}^{VI}}{price_{i't}^{NVI}} \right) = \beta Tax_t + \lambda_{vs} + \epsilon_{tvs} \quad (8)$$

where $price_{it}^{VI}$ is the diesel fuel price in week t chosen by vertically-integrated gas station i , and $price_{i't}^{NVI}$ is the diesel fuel price in week t chosen by non-vertically-integrated (i.e. vertically-separated) gas station i' . Because, all else equal, vertically-integrated firms tend to increase retail prices more than vertically-separated firms after the implementation of a tax, β is expected to be positive. That is, relative to vertically-separated gas stations, vertically-integrated gas stations are expected to increase prices more.

First, we estimate equation [\(8\)](#) using a sample of all possible pairs of vertically-integrated and vertically-separated gas stations in provinces where a tax increase was implemented. Column (1) in [Table 3](#) reports the estimate of β , with standard errors clustered at the gas station-pair level in parentheses. As expected, the estimated coefficient is significant and equal to 0.0014; that is, this coefficient suggests an effect similar in magnitude to the one found in the OLS estimates. Again, our results indicate that compared to non-vertically-integrated firms, vertically-integrated firms tend to set higher prices after the implementation of a tax increase.

As explained above, vertically-integrated firms and non-vertically integrated firms may face a different demand.^{[28](#)} These differences in gas stations' demand may actually be important in

²⁸To see this, consider, for instance, the fact that most (95%) of the gas stations in toll highways are controlled by

Table 3: Comparing matched VI firms and non-VI for diesel prices

	(1)	(2)	(3)
		Matched by	
	Not matched	Prices	Prices+other
Tax	0.00141*** (0.0000425)	0.00190*** (0.000587)	0.00141** (0.000595)
G. s. pair fe	✓	✓	✓
R^2	0.664	0.679	0.568
Number of obs.	111689	883	830

Note: Column (1): All possible pairs of VI and non-VI gas stations. Column (2): VI and non-VI gas stations pairs matched using fuel prices before the tax change. Column (3): VI and non-VI gas stations pairs matched using fuel prices before the tax change and other demand-related variables. The significance levels are as follows: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Standard errors are clustered at the gas station-pair level.

explaining differences of the impact of the tax on prices, causing a bias in our estimates. To overcome this potential problem, we restrict our comparison to pairs of vertically-integrated and vertically-separated gas station with similar demand characteristics.

First, we match gas stations based on fuel prices before the implementation of the tax change. That is, we argue that gas stations that posted similar prices (before the introduction of the tax change) were likely to face similar market demand. Second, we match gas stations based on fuel prices before the implementation of the tax changes and other demand-related variables, such that whether they are located along a highway or not, and whether they are located along a toll highway or not. By restricting our sample to matched pairs, we remove the bias that may exist in our estimates if demand-related variables are ignored. To match gas stations in our sample, we use the well-known technique of propensity score matching —see Rosenbaum and Rubin (1983) and Rosenbaum and Rubin (1984). More precisely, as done by Nunn (2007), we use the so-called nearest neighbor matching procedure; that is, for each vertically-integrated gas station we choose an independent (vertically-separated) one for which the distance between their propensity scores is minimized —see Nunn (2007) for additional details.

Columns (2)-(3) in Table 3 contain estimates of equation (8) using the sample of matched gas station pairs. In column (2) gas station pairs are matched by retail prices before the implementation of the tax. The estimated coefficient is again positive, statistically significant, and similar in magnitude to the one included in column (1). A very similar coefficient is also obtained when we match gas the vertically-integrated firm.

station pairs using other variables —see column (3). Overall, these results confirm that the increase in the tax affected retail prices to greater extent in gas stations that are vertically-integrated relative to those that are independent of the oil refiner.

We continue by acknowledging the potential concern that the world for our current control group may have also changed in the post-reform period. Ideally, the control group is one whose world has not changed in the post period —i.e. they got the placebo pill. In our setting, theoretically, gas stations in the control group but located close to the regional border —areas with no tax but close to tax change— have the same incentive to raise prices, as Spaniards within each region shop across their distance thresholds —see (Bajo-Buenestado and Borrella-Mas, 2019). This is why we use an alternative strategy in which the control group is formed by gas stations located in the only province without border with the treated provinces. By doing so, our natural experiment will be closer to the ideal experiment in which one group receive treatment and the other does not. The results of this empirical exercise are included in Table 4

Table 4: The effect of being VI on diesel prices. Control group formed by the only province without border with treated ones

	(1)	(2)	(3)	(4)	(5)
<i>Treated * VI</i>	0.008*** (0.003)	0.008** (0.003)	0.008*** (0.002)	0.006*** (0.002)	0.007*** (0.002)
<i>Treated</i>	0.011*** (0.003)	0.011*** (0.003)	0.019*** (0.002)	0.020*** (0.002)	0.016*** (0.002)
<i>VI</i>	0.016*** (0.003)	0.016*** (0.003)			
Mean dep. var. non-treated	1.058				
γ_t	✓	✓	✓	✓	✓
α_i			✓	✓	✓
Control vars.		✓		✓	✓
<i>Prov_i * Brent</i>					✓
N. Gas Stations	121	121	121	121	121
N. Observations	6,126	6,126	6,126	6,126	6,126

Note: Column (1): Basic DiD with week fixed effects. Column (2): DiD with week fixed effects and control variables. Column (3): DiD with gas station and week fixed effects. Column (4): DiD with both fixed effects and control variables. Column (5): DiD with week and gas station fixed effects, control variables, and also province*brent fixed effects. The significance levels are as follows: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Standard errors are clustered at the gas station level.

As we can see in this Table, the pass-through is basically unchanged. In any case, although we acknowledge that the world may have also changed for our current control group, we do not believe

that this is a major problem for our main strategy because, even if the results are biased due to contamination bias, this bias works against finding an effect, so it is likely just a slight underestimate of the true effect.

Finally, we also check that the main estimates obtained are not driven by a subset of gas stations located in highways or in toll-highways. The reason for doing so is that the concentration of vertically-integrated gas stations is higher in these types of roads. Hence, we re-estimate our main regression model excluding either each type of road, or both.

The results of this additional robustness check are presented in Table 5. Again we do not find significant differences with respect to our main estimates, thus ruling out the possibility that the concentration of vertically-integrated gas stations around highways and toll-highways are driven our results.

5.2.2 Research design validity

In the spirit of the evaluation of any policy area, the effect of being vertically-integrated for any gas station i is given by the difference between the outcome in this gas station at time t —after the increase in the fuel tax in Portugal— and the outcome in this gas station had it not been vertically-integrated:

$$\beta_{it} = Y_{it}^T - Y_{it}^{NT}, \quad (9)$$

where β_{it} denotes the gas station-specific treatment effect, Y_{it}^T denotes the outcome in the treated group of gas stations if vertically-integrated; and Y_{it}^{NT} denotes the outcome in the treated group of gas stations had they not been vertically-integrated —see [Blundell and Dias \(2009\)](#).

The only assumption that we need in order to identify the effect of interest, β_3 , is that selection into treatment is independent of ϵ_{it} , i.e. that outcomes in treatment and control groups would follow the same time trend in the absence of the treatment. Although the common trend assumption is not directly testable, because the contractual relationship is obviously not the same in both groups of gas stations, we can nonetheless implement several tests to confirm the validity of our identifying strategy.

First, we can perform a sensitivity analysis by estimating a placebo *DiD* test. For doing so,

Table 5: The effect of being VI on diesel prices (no highways-no toll)

	(1)	(2)	(3)	(4)	(5)
<i>Panel A: No toll</i>					
<i>Treated * VI</i>	0.011*** (0.003)	0.011*** (0.004)	0.007*** (0.002)	0.006** (0.002)	0.007*** (0.002)
<i>Treated</i>	0.013*** (0.003)	0.013*** (0.003)	0.022*** (0.001)	0.024*** (0.002)	0.023*** (0.002)
<i>VI</i>	0.011*** (0.002)	0.011*** (0.003)			
Mean dep. var. non-treated	1.043				
N. Gas Stations	160	160	160	160	160
N. Observations	8,152	8,152	8,152	8,152	8,152
<i>Panel B: No highways</i>					
<i>Treated * VI</i>	0.007** (0.004)	0.007* (0.004)	0.007*** (0.002)	0.005** (0.002)	0.007*** (0.002)
<i>Treated</i>	0.011*** (0.003)	0.011*** (0.004)	0.018*** (0.002)	0.021*** (0.002)	0.019*** (0.002)
<i>VI</i>	0.015*** (0.003)	0.015*** (0.003)			
Mean dep. var. non-treated	1.043				
N. Gas Stations	159	159	159	159	159
N. Observations	8,188	8,188	8,188	8,188	8,188
<i>Panel C: No toll & highways</i>					
<i>Treated * VI</i>	0.010*** (0.004)	0.010** (0.004)	0.007*** (0.002)	0.005* (0.003)	0.006** (0.002)
<i>Treated</i>	0.013*** (0.004)	0.013*** (0.004)	0.021*** (0.002)	0.024*** (0.002)	0.022*** (0.002)
<i>VI</i>	0.010*** (0.003)	0.009*** (0.003)			
Mean dep. var. non-treated	1.043				
γ_t	✓	✓	✓	✓	✓
α_i			✓	✓	✓
Control vars.		✓		✓	✓
<i>Prov_i * Brent</i>					✓
N. Gas Stations	136	136	136	136	136
N. Observations	6,992	6,992	6,992	6,992	6,992

Note: Panel A: Sample excluding gas stations located in toll highways. Panel B: Sample excluding gas stations located in standard highways. Panel C: Sample excluding gas stations located in toll/standard highways. Column (1): Basic DiD with week fixed effects. Column (2): DiD with week fixed effects and control variables. Column (3): DiD with gas station and week fixed effects. Column (4): DiD with both fixed effects and control variables. Column (5): DiD with week and gas station fixed effects, control variables, and also province*brent fixed effects. The significance levels are as follows: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Standard errors are clustered at the gas station level.

we construct a “fake” experiment by using as “fake” treatment group those gas stations located in a province without a regional tax change. In particular, we use Vizcaya as our “fake” treatment province, while keeping Álava, Guipúzcoa and La Rioja in the control group. The intuition behind is that differences between gas stations in those provinces are not expected, as none of them changed the regional excise fuel tax. Hence, any *DiD* estimates different from 0 would provide evidence against the parallel trend assumption. We show in Table 6 that this is not the case, thus offering support to the validity of our research design.

Table 6: Placebo test of the effect of being VI on diesel prices

	(1)	(2)	(3)	(4)	(5)
<i>Treated * VI</i>	-0.007 (0.005)	-0.007 (0.005)	0.003 (0.004)	0.003 (0.004)	0.003 (0.004)
<i>Treated</i>	0.006 (0.004)	0.006 (0.004)	-0.002 (0.004)	0.000 (0.004)	0.003 (0.004)
<i>VI</i>	0.014*** (0.003)	0.014*** (0.003)			
Mean dep. var. non-treated	1.043				
γ_t	✓	✓	✓	✓	✓
α_i			✓	✓	✓
Control vars.		✓		✓	✓
<i>Prov_i * Brent</i>					✓
N. Gas Stations	87	87	87	87	87
N. Observations	4,522	4,522	4,522	4,522	4,522

Note: Column (1): Basic DiD with week fixed effects. Column (2): DiD with week fixed effects and control variables. Column (3): DiD with gas station and week fixed effects. Column (4): DiD with both fixed effects and control variables. Column (5): DiD with week and gas station fixed effects, control variables, and also province*brent fixed effects. The significance levels are as follows: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Standard errors are clustered at the gas station level.

Second, we can formally test the evolution of pre-trends by interacting the treatment variable with time dummies –see Autor (2003). To explore these dynamics, we estimate our main specification described by equation (7), augmented with leads and lags of being vertically-integrated. Specifically, the estimated regression model is as follows:

$$\ln(\text{price}_{it}) = \sum_{\tau=-25}^{-1} \beta_{\tau} \text{Treated}_i * \text{Week}_{\tau} + \sum_{\tau=0}^{26} \beta_{\tau} \text{Treated}_i * \text{Week}_{\tau} + \quad (10)$$

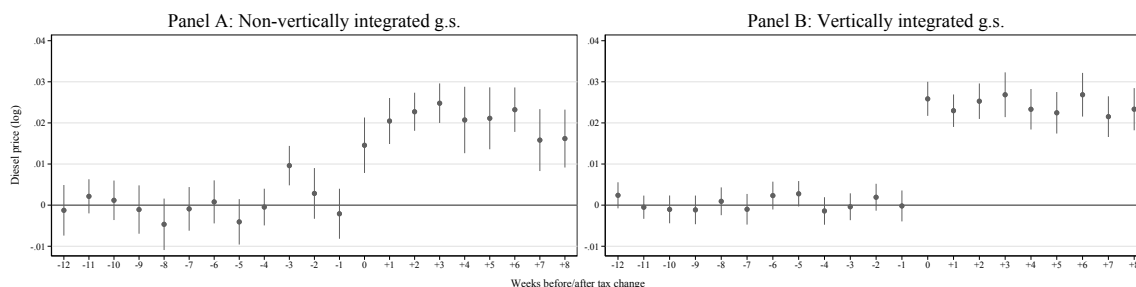
$$+ X'_{it} \delta + \gamma_t + \alpha_i + \epsilon_{it} \quad VI = 0, 1$$

where the dependent variable is the same as before, γ_t are week dummies and we include the

interactions of the week dummies and the treatment indicator for all minus one pre-treatment periods (“leads”) and all minus one post-treatment periods (“lags”).²⁹ If the outcome trends between treatment and control groups are the same, then all leads should be insignificant, i.e., the lead effects are informative regarding whether the estimated effect is stemming from a previously existing trend, instead of coming from the real effect of the regional tax change. Figure 3 shows the estimated impact of the tax increase, separately for gas stations being non-vertically-integrated and being vertically-integrated, on diesel prices for up to twelve weeks before the tax change (in order to include the complete period of the tax announcement and, in addition, two extra weeks), for the relevant week in which the tax was modified and for up to eight weeks after this change.

As discussed in Coglianesi et al. (2017), there are several reasons why anticipatory changes in fuel consumption might be possible. For example, drivers may fill their fuel tank just before the tax change and store it in the tank as long as possible. If this is the case, we would expect small changes in diesel prices around the tax change. However, the coefficients on the treatment leads are close to 0 and not significant, in comparison to a benchmark of zero (indicated with the horizontal black line), thus ruling out anticipatory responses in fuel consumption before the tax increase.

Figure 3: Time passage relative to week of tax change



Note: The figure shows the estimated impact of the tax change, separately for non-vertically-integrated gas stations in panel A and for vertically-integrated gas stations in Panel B, on diesel prices for up to twelve weeks before the tax change, for the relevant week in which the tax was modified and for up to eight weeks after this change, using equation (10). Vertical bands represent ± 1.96 times the standard error of each point estimate.

In addition to providing strong support for the validity of the common trend assumption, Figure 3 also shows a higher jump for vertically-integrated gas stations affected by the tax change, compared to non-vertically-integrated ones, which is consistent with the previous argument that vertically-integrated gas stations react more after a tax change.

²⁹Specifically, we include 25 out of 26 weeks before the tax change, and 26 out of 27 weeks after this change.

6 Conclusions

Many authors have previously studied the extent to which the horizontal market structure affects the pass-through of taxes to consumer prices. But, does the vertical market structure affect it too? To answer this question, we set up and solve the optimal pricing problem of a price-setting retailer that seeks to maximize profits. We use the retailer's optimal pricing rule to make predictions on the incidence of consumers of a change in a per-unit specific tax. In particular, we differentiated between the case in which the retailer is vertically-integrated with a (monopolist) wholesaler, and the case in which it is independent of the (monopolist) wholesaler. We find that, *ceteris paribus*, the pass-through of a tax increase to consumer is much greater in the former case than in the latter one.

We test these theoretical predictions using data from the Spanish gasoline market. For that purpose, we use a confidential dataset on the vertical relationship that exists between a major oil refiner and the gas stations that sell gasoline under the brand of such a refiner. In particular, we test the heterogeneous effect of a regional tax change on final prices depending on the structure of the vertical chain of each of the gas stations included in our dataset. Consistently with the theoretical predictions, we find that gas stations that are vertically-integrated with the refiner passed-through about 97% of the regional state tax onto final prices, while those that are independent of the wholesaler passed-through just about 72% of the tax.

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Appendix A (For Online Publication). Proofs

Lemma A.1 $(\hat{p} - c - \tau) < (p^* - w - \tau)$

Proof. Consider equation (4). Solving this equation for w^* , we arrive at

$$w^* = c - \frac{D(p^*)}{\frac{\partial D(p^*)}{\partial p^*} \frac{\partial p^*(w, \tau)}{\partial w^*}} \quad (\text{A.1})$$

Let us denote $\varepsilon(p) \equiv -\frac{\partial D(p)}{\partial p} \frac{p}{D(p)}$; moreover, let $\rho \equiv \frac{\partial p^*(w, \tau)}{\partial w^*}$. Thus, the previous expression can be rewritten as follows

$$w^* = c + \frac{p}{\varepsilon(p)} \frac{1}{\rho} \quad (\text{A.2})$$

Next, let us consider equation (2), which using the previous notation can be rewritten as follows,

$$(p^* - w - \tau) = \frac{p}{\varepsilon(p)} \quad (\text{A.3})$$

Replacing (A.2) into (A.3), we arrive at

$$(p^* - c - \tau) = \frac{p}{\varepsilon(p)} \left(1 + \frac{1}{\rho}\right) \quad (\text{A.4})$$

or, equivalently,

$$p^* = \frac{c + \tau}{1 - \frac{1}{\varepsilon(p)} - \frac{1}{\varepsilon(p)\rho}} \quad (\text{A.5})$$

Next, let us consider equation (6), which using the previous notation can be rewritten as follows,

$$(\hat{p} - c - \tau) = \frac{p}{\varepsilon(p)} \quad (\text{A.6})$$

or, equivalently,

$$\hat{p} = \frac{c + \tau}{1 - \frac{1}{\varepsilon(p)}} \quad (\text{A.7})$$

Since the demand is iso-elastic, and since we know that $\rho > 0$ (by Lemma 1), then $-\frac{1}{\varepsilon(p)\rho} < 0$, which implies that $1 - \frac{1}{\varepsilon(p)} - \frac{1}{\varepsilon(p)\rho} < 1 - \frac{1}{\varepsilon(p)}$, which implies that $\frac{c+\tau}{1 - \frac{1}{\varepsilon(p)} - \frac{1}{\varepsilon(p)\rho}} > \frac{c+\tau}{1 - \frac{1}{\varepsilon(p)}}$. That is, $p^* > \hat{p}$. This implies that $\frac{p^*}{\varepsilon(p^*)} > \frac{\hat{p}}{\varepsilon(\hat{p})}$. Therefore, by equations (A.3) and (A.6), it follows that $(p^* - w - \tau) > (\hat{p} - c - \tau)$.³⁰ \square

Proof of Proposition 1. On the one hand, applying the implicit function theorem to equation (2)

³⁰This result can be generalized for an increasing price-elasticity function as long as $(p^* - \hat{p}) > \varepsilon p^* - \varepsilon \hat{p}$, which implies that $\frac{p^*}{\varepsilon(p^*)} > \frac{\hat{p}}{\varepsilon(\hat{p})}$.

gives

$$\frac{dp^*}{d\tau} = -\frac{\left(-\frac{\partial w}{\partial \tau} - 1\right) \frac{\partial D(\cdot)}{\partial p}}{2\frac{\partial D(\cdot)}{\partial p} + (p^* - w - \tau) \frac{\partial^2 D(\cdot)}{\partial p^2}} \quad (\text{A.8})$$

or, equivalently,

$$\frac{dp^*}{d\tau} = \left(\frac{\partial w}{\partial \tau} + 1\right) \frac{\frac{\partial D(\cdot)}{\partial p}}{2\frac{\partial D(\cdot)}{\partial p} + (p^* - w - \tau) \frac{\partial^2 D(\cdot)}{\partial p^2}} \quad (\text{A.9})$$

On the other hand, applying the implicit function theorem to equation (6) gives

$$\frac{d\hat{p}}{d\tau} = -\frac{-\frac{\partial D(\cdot)}{\partial p}}{2\frac{\partial D(\cdot)}{\partial p} + (\hat{p} - c - \tau) \frac{\partial^2 D(\cdot)}{\partial p^2}} \quad (\text{A.10})$$

or, equivalently,

$$\frac{d\hat{p}}{d\tau} = \frac{\frac{\partial D(\cdot)}{\partial p}}{2\frac{\partial D(\cdot)}{\partial p} + (\hat{p} - c - \tau) \frac{\partial^2 D(\cdot)}{\partial p^2}} \quad (\text{A.11})$$

The goal of this proof is to show that $\frac{dp^*}{d\tau} < \frac{d\hat{p}}{d\tau}$. First, notice that both equation (A.9) and (A.11) are positive. This is because, for both expressions, the denominator is strictly negative (due to the second order condition requirement for the maximization problems), and because is also strictly negative —since $\frac{\partial D(\cdot)}{\partial p} < 0$.

By the previous lemma, we know that $(\hat{p} - c - \tau) < (p^* - w - \tau)$. Therefore, by assumption, we know that $(\hat{p} - c - \tau) \frac{\partial^2 D(\cdot)}{\partial p^2} < (p^* - w - \tau) \frac{\partial^2 D(\cdot)}{\partial p^2}$. Moreover, due to the strictly concavity of the demand function, we know that $\frac{\partial D(p^*)}{\partial p^*} < \frac{\partial D(\hat{p})}{\partial \hat{p}}$. Therefore, $\frac{\partial D(p^*)}{\partial p^*} (\hat{p} - c - \tau) \frac{\partial^2 D(\cdot)}{\partial p^2} < \frac{\partial D(\hat{p})}{\partial \hat{p}} (p^* - w - \tau) \frac{\partial^2 D(\cdot)}{\partial p^2}$. Moreover, since $2\frac{\partial D(\hat{p})}{\partial \hat{p}} \frac{\partial D(p^*)}{\partial p^*} > 0$, then $2\frac{\partial D(\hat{p})}{\partial \hat{p}} \frac{\partial D(p^*)}{\partial p^*} + \frac{\partial D(p^*)}{\partial p^*} (\hat{p} - c - \tau) \frac{\partial^2 D(\cdot)}{\partial p^2} < 2\frac{\partial D(\hat{p})}{\partial \hat{p}} \frac{\partial D(p^*)}{\partial p^*} + \frac{\partial D(\hat{p})}{\partial \hat{p}} (p^* - w - \tau) \frac{\partial^2 D(\cdot)}{\partial p^2}$; that is, $\frac{\partial D(p^*)}{\partial p^*} \left[2\frac{\partial D(\hat{p})}{\partial \hat{p}} + (\hat{p} - c - \tau) \frac{\partial^2 D(\cdot)}{\partial p^2}\right] < \frac{\partial D(\hat{p})}{\partial \hat{p}} \left[2\frac{\partial D(p^*)}{\partial p^*} + (p^* - w - \tau) \frac{\partial^2 D(\cdot)}{\partial p^2}\right]$, which implies that $\frac{\frac{\partial D(p^*)}{\partial p^*}}{\left[2\frac{\partial D(p^*)}{\partial p^*} + (p^* - w - \tau) \frac{\partial^2 D(\cdot)}{\partial p^2}\right]} < \frac{\frac{\partial D(\hat{p})}{\partial \hat{p}}}{\left[2\frac{\partial D(\hat{p})}{\partial \hat{p}} + (\hat{p} - c - \tau) \frac{\partial^2 D(\cdot)}{\partial p^2}\right]}$

Finally, by Lemma 3, we know that $\frac{dw}{d\tau} < 0$. Then, it is straightforward to see that $\left(\frac{\partial w}{\partial \tau} + 1\right) < 1$.

Combining the previous results, we can conclude that

$$\left(\frac{\partial w}{\partial \tau} + 1\right) \frac{\frac{\partial D(p^*)}{\partial p^*}}{\left[2\frac{\partial D(p^*)}{\partial p^*} + (p^* - w - \tau) \frac{\partial^2 D(\cdot)}{\partial p^2}\right]} < \frac{\frac{\partial D(\hat{p})}{\partial \hat{p}}}{\left[2\frac{\partial D(\hat{p})}{\partial \hat{p}} + (\hat{p} - c - \tau) \frac{\partial^2 D(\cdot)}{\partial p^2}\right]}$$

or, in other words, that $\frac{dp^*}{d\tau} < \frac{d\hat{p}}{d\tau}$. \square