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ABSTRACT

The canonical theory of taxation holds that the incidence of a tax is independent of the side of the market which is responsible for remitting the tax to the government. However, this prediction does not survive in certain circumstances, for example when the ability to evade taxes differs across economic agents. In this paper, we estimate in the context of state diesel fuel taxes how the incidence of a quantity tax depends on the point of tax collection, where the level of the supply chain responsible for remitting the tax varies across states and over time. Our results indicate that moving the point of tax collection from the retail station to higher in the supply chain substantially raises the pass-through of diesel taxes to the retail price. Furthermore, tax revenues respond positively to collecting taxes from the distributor or prime supplier rather than from the retailer, suggesting that evasion is the likely explanation for the incidence result.

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1 Introduction

The independence between statutory and economic incidence of a tax is a widely accepted result in the theory of taxation. The textbook law of tax incidence holds that the party responsible for remitting the tax to the government has no impact on who actually bears the burden, at least in the long run. Despite its general acceptance, this law holds only under special circumstances. In particular, when parties differ in their ability to evade taxes, the identity of the tax remitter may impact the pattern of post-tax prices and therefore the location of their burden. Due to different evasion technologies available to the different sides of a market, a tax levied on the demand side may shift the demand curve to a different degree than a similar tax levied on supply side would shift the supply curve.

This issue is relevant to the current debate on whether a carbon tax should be levied on upstream suppliers or downstream users. Opportunities to avoid taxes vary at different points in the supply chain. Although a number of papers (e.g. Metcalf (2009), Neimeier et al. (2008), Fischer et al. (1998)) highlight the administrative, distributional and political advantages of levying a carbon tax at different points in the supply chain, the literature largely assumes away an impact on the incidence of taxes. For example, Metcalf (2009) notes "One might argue that it would be better to levy the tax downstream because the carbon price would be more visible to end users and thus more likely to figure into energy consumption and planning decisions. Such an argument ignores a basic principle of tax incidence analysis: the ultimate burden and behavioral response to a tax does not depend on where in the production process the tax is levied." Similarly, Fischer et al. (1998) comments "...a downstream approach will have the same ultimate effects on fossil fuel and other prices as an upstream program. This corollary of the basic proposition that the ultimate incidence of a tax is independent of where it is applied is frequently misunderstood by proponents of downstream-based GHG emissions trading."

In this paper, we empirically examine how the identity of the tax remitter affects incidence in the diesel fuel market and present empirical evidence that the identity of the remitting party affects both collections and the incidence of taxes. Our context is state diesel fuel taxes. States differ in the stage of the supply chain responsible for remitting the tax (none requires final consumer remittance), and over time states have in general moved the point of tax collection to higher in the supply chain. In the early 1980s, states were almost evenly split between collecting taxes from retail stations and collecting from intermediate wholesale distributors. Over the subsequent twenty years, many states have moved away from collecting from retail stations and toward collecting from prime suppliers. States changed tax collection regimes at different points in time, a fact which we will exploit in this paper.

In addition to the considerable variation in the point of collection, the nature of tax evasion in the diesel market makes it a desirable setting for studying the effect of remittance on incidence. Several factors contribute to creating opportunities for evading diesel taxes. Due to fixed per-firm costs, it is relatively costly to monitor the remittance of the tax when there are many remitters each responsible for a small fraction of total revenue, as when taxes are collected from retail stations. Also, variation in tax rates across jurisdictions and across the uses of diesel create opportunities for misstating the ultimate state of sale or the intended use of a gallon of diesel.[1] Importantly, the opportunities for evasion differ considerably across the stages of the

[1] As we discuss below, the rate of tax on diesel fuel depends on whether the fuel is used for residential heating or for commercial purposes.

supply chain. For instance, hiding taxed sales is more difficult for prime suppliers because they are relatively less costly to monitor. On the other hand, a gallon of diesel sold at the retail level is usually intended for on-highway use, so retailers will find it more difficult to evade by misstating the intended use or state of sale. Which form of evasion is more important for tax collection is an empirical matter.

We find that the rate of pass-through of diesel taxes to retail prices is dependent on the location of remittance responsibility. Retail diesel prices are higher, and diesel taxes are passed through to retail prices to a greater extent, in states where the point of collection is at the distributor or prime supplier level rather than at the retail level. This suggests that this collection regime reduces evasion. Lending credence to this result, we are able to trace the impact of collecting at the prime supplier level through the supply chain. An increase in the tax raises the wholesale price in supplier-remitting states, although not in retailer-remitting states. Moreover, conditional on the wholesale price, supplier remittance has no effect on pass-through. In other words, the effect of an increase in taxes on retail prices in supplier remitting states can be entirely explained via their effect on wholesale prices.

To examine tax evasion as an explanation for this result, we estimate the response of tax collections to the point of tax collection. We find evidence suggesting that, ceteris paribus, states see less tax revenue when taxes are collected at the retail level. This is consistent with the incidence results, which suggest that retailers have more ability to evade taxes than higher levels of the supply chain.

The tax collection regime is unlikely to be randomly assigned, and may be chosen in a way that maximizes revenues or minimizes the cost of tax collection. While this may suggest that our estimated effects of the tax collection regime are local, heterogenous treatment effects are less of a concern in this paper since we are merely testing a null hypothesis of tax collection regime having *no* effect on the pass-through of prices. More importantly, however, is the concern that unobserved variables may influence both evasion and the tax regime. To alleviate such concerns, we exploit the timing of changes in tax collection regime, showing that both incidence and collections change discontinuously at the date of the change in remitting party.

The tax literature has recognized for some time the importance of tax administration and collection, such as Musgrave (1969). Sorensen (1994), Kau and Rubin (1981), and Balke and Gardner (1991) suggest links between the size of government or the structure of tax systems and tax administration. However, theoretical work has largely ignored the implications of evasion and tax collection on incidence, with a possible exception being Tanzi (1992). Slemrod (2008) suggests that statutory and economic incidence are not necessarily independent in the presence of evasion, and discusses the conditions under which the textbook invariance principle fails.

Despite its prominent place in the theory of taxation, there is scant empirical work testing the independence of statutory incidence. Saez et al (2012) examine the payroll tax in Greece, where a rule change extended the earnings cap for individuals starting work in 1993 or later. They find that the increase in the employer portion of the tax was passed through to wages, while the employee portion was not, perhaps since posted salaries exclude the employer portion of the payroll tax. The authors suggest that institutional factors may therefore play an important role in the incidence of a tax.

The nature of tax enforcement and how it affects parties at different points in the supply chain is considered in the context of the value-added tax (VAT) by De Paula and Scheinkman

(2010). They show that the self-enforcing nature of the VAT leads to spillovers in informality between firms at neighboring levels of the supply chain. In related work, Pomeranz (2011) finds in a randomized field experiment that random audit announcements are transmitted to the compliance behavior of firms up the supply chain.

Prior empirical work has examined evasion and enforcement of diesel taxes. Marion and Muehlegger (2008) study the dyeing of untaxed diesel, a key enforcement innovation in the U.S. Agostini and Martinez (2012) study the tax reporting effects of audit threats in Chile.

A handful of recent studies have estimated the pass-through rate of fuel taxes to retail prices. Doyle and Samphantharak (2008) estimate the effect of gas tax holidays in Illinois and Indiana on retail prices. Marion and Muehlegger (2011) estimate the dependence of the pass-through rate of fuel taxes on a variety of factors related to supply conditions in the fuel market. Other relevant work in the pass-through rate of fuel taxation includes Alm et al (2009), Chouinard and Perloff (2004,2007).[2] The literature related to the pass-through rate of retail sales taxes broadly is more sparse, as suggested by Poterba (1996). Besley and Rosen (1999), who estimate the pass-through rate of city sales taxes to prices for twelve commodoties, is an exception. A number of papers including Sung, Hu and Keeler (1994), Barnett et al (1995), Delipalla and O'Donnell (2001), Harding et al (2009), and Chiou and Muehlegger (2009) estimate cigarette tax incidence. A smaller literature has examined the incidence of labor market taxes, which are often assumed to be fully borne by workers (Fullerton and Metcalf, 2002). Rothstein (2009) finds that the EITC expansion in the 1990s reduced wages among low-skilled workers, so that low-skilled single mothers benefitted by only 70 cents per dollar of tax credits received. Wages declined for non-eligible low-skilled workers as well, which resulted in employers benefitting by 0.72 cents for every dollar of benefits.

The rest of the paper proceeds as follows. Sections 2 and 3 analyze a model of the evasion decision and describes under what circumstances statutory incidence alters economic incidence. Section 4 provides relevant institutional details. Section 5 describes the data and methodology. Section 6 describes the empirical results regarding pass-through, and section 7 shows the effect of remittance on tax compliance. Section 8 concludes.

2 Pass-through in the Presence of Tax Evasion

Standard models of tax incidence treat compliance and monitoring as costless activities, which is a simplification that in many circumstances does not hold and could have important implications for the distribution of the burden of taxation. To see this, consider the demand and supply sides of a market, where these can either be thought of as consumers and firms, or alternatively two different levels of a supply chain. In equilibrium, price equates demand and supply: $Q(p) = S(p)$. Introducing a per-unit tax that must be remitted by suppliers alters this equilibrium to $Q(p_r) = S(p_r - t_r)$, where p_r denotes the retail price faced by consumers and t_r is the retail stage tax. Alternatively, a similar tax that is instead remitted by the demand side of the market results in an equilibrium price p_r^p (price received by producers selling to the retail consumers) such that $Q(p_r^p + t_r) = S(p_r^p)$. The quantity sold and the pattern of net-of-tax prices must be

[2] Early empirical work on incidence includes Due (1954), Brownlee and Perry (1967), Woodard and Siegelman (1967), and Sidhu (1971). Chernick and Reschovsky (1997) consider the distributional impact of the gasoline tax by examining gasoline expenditures across different deciles of the income and expenditure distribution.

the same in these two equilibria, where $p_r^p + t_r = p_r$.[3]

This irrelevance result is driven by demand and supply depending only on the tax-adjusted prices. Allowing for differences in either the evasion technology or the cost of monitoring across the demand and supply sides of the market potentially alters this conclusion. Consider the possibility that demand or supply depends not just on the relevant prices but also on the tax rate remitted by each side: the overall tax rate remains t_r, but t_s of it is to be paid by the suppliers and $t_r - t_s$ by the consumers so that the demand is given by $Q(p_r^p + t_r, t_r - t_s) = S(p_r^p, t_s)$. In some cases (as in the payroll tax) statutory incidence is indeed split between the two sides of the market and we are asking how a change in it would modify the actual incidence. More often statutory incidence and remittance responsibility fall on one side, but even in such a case it is still illuminating to consider marginal changes. Due to differences between the two sides of the market in terms of the potential for tax evasion or compliance costs, or due to behavioral or institutional reasons, demand and/or supply can depend on the remitted tax independently of the price.

It is easy to show by differentiating the equilibrium condition $Q(p_r^p + t_r, t_r - t_s) = S(p_r^p, t_s)$ with respect to t_s, that the effect of change in the tax share of each side will in general alter the equilibrium price: $\frac{dp}{dt_s} = \frac{\frac{\partial S}{\partial t_r} + \frac{\partial Q}{\partial t_r}}{\frac{\partial Q}{\partial p} - \frac{\partial S}{\partial p}}$. Only in the special case $\frac{\partial S}{\partial t_r} + \frac{\partial Q}{\partial t_r} = 0$ will the price not respond to a change in remittance responsibility. The textbook case assumes that both terms are zero, leading to the result of the irrelevance of statutory incidence.

More generally, if being a remitter is beneficial holding price constant (e.g., when it creates evasion opportunities), then both terms would be positive. As the tax responsibility is shifted to producers, their price should fall reflecting gains that they accrue. If bearing a tax is costly (e.g., due to compliance costs), this conclusion would be reversed. The effect on output depends on the relative responsiveness to the tax and price on either side: assuming a positive effect of being the remitter of the tax (evasion opportunities), shifting the statutory to the relatively more tax sensitive side increases output. Only in a knife-edge case, when these relative sensitivities are the same, would the tax not matter for output.

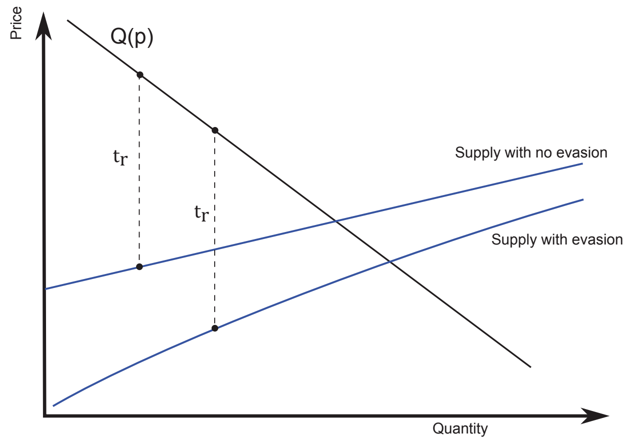
Figure 1 shows how evasion can affect the equilibrium price in the special case when only suppliers can evade. When evasion is not possible, the supply and demand curves are standard. Introducing opportunities for evasion can shift the supply curve to the right due to evasion opportunities that it affords to suppliers, leading to a new equilibrium with higher output and lower producer and consumer prices. A tax can have a smaller impact on prices in the presence of evasion (or, more generally, when the tax is collected from the side of the market more able to evade). The rest of this section is devoted to micro-founding this intuition in the context corresponding to diesel taxation, where evasion opportunities exist.

2.1 Homogeneous firms

We offer a simple model to understand the impact of tax evasion on tax incidence and the pass-through rate. We assume, as before, that demand is $Q(p_r)$, where p_r denotes the tax-inclusive price charged by retailers to final consumers. The supply side of the market consists of retailers and wholesalers. Retailers buy product from wholesalers at price p_w and face variable costs that scale with size, $c_r(q_r)$, where q_r is the amount that each retailer sells with fixed costs F_r.

[3]We will assume throughout perfect competition, though this argument also survives considering market power. See Appendix A for details.

Figure 1: Equilibrium effect of tax evasion



The government levies a per-unit tax of t_r on retailers. Firms required to remit the tax can evade it. We denote the quantity of evasion as e_r and the private cost of tax evasion as $\phi_r(e_r, q_r)$. This function reflects the resources expended in concealing tax liabilities and the expected value of penalties assessed by the tax authority. Throughout the model, we maintain the assumption that the marginal cost of evasion is positive and increasing in the quantity evaded. We begin by assuming that the evasion cost function is identical across firms, an assumption that we will later relax to allow for a more complete characterization of the distributional impact of taxation.

For expositional simplicity, we focus on a specific case where: (1) all firms evade at an interior solution, and (2) the cost of evasion is independent of the total quantity produced by the firm. In this case, profits of the retailer are given by:

$$\Pi_r(q_r, e_r) = (p_r^p - p_w)q_r - c_r(q_r) + t_r e_r - \phi_r(e_r) - F_r \tag{1}$$

where $p_r^p = p_r - t_r$ is the net-of-tax price. Given the simple evasion technology, the solution for tax evasion is independent of the quantity sold and is characterized by $t_r = \phi_r'(e_r)$ so that evasion is a function of the tax rate only, $e_r^*(t_r)$, and the ability to evade provides a rent of $R(t_r) = t_r e_r^*(t) - \phi_r(e_r^*(t_r))$ that is increasing in the tax rate (note that $R'(t_r) = e_r^*(t_r)$ by the envelope theorem).

Observation 1. *Holding the net-of-tax price constant, a higher tax rate increases rents from tax evasion and hence the profits of tax-remitting retailers.*

Higher taxation hurts retailers unless fully passed-on to consumers, yet increases rents from tax evasion. Intuitively, higher taxes provide to remitters a valuable opportunity to steal potential tax revenue.

The production decision of a firm is fully characterized by the first-order condition $p_r^p - p_w = c'(q_r)$ yielding the solution of $q_r^*(p_r^p - p_w)$. We denote the maximized tax-exclusive operating (i.e., accounting for the variable but not the fixed cost) profits as

$$\Pi_r^V(p_r^p - p_w) = (p_r^p - p_w)q_r^*(p_r^p - p_w) - c_r(q_r^*(p_r^p - p_w))$$

To complete the model, we assume that there is free entry in this industry. In equilibrium, firms earn zero profits and markets clear so that

$$\begin{aligned} \Pi_r(q_r^*(p_r^p - p_w), e^*(t_r)) &= \Pi_r^V(p_r^p - p_w) - (F_r - R(t_r)) = 0 \text{ and} \\ N \cdot q_r^*(p_r^p - p_w) &= Q(p_r^p + t_r), \end{aligned}$$

where N is the number of firms in equilibrium. The first equation, a zero-profit condition, pins down the value of p_r^p. The second condition determines the number of firms that will exist in equilibrium.

A higher value of t_r must imply a lower value of p_r^p: because higher taxes generate rents, the tax-exclusive operating profit of firms must decline in order to maintain the zero-profit condition. In other words, the industry supply curve does not remain constant when the tax rate changes but instead shifts down, as in Figure 1.[4] More specifically, we need to have:

$$\frac{\partial \Pi_r^V}{\partial p}\left(\frac{dp_r^p}{dt_r} - \frac{dp_w}{dt_r}\right) + R'(t_r) = 0\,. \tag{2}$$

Using the envelope theorem for both $\Pi_r^V()$ and $R()$ implies that

$$\frac{dp_r^p}{dt_r} = -\frac{e_r^*(t_r)}{q_r^*(p_r^p - p_w)} + \frac{dp_w}{dt_r}\,. \tag{3}$$

For now, we assume that p_w is fixed. We will relax this assumption in Section 3 when we introduce the wholesale sector explicitly. Under this assumption, we have the following observation.

Observation 2. *When t_r rises, the net-of-tax price received by the retailers $\frac{dp_r^p}{dt_r}$ falls by $\frac{e_r^*}{q_r^*}$ and correspondingly the consumer price increases by $1 - \frac{e_r^*}{q_r^*}$.*

Hence, incidence of the tax is determined here by the extent of tax evasion. Absent tax evasion, full incidence falls on the consumers, since free entry implies that supply is infinitely elastic to the pre-tax price. With tax evasion, aggregate supply adjusts in response to the tax rate due to rents associated with it. The effective tax rate for each (price-taking firm) is $t_r \cdot \left(1 - \frac{e_r^*}{q_r^*}\right)$, and this is the amount that is shifted to the consumers.

2.2 Heterogeneous evasion ability

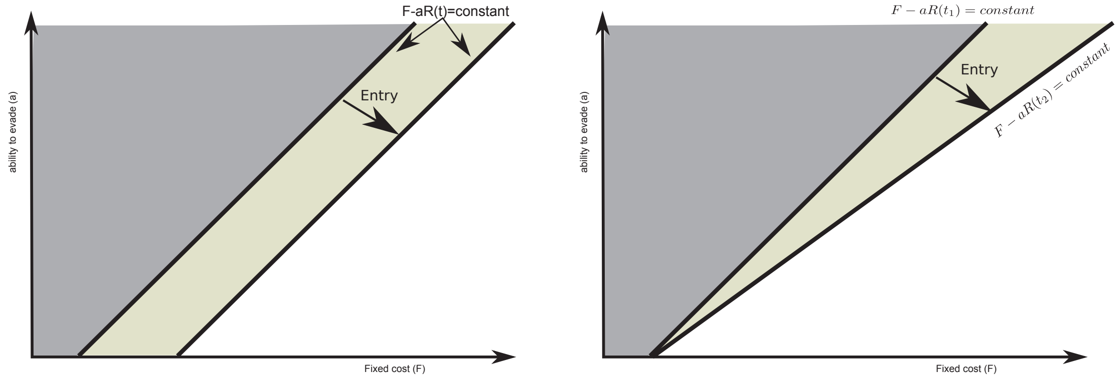
The burden of taxes may vary across firms according to their ability to evade. In this section, we introduce such heterogeneity, and we examine in detail the effect of taxes on industry profits and on the distribution of the tax burden across firms.

We modify the model to allow for heterogeneity along two dimensions. Potential firms are heterogeneous in fixed cost F_r and a parameter a_r that indexes evasion technology. Upon observing its value of these two parameters, the firm makes a decision whether to remain in the industry. These parameters are jointly distributed $G(F_r, a_r)$, with the corresponding density of $g(F_r, a_r)$.[5] The composition of firms in the industry (which depends on how many firms with a given set of characteristics exist) will be an important aspect of our analysis.

[4] Note that in the homogeneous-firm case the supply curve is horizontal.

[5] It is certainly possible that F_r and a_r are correlated. Considering firms that may to some effect choose/invest in combinations of the two skills is an interesting extension but beyond the scope of this paper.

Figure 2: Entry as the result of a price increase (Panel A) and tax increase (Panel B)



(a) Price Increase

(b) Tax Increase

We specify the evasion technology in a simple way by writing the cost function as $\phi_r(e_r, a_r) = a_r\phi_r(e_r/a_r)$ so that $e_r(t, a_r) = a_r e_r(t, 1)$ and $R(t_r, a_r) = a_r R(t_r, 1) \equiv a_r R(t_r)$. Thus, the parameter a_r scales up both the level of tax evasion and tax evasion rent proportionally.

We define an effective fixed cost $M = F_r - a_r R(t_r)$, which we will use to index firms given the value of t_r. It summarizes the information relevant for the firm's entry decision, with each firm comparing the value of its tax-exclusive operating profits Π^V to M.

The shaded areas of Figure 2a illustrate the characteristics of firms that enter, as well as the effect of increasing the price on the threshold values of a_r and F_r required for entry. Denote the effective fixed cost of the marginal firm as $\widehat{M}$. As $\widehat{M}$ increases, the frontier shifts out to the right uniformly, and for any value of a_r firms with higher fixed costs, F_r, enter.

Figure 2b shows the effect of an increase in the tax rate. For any value of a_r, increased evasion rents allow for firms with a higher F_r to now enter. The strength of this effect depends on a_r, because the ability to evade determines the rent from tax evasion. In particular, at $a_r = 0$ a change in the tax rate does not stimulate entry.

To obtain the number of retailers entering the market, we integrate the joint density of fixed costs and evasion ability over those values of F_r and a_r that lead to nonnegative profits. The interior integral in the following expression determines the number of firms at each value of a_r for whom the fixed cost is sufficiently low to enter. The outside integral then integrates across all values of a_r.

$$H(\widehat{M}, t_r) = P(F_r - a_r R(t_r) < \widehat{M}) = \int_0^\infty \int_0^{\widehat{M}+aR(t_r)} g(F, a)\, dF\, da$$

It is straightforward to evaluate how the number of firms changes with $\widehat{M}$ and t_r:

$$\frac{\partial H(\widehat{M}, t_r)}{\partial \widehat{M}} = \int_0^\infty g(\widehat{M} + aR(t_r), a)\, da$$

and

$$\frac{\partial H(\widehat{M}, t_r)}{\partial t_r} = \int_0^\infty aR'(t_r) g(\widehat{M}+aR(t_r), a)\, da = \int_0^\infty e(t_r, a) g(\widehat{M}+aR(t_r), a)\, da = \mathrm{E}[e|\widehat{M}, t_r] \frac{\partial H}{\partial \widehat{M}}$$

where the latter formula uses the fact that $aR'(t_r) = e$ by the envelope theorem. $\mathrm{E}[e|\widehat{M}, t_r]$ denotes the average value of evasion for the marginal firms (those with $M = \widehat{M}$), and its presence signifies that taxation encourages entry in proportion to the extent of evasion.

To trace out the supply curve, note that in free-entry equilibrium all retail firms satisfying

$$\Pi_r^V(p_r^p - p_w) \geq M = F_r - a_r R(t_r) \tag{4}$$

enter. Hence, the overall supply curve is given by

$$S(p_r^p - p_w, t_r) = H(\Pi_r^V(p_r^p - p_w), t_r) \cdot q_r(p_r^p - p_w)\,,$$

where the first term represents the number of firms entering the industry and the second term denotes output per firm. The elasticity of industry supply, depends on the elasticity of the number of firms and the elasticity of output per firm: $\varepsilon_S^p = \varepsilon_N^p + \varepsilon_q^p$. Industry supply is (weakly) increasing in price and, as long as there is at least some tax evasion, in the tax rate as well. (See Appendix A for details.)

To understand the effect of a change in t_r on the equilibrium price, consider how profits change for a given value of a_r. The location of a marginal firm F_r^* is determined by

$$\frac{\partial \Pi_r^V}{\partial p} \cdot \left(\frac{dp_r^p}{dt_r}\right) - \frac{d\{F_r^* - a_r R(t_r)\}}{dt_r} = 0 \implies \frac{dp_r^p}{dt_r} = -\frac{e(a_r, t_r)}{q_r} + \frac{\frac{dF_r^*}{dt_r}}{q_r}\,. \tag{5}$$

This identity highlights two different forces that determine pass-through. The retail price received by the producers falls in proportion to tax evasion — this is a shift in the supply curve due to a change in t_r. This effect is mitigated by entry in the industry corresponding to an increase in the fixed cost that allows firms to survive — this corresponds to a shift along the new supply curve. Critically, the pass-through rate is reduced by the extent of tax evasion.

2.2.1 Equilibrium pass-through rate

Identity (5) reflects the pass-through rate only implicitly because it depends on unknown effects on entry, $\frac{dF_r}{dt_r}$. The shift along the supply curve depends on supply and demand elasticities. To determine them, we need to consider the equilibrium of the market, i.e. where $S(p_r^p - p_w, t_r) = D(p_r^p + t_r)$. Differentiating with respect to the tax rate yields

$$\frac{\partial S}{\partial p} \cdot \left(\frac{dp_r^p}{dt_r}\right) + \frac{\partial S}{\partial t_r} = \frac{\partial D}{\partial p}\left(\frac{dp_r^p}{dt_r} + 1\right),$$

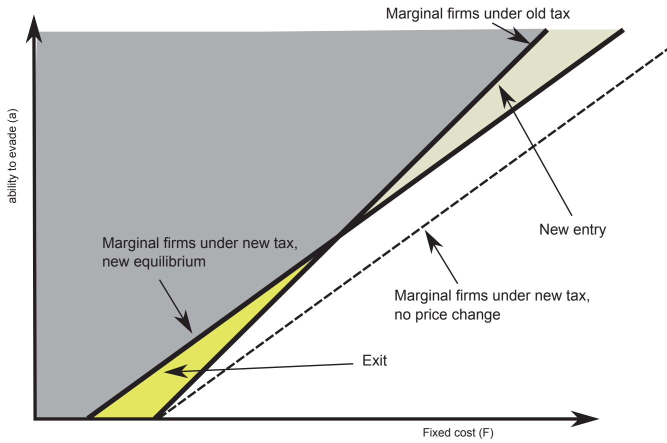
which after substitution for the derivative of the supply curve and expressing in terms of elasticities yields

$$\frac{dp_r^p}{dt_r} = \frac{\varepsilon_D^p}{\varepsilon_N^p + \varepsilon_q^p - \varepsilon_D^p} - \frac{\varepsilon_N^p}{\varepsilon_N^p + \varepsilon_q^p - \varepsilon_D^p} \cdot \frac{\mathrm{E}[e|\widehat{M}, t_r]}{q_r}, \tag{6}$$

where $\varepsilon_D^p < 0$, ε_N^p, and ε_q^p are the price elasticities of demand, the number of firms, and per firm quantity, respectively. (Note that we normalize all elasticities by multiplying through by p_r^p.) In the absence of evasion ($e = 0$), this is the standard formula for tax incidence since $\varepsilon_N^p + \varepsilon_q^p$ is the supply elasticity.

The effect due to tax evasion is represented by $\frac{\mathrm{E}[e|\widehat{M}, t_r]}{q_r}\varepsilon_N^p$, and it counteracts the demand

Figure 3: Changes in the composition of firms in equilibrium



effect. As identity (5) highlights, the increase in rents from tax evasion reduces pass-through. That identity corresponds to a fixed level of a_r, but integrated over all levels of ability, the impact of evasion is $\frac{\mathrm{E}[e|\widehat{M},t_r]}{q_r}$ as in formula (6). The importance of the evasion channel depends on how elastic is entry relative to other determinants of supply and demand.

Equation (6) illustrates that the pass-through of benefits from evasion depend on the evasion of the marginal entrant. An increase in the tax rate increases rents for all existing tax evaders in proportion to their evasion, but this effect is inframarginal and does not enter the pass-through rate. What does enter is tax evasion on the margin, $\frac{\mathrm{E}[e|\hat{M},t_r]}{q_r}$. The higher is marginal evasion, the less consumer price changes.[6] To understand this point, consider two extreme assumptions. At one extreme where entry is not allowed and $\varepsilon_N^P = 0$, all tax evasion is inframarginal and has no effect on pass-through. The other extreme, when $\varepsilon_N^P = \infty$, corresponds to the case of homogeneous firms as in Section 2.1. Here, the last term of (6) reduces to $\frac{\mathrm{E}[e|\hat{M},t_r]}{q_r}$, so that evasion rents reduce pass-through one-for-one.

The case of inelastic demand ($\varepsilon_D^p = 0$) is likely to be of interest for fuel markets. Here the impact of tax evasion on the pass-through rate is qualified by $\frac{\varepsilon_N^p}{\varepsilon_N^p + \varepsilon_q^p}$, so that it depends on the relative importance of entry in the overall supply elasticity.[7]

2.2.2 Taxation and industry firm composition

Figure 3 shows the logic of entry/exit decisions. An increase in the tax rate encourages firms to enter the tax-remitting industry by shifting the frontier out to the dashed line. The reduction in price that follows reduces profits and induces firms to exit. Entering firms are disproportionately those with high ability to evade. Exiting firms are spread out over the distribution. As a result, the composition of firms in the industry shifts away from low-evading firms (low values of a) to high-evading firms (high values of a).

Changes in taxation affect inframarginal firms through the price of output and the rents to

[6] This effect is not one-for-one, though, because a lower producers' price discourages entry by reducing regular profits in an analogous way to the standard incidence effect.

[7] It is worth noting that the precise formulation is driven by the clean separation between evasion and output per firm that we have assumed.

evasion. An increase in taxation increases evasion rents for all firms and reduces the net-of-tax output price. These conflicting effects create winners and losers among firms that stay in the industry, depending on the ability to evade. For firms with a high value of a_r, the evasion rent effect dominates and net profits increase. This implies that firms more able and willing to evade taxes should prefer (and lobby) that taxes be collected from their stage of production.

2.2.3 Taxation and industry profits

In the standard case without evasion, the pass-through fraction determines how the overall burden of tax is split between the two sides of the market. This is not the case here. While the effect of the tax on consumers goes through the price only, the effect on producers has two components: a price effect and the direct effect on the rents from tax evasion. Consider total industry profits:

$$\Pi = \int_{F_r - a_r R(t_r) \leq \Pi_r^V(p_r^p - p_w)} \left(\Pi_r^V(p_r^p - p_w) - F_r + R(t_r, a_r) \right) \, dG(a_r, F_r) \,,$$

where the integration is over all producing firms. Taking derivatives of this expression with respect to t_r is simplified by the fact that marginal entering firms have zero profits, so that the effect of a change in the number of firms vanishes. Consequently,

$$\frac{d\Pi}{dt_r} = \int_{F_r - a_r R(t_r) \leq \Pi_r^V(p_r^p - p_w)} \left\{ \left(\frac{dp_r^p}{dt_r} \right) q + e(t_r, a_r) \right\} dG(a_r, F_r) \,.$$

Writing $\bar{e}$ for average tax evasion and $\bar{q}$ for average output (which in our context is the same as each firm's output), this can be rewritten as

$$\frac{d\bar{\Pi}}{dt_r} = H(\Pi_r^V(p_r^p - p_w), t_r)\bar{q} \left(\frac{dp_r^p}{dt_r} + \frac{\bar{e}}{\bar{q}} \right) \,.$$

As before, if not for the presence of $\frac{\bar{e}}{\bar{q}}$, this result would be standard: the effect on industry profit is proportional to output and the change in the price margin (and because the effect on consumers is also proportional to the output, it is the price change that determines the relative burden on the producers). The presence of tax evasion increases profits and mitigates the impact of the price change, and the burden on producers is lower than the pass-through rate would indicate.

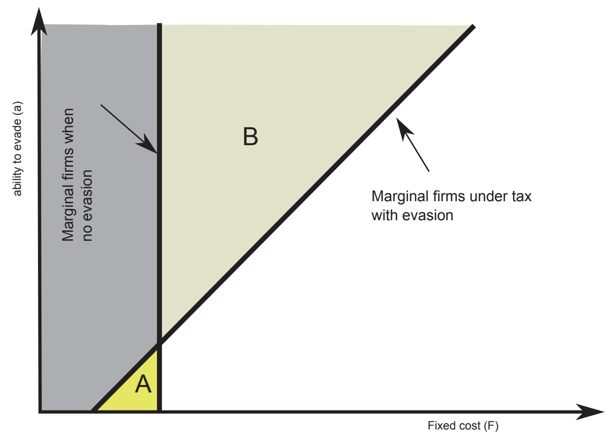
Substituting from formula 6 yields

$$\frac{d\bar{\Pi}}{dt_r} \Big/ \left\{ H(\Pi_r^V(p_r^p - p_w), t_r)\bar{q} \right\} = \frac{\varepsilon_D^p}{\varepsilon_N^p + \varepsilon_q^p - \varepsilon_D^p} + \frac{\bar{e}}{\bar{q}} - \frac{\varepsilon_N^p}{\varepsilon_N^p + \varepsilon_q^p - \varepsilon_D^p} \cdot \frac{\mathrm{E}[e|\widehat{M}, t_r]}{\bar{q}} \,. \qquad (7)$$

Equation (7) says that the role of tax evasion in determining the full impact of the tax rate on industry profits flows through two channels. One reflects the average tax evasion, which influences (positively) industry profits from rents. The other reflects the effect of tax evasion on the margin, which is critical for determining the effect on the equilibrium price.

In general, marginal and average tax evasion are not restricted (they depend on the shape of the distribution and, in particular, the correlation between fixed cost and ability to evade) so

Figure 4: Changes in the composition of firms depending on point of taxation



that the overall effect can go in either direction. Trivially, the impact of taxation on profits may be negative — it will be so when tax evasion is not present. If non-evaders have low fixed cost, the average tax evasion can be close to zero while marginal tax evasion is substantial, so that the sum of the last two (evasion-related) terms can be negative. Furthermore, the whole expression can also be positive. To see this, note that making some of the inframarginal firms better at evasion would increase average tax evasion without affecting either these firms' behavior or the equilibrium. As a result, a judicious choice of the distribution of characteristics will allow for making $\frac{\bar{e}}{\bar{q}}$ sufficiently large and turning the whole expression positive.

In sum, the cost of the tax for the industry as the whole may be lower or higher than the standard formula would indicate.

2.2.4 How Evasion Affects Firm Composition and Industry Profits

Recall that Figure 1 illustrates the effect of a tax remitted by retailers on the market equilibrium. To illustrate the effect of evasion on retailer prices and industry profits, we show the equilibrium both with and without evasion. Two observations are worth noting. First, compared to the no evasion case, evasion shifts the supply curve outward. This effect partially compensates consumers for the presence of the tax. Second, evasion has distributional implications for the producers. The higher pass-through under no evasion corresponds to a movement up the demand curve, so that overall output is lower relative to the case with evasion. Hence, eliminating evasion corresponds to (1) higher regular profits for the surviving firms (because price increases) and (2) fewer firms in the industry (because output per firm is higher and yet overall output is lower).

Figure 4 illustrates the effect on the composition of the firms. Firms in region B exist when evasion is possible but disappear when evasion is not possible. Low fixed cost but evasion-averse evading firms in region A do not exist when evasion is possible, but the increase in output price when evasion is eliminated makes it possible for them to enter and survive.

For the effect on industry profits as the whole, equation (7) provides some guidance.[8] As

[8]The comparison of the right-hand sides makes sense when output levels are identical, because otherwise there are also level differences in profits. One such case is when we consider a small tax around $t = 0$. Another is when

previously discussed, the effect of evasion is ambiguous in general. When there is no tax evasion, the formula still applies but the tax evasion terms naturally vanish. Hence, predictions about under which regime the right-hand side of this formula is bigger depend on the distribution of firms and behavioral elasticities.

Thus, eliminating tax evasion has multiple effects from the point of view of the industry. First, it creates winners and losers among firms. Second, the effect on the overall profits in the industry is in general ambiguous and depends on the relative tax evasion pursued by average versus marginal firms. Third, it reduces the number of firms in the industry.

3 Remitting party and pass-through

We now consider adding a wholesale sector to the model, which will allow us to analyze moving the remittance responsibility to a different level of the supply chain. As with the retail sector, we assume there is a large number of potential wholesalers, heterogeneous with respect to fixed cost F_w and ability to evade a_w, that make entry decisions and maximize profits. The tax (if any) that is levied on wholesale firms is denoted by t_w, and these firms are not directly affected by the tax imposed on the retailers t_r. We denote by p_w^p the net-of-tax price that is charged by the producers, so that $p_w = p_w^p + t_w$. Maximized profits in the wholesale sector are denoted by $\Pi_w^V(p_w^p)$ and the rents from tax evasion are $R_w(t_w, a_w) = a_w R_w(t_w)$. The partial equilibrium analysis of the effect of changes in p_w^p and t_w on this upstream stage is the same as before.

An equilibrium relationship links demand and the output levels in the two sectors:

$$D(p_r^p + t_r) = S(p_r^p - p_w^p - t_w, t_r) = W(p_w^p, t_w)\,,$$

where W is the overall supply in the wholesale industry that depends on the price it charges and the tax that it can evade. Focusing first on the effect of t_r on p_w^p, we can use the equality between final demand and wholesale output to obtain:

$$\frac{\partial D}{\partial p}\left(\frac{dp_r^p}{dt_r}+1\right) = \frac{\partial W}{\partial p}\frac{dp_w^p}{dt_r} \implies \frac{dp_w^p}{dt_r} = \frac{\varepsilon_D^p}{\varepsilon_W^p}\left(\frac{dp_r^p}{dt_r}+1\right) \tag{8}$$

where ε_W^p is the elasticity of wholesale output (and, where as before, we are defining it by multiplying by p_r^p). Substituting into (6), recalling $\varepsilon_S^p = \varepsilon_N^p + \varepsilon_q^p$, and simplifying yields:

$$\frac{dp_r^p}{dt_r} = \frac{\varepsilon_D^p(\varepsilon_S^p + \varepsilon_W^p)}{\varepsilon_S^p\varepsilon_W^p - \varepsilon_D^p\varepsilon_S^p - \varepsilon_D^P\varepsilon_W^p} - \frac{\varepsilon_N^p\varepsilon_W^p}{\varepsilon_S^p\varepsilon_W^p - \varepsilon_D^p\varepsilon_S^p - \varepsilon_D^P\varepsilon_W^p}\cdot\frac{\mathrm{E}[e|\widehat{M}, t_r]}{q_r}\,.$$

Hence, our original conclusions are modified only slightly: the standard formula has to be modified to reflect supply responses along the whole supply chain,and the effect of evasion is mitigated by ε_W^P. When $\varepsilon_W^P = \infty$, the price in the wholesale sector is fixed, so that our previous analysis applies. When $\varepsilon_W^P < \infty$, the effect of tax evasion on retail price is mitigated because it is partially accommodated on the wholesale side. See appendix A for the effect of t_r on the wholesale price p_w^p.

The effect of the tax in the wholesale sector can be analyzed in the same way as the tax in

demand is inelastic, $\varepsilon_D^p = 0$. In what follows, when considering the wholesale tax we will consider a marginal shift of the tax across sectors.

the retail sector. First, note that analogously to equation (6) we can derive

$$\frac{dp_w^p}{dt_w} = -\frac{\varepsilon_S^p}{\varepsilon_S^p + \varepsilon_W^p} - \frac{\varepsilon_{WN}^p}{\varepsilon_S^p + \varepsilon_W^p} \cdot \frac{\mathrm{E}[e_W|\widehat{M}, t_W]}{q_W} + \frac{\varepsilon_S^p}{\varepsilon_S^p + \varepsilon_W^p} \frac{dp_r^p}{dt_w} \tag{9}$$

so that the pass-through rate of the wholesale tax modifies regular pass-through by the impact of the wholesale tax on evasion in the wholesale industry, scaled by the entry elasticity in that industry (ε_{WN}^p), and needs to be adjusted for the impact of the tax on the price in the retail sector, $\frac{dp_r}{dt_w}$, if any. Then, by differentiating the equilibrium condition in the final goods market $D(p_r^p + t_r) = S(p_r^p - p_w^p - t_w, t_r)$ with respect to t_w to establish the relationship between $\frac{dp_r^p}{dt_w} = \frac{\varepsilon_S^p}{\varepsilon_S^p - \varepsilon_D^p}\left(\frac{dp_w^p}{dt_w} + 1\right)$ and substituting, one obtains

$$\frac{dp_w^p}{dt_w} = \frac{\varepsilon_D^p \varepsilon_S^p}{\varepsilon_S^p \varepsilon_W^p - \varepsilon_D^p \varepsilon_S^p - \varepsilon_D^P \varepsilon_W^p} - \frac{\varepsilon_{WN}^p(\varepsilon_S^p - \varepsilon_D^p)}{\varepsilon_S^p \varepsilon_W^p - \varepsilon_D^p \varepsilon_S^p - \varepsilon_D^P \varepsilon_W^p} \cdot \frac{\mathrm{E}[e_w|\widehat{M}, t_w]}{q_w} \tag{10}$$

As to the impact on the retail price:

$$\frac{dp_r^p}{dt_w} = \frac{\varepsilon_S^p}{\varepsilon_S^p - \varepsilon_D^p}\left(\frac{dp_w^p}{dt_w} + 1\right) = \frac{\varepsilon_S^P \varepsilon_W^P}{\varepsilon_S^p \varepsilon_W^p - \varepsilon_D^p \varepsilon_S^p - \varepsilon_D^P \varepsilon_W^p} - \frac{\varepsilon_{WN}^p \varepsilon_S^p}{\varepsilon_S^p \varepsilon_W^p - \varepsilon_D^p \varepsilon_S^p - \varepsilon_D^P \varepsilon_W^p} \cdot \frac{\mathrm{E}[e_w|\widehat{M}, t_w]}{q_w}.$$

Finally, in order to compare the impact of the two types of taxes on the retail price, note that $\frac{dp_r}{dt_r} = \frac{dp_r^p}{dt_r} + 1$, while $\frac{dp_r}{dt_w} = \frac{dp_r^p}{dt_w}$. Hence, considering $\Delta t_r + \Delta t_w = 0$ yields

$$\frac{dp_r}{dt_r}\Delta t_r + \frac{dp_r}{dt_w}\Delta t_w = \frac{\varepsilon_X^P}{\varepsilon_X^P - \varepsilon_D^P}\left(\frac{\varepsilon_{WN}^p}{\varepsilon_{WN}^p + \varepsilon_{Wq}^p}\frac{\mathrm{E}[e_w|\widehat{M}, t_w]}{q_w} - \frac{\varepsilon_N^p}{\varepsilon_N^p + \varepsilon_q^p}\frac{\mathrm{E}[e|\widehat{M}, t_r]}{q_r}\right)\Delta t_r\,, \tag{11}$$

where $\varepsilon_X^p = \frac{\varepsilon_S^p \varepsilon_W^p}{\varepsilon_S^p + \varepsilon_W^p}$, the whole supply chain output elasticity. The sign of this effect depends on the sign of the term in parentheses. When either (1) $\varepsilon_q^p = 0$ or $\varepsilon_N^p = \infty$ and (2) $\varepsilon_{Wq}^p = 0$ or $\varepsilon_{WN}^p = \infty$ (i.e., in each market the entry margin solely determines responsiveness), the expression in brackets reduces to $\frac{\mathrm{E}[e_w|\widehat{M}, t_w]}{q_w} - \frac{\mathrm{E}[e|\widehat{M}, t_r]}{q_r}$, so that shifting the tax to the retail sector increases consumer prices if the retail sector has relatively less evasion on the margin and decreases prices otherwise. Notice that the first term in (11) is the standard incidence expression, implying that the point of taxation choice scales the standard incidence by the difference in tax evasion in the two sectors.[9]

As an example, consider the case of the degenerate distribution where all firms have an identical fixed cost and evasion ability so that $\varepsilon_N^p = \varepsilon_{WN}^p = \varepsilon_S^p = \varepsilon_W^p = \varepsilon_X^p = \infty$. In this case, equation (11) reduces to

$$\frac{dp_r}{dt_r}\Delta t_r + \frac{dp_r}{dt_w}\Delta t_w = \left(\frac{e_w^*}{q_w^*} - \frac{e_r^*}{q_r^*}\right)\Delta t_r. \tag{12}$$

Only in the special case when evasion happens to be exactly the same in each sector does the point of taxation not matter.

[9]See Appendix A for the effect of incidence shift on the wholesale price.

3.1 The effect on equilibrium and taxable quantity

The effect of a change in the remittance pattern ($\Delta t_r + \Delta t_w = 0$) on the equilibrium output Q, given by $\Delta Q = Q'(p_r)\left(\frac{dp_r}{dt_r}\Delta t_r + \frac{dp_r}{dt_w}\Delta t_w\right)$ is simply proportional to the effect on the retail price that is described by formula (11). The effect on taxable output is more complicated. Overall taxable output differs from the equilibrium quantity by the amount of tax evasion in the two sectors, $Q - E - E_w$, where E is overall evasion in the retail sector and E_w is the overall evasion in the wholesale sector. Overall evasion in each sector is simply the aggregate of evasion by all firms in that sector. Hence, evasion in the retail sector is

$$E = \int_0^\infty \int_0^{\Pi^V(p_r^p - p_w) + aR(t_r)} e(t_r, a) g(F, a)\, dF\, da$$

and evasion in the wholesale sector is analogous.

The effect of a change in taxation reflects two different channels. First, it affects marginal firms by changing the fixed cost required for entry $\Pi^V(p_r^p - p_w) + aR(t_r)$ (for any a). The rent from evasion $R(t)$ changes in both sectors, as do price margins and thereby profits. As we have discussed in the previous section, these effects reflect the tax evasion of the *marginal* firms.

Second, the change in taxation affects tax evasion of existing firms, $e(t_r, a)$ and $e^w(t_w, a)$. Recall that tax evasion in this model has been purely determined by tax evasion technology $a\phi_x(e/a)$ (where $x \in \{r, w\}$) as $t_x = \phi_x(e/a)$. We have not restricted ϕ_r and ϕ_w other than assuming that they are increasing and convex. Holding the sign of the difference in tax evasion for marginal (low a) firms in the two sectors constant, we can vary the shape of these two functions to obtain the opposite relationship for the infra-marginal firms. Hence, in general, the effect of a change in the point of remittance on total evasion in the two sectors reflects the interplay between the marginal and inframarginal effects that can in principle go in the direction that is opposite to what the effect on the price (which is determined by marginal evasion only) might indicate. However, it is natural to expect that some notion of a "high-evasion" sector might translate into high evasion both on the margin and for existing firms.

Finally, this observation also suggests that the effect of a change in the point of taxation on the *responsiveness* of taxable quantity to overall tax rate is unlikely to follow a simple pattern. In particular, inframarginal firms in the high evasion sector may be less responsive (e.g., because they have reached the feasible limit on the amount of evasion that they can pursue) than those in the low-evasion sector, so that taxable quantity need not be less responsive when it is shifted to the low-evasion sector.

4 Institutional Details

4.1 The Diesel Supply Chain and Tax Remittance

Crude oil is distilled into its constituent products at oil refineries. After the distillation process, No. 2 distillate, the general term describing diesel fuel, is further processed to meet regulatory standards dictating sulfur content, which differs depending on location of eventual sale, season, and intended use.[10] The final product is held by prime suppliers at bulk terminals. There

[10]From October 1993 to August 2006, the allowable sulfur content for on-highway diesel fuel was 500 parts per million (ppm). Federal regulations did not constrain the sulfur content of diesel intended for other uses. Beginning

it is purchased by regional wholesale distributors, sometimes called "jobbers," for eventual delivery to retail outlets or directly to larger-scale end-users such as trucking companies. No. 2 distillate for use in home heating and industrial processes is referred to as fuel oil, while that used in vehicles is referred to as diesel. The two types are chemically equivalent other than the potentially different regulated sulfur content.

Diesel intended for highway use is subject to federal taxes of 24.4 cents per gallon and state taxes that currently range from 8 to 35.1 cents per gallon. Federal fuel taxes are the primary source of revenue for the Federal Highway Trust, which funds infrastructure investment.

Over time, the responsibility for the remittance of federal taxes has moved up the supply chain. Federal tax collection traditionally occurred at the retail level. In 1988, the point of taxation was moved to the wholesale distributor level, and in 1994 the responsibility for remittance was shifted again to its current location at the prime supplier level. There has also been considerable variation in the point of collection for state diesel taxes, both across states and over time, which we exploit in our empirical analysis that follows.

4.2 Opportunities for Evasion and Avoidance

Several characteristics of the market for diesel and the method of tax collection affect the opportunities for tax evasion and therefore how remittance can impact tax incidence. With a few exceptions, evasion can generally be grouped into one of three categories: the misreporting of the intended use of fuel, not remitting owed taxes, and bootlegging.

An incentive to misreport exists because diesel is taxed differentially depending on use. On-highway use is subject to state and federal taxes, but diesel used for home heating, industry or agriculture is untaxed. Because both taxable and non-taxable uses are significant sources of demand for diesel,[11] prime suppliers and distributors responsible for tax remittance may be able to credibly misreport diesel sold to retail stations as being for untaxed use. Historical evidence, documented in Marion and Muehlegger (2008), suggests that misreporting reduced tax revenues by 25-30 percent prior to the introduction of red dye for untaxed diesel fuel.[12]

Some evasion of this type is done by end-users who consume both taxed and untaxed fuel. To this extent, the placement of statutory incidence in the supply chain is not relevant. Large scale schemes, where wholesalers purchase fuel oil and sell this to retail outlets as on-highway diesel, presumably would be curtailed by retail collection.

A second form of evasion involves an incurred tax liability being incurred that is not remitted to the government. This is most likely to occur at the retailer or distributor level. Simple

September 1, 2006, the EPA began phasing in Ultra Low Sulfur Diesel Fuel requirements, requiring that sulfur content not exceed 15 ppm. By 2010 all diesel sold for on-highway use met this standard. Non-road diesel was required to move to 500 ppm in 2007, and the 15 ppm standard is currently being phased in.

[11] According to data from the Energy Information Administration, in 2004, 59.6 percent of distillate sales to end users were retail sales for on-highway use.

[12] Beginning in October 1993, terminals were required to add red dye to diesel fuel sold for untaxed off-highway use. This allowed for a simple visual inspection to verify that taxes had been paid on a particular gallon – a truck with red diesel in its gas tank was evading taxes. In the month the dye program began, reported sales of diesel for use on-highway rose by 25-30 percent, with a corresponding decline in reported sales for untaxed uses. Although the dye program was initially highly successful at curtailing this form of evasion, several new techniques have been employed by evaders to skirt the dyeing regulations. In particular, evaders have been found offloading fuel without injecting dye, removing dye from the fuel, and/or masking the dye's color. Also, misreporting the fuel's intended use may still be an issue in some circumstances, as states allow for refunds of the tax remitted if the user later claims the fuel was used for untaxed purchases. This is often true in agriculture uses.

underreporting is one possible issue. Another classic example is the "daisy chain," which is sometimes observed when the distributor is responsible for remitting the tax. Under this scheme a gallon of diesel is sold by the prime supplier to the wholesale distributor, who then sells it to other dummy distributors in a series of (likely paper-only) transactions. At some point the gallon is sold to a retail station, and the party responsible for remitting the tax "disappears."

Moving the point of taxation up the supply chain reduces the number of parties with a tax liability. According to the Internal Revenue Service, there are 1,343 active bulk fuel terminals in the United States, compared with around 855,915 retail gasoline station establishments reported in the County Business Patterns. Monitoring and identifying underpayment of tax liabilities is therefore thought by tax enforcement authorities to be substantially easier when the tax is remitted by parties higher in the supply chain, simply by virtue of there being fewer parties to monitor. (Baluch, 1996)

A third type of evasion exploits differential rates of taxation across different jurisdictions. Bootlegging is one example, where purchases are made by a distributor in a low-tax state, and then sold to retailers in a neighboring high-tax state at a higher price that reflects the tax rate in place. A second example involves a distributor that purchases fuel from a supplier claiming it is intended for export to another state and thereby not subject to the state tax. Rather than exporting, the firm then sells it to a within-state retail station.

Trucking companies pay state diesel taxes based on miles driven in each state. An interstate trucker submits a tax return to the International Fuel Tax Agreement (IFTA) that states the miles driven by state and is then credited or taxed based on the difference between the tax owed and tax already paid. This creates an incentive to understate total miles driven, and also to overstate miles driven in high tax states.

Interjurisdictional evasion also arises through Native American reservations in a variety of ways. Due to the sovereignty of the reservations, foreign imports to a reservation are not tracked by the federal government or state governments. Imported gallons can then be diverted to retail stations outside the reservation.

Finally, it is also possible to illicitly import untaxed fuel from abroad, subsequently selling the fuel to retail stations. With the exception of IFTA evasion by truckers, most forms of interjurisdictional methods for evasion are curtailed by placing the responsibility of remittance at the retail level, which makes the state of sale more easily verified.

In the context of diesel taxation, the theoretical model and institutional details suggest that tax pass-through should be greater when the remitting party is upstream rather than downstream. Especially since the dyeing regime was instituted, most of the opportunities for evasion exist downstream of the wholesale terminal, at either the distributor or retailer level. Moreover, wholesalers are typically major oil brands with operations in many states, while distributors and retail stations are smaller, more numerous and ownership is less concentrated. If detection of illegal activity is easier or close scrutiny less costly, evasion opportunities at the wholesale terminal may be further curtailed. Finally, opportunities for entry likely differ. Entry and exit are relatively easy at the distributor and retail level relative to at the terminal level, where entry may face constraints related to permitting and siting, which means that rents from evasion are less likely to be competed away at the prime supplier level. All three would tend to increase pass-through of a tax remitted by terminal owners relative to a tax remitted further downstream.

5 Data and Methodology

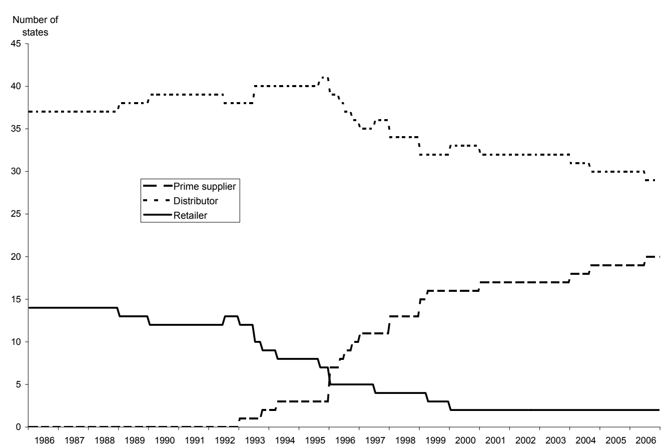
To this point we have argued that the pass-through rate of a tax to the retail price can, in a setting where evasion is important, depend on the location of tax remittance responsibility. We now proceed to examine the evidence for this hypothesis in the diesel fuel market.

5.1 Data

We collected data on the point of tax collection from successive annual issues of "Highway Taxes and Fees: How They Are Collected and Distributed," published by the Federal Highway Adminstration. For each state and year, the Federal Highway Administration contacts state tax authorities and collects data on the point of collection for diesel and gasoline taxes.

In Figure 5, we display the variation in the point of taxation over time. In the mid-eighties, the majority of states collected taxes from distributors. At the beginning of our sample in 1986, distributors were responsible for remittance in 37 states, with the balance of states collecting from retailers. The early nineties saw a trend toward collecting taxes from higher points in the supply chain, in particular from the prime supplier. In January 1993, Michigan became the first state to do so, and by the end of 2006 twenty states collected taxes from prime suppliers. While a plurality of states still collect from wholesale distributors, the practice of collecting from retailers has been almost entirely phased out, with only New Jersey and Oregon collecting tax from retailers at the end of our sample in 2006.[13]

Figure 5: Tax remittance liability over time



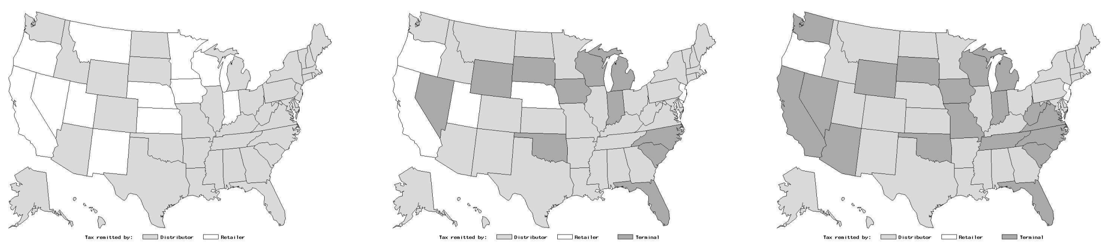
In Figure 6, we present maps of the variation in the point of tax collection across states for 1990, 1997, and 2004.[14] In 1990, the entire eastern section of the U.S. collected taxes from the distributor. The collection of taxes at the retail level was concentrated in Midwestern and Western states. Panels B and C describe the geographic characteristics of the transition to taxing

[13]Oregon is a special case. There, diesel used for trucking is not taxed directly, and instead a levy on weight-miles driven within the state is collected. Given the importance of trucking in the diesel market, we will in general exclude Oregon from the analysis.

[14]Darker shading corresponds to further upstream tax collection. The lightest shade corresponds to states that collect from retailers. The darkest states collect taxes from the wholesale terminal operators.

at higher levels of the supply chain. During this time, the West, Midwest, and mid-Atlantic transitioned largely toward collecting diesel taxes from terminal operators. Collection at the distributor level was concentrated in the northeast, south, and mountain states. An interesting observation from this figure is that the point-of-collection policy seems to be spatially correlated, which suggests that there are spillovers of some kind across states in tax collection.

Figure 6: Tax Collection By State



(a) Year 1990 (b) Year 1997 (c) Year 2004

In Table 1, we further describe the nature of the variation in tax collection by showing the matrix of changes in point of collection. We observe 29 changes in the point of tax collection, of which 28 move the point of collection upstream. Eight of these are changes from retailer collection to distributor collection, five are retailer to supplier shifts, and fifteen are distributor to supplier shifts. Only one state, New Jersey, moves the point of collection downstream, from the distributor level to retail outlets.

Several monthly diesel price series are available at the state level from the Energy Information Administration (EIA). The EIA collects diesel prices for select states, mostly comprising states in the Northeast, Mid-Atlantic, Upper Midwest and a handful of Northwestern states with relatively high use of home heating oil. Beginning in 1983, the EIA reports an average price of No. 2 distillate, which includes taxed diesel fuel, untaxed diesel fuel, and heating oil. It distinguishes between diesel sold through retail outlets and that sold for resale. However, the resale price can include sales by prime suppliers to local distributors, or from local distributors to retail stations, which will pose a disadvantage in assessing how tax collection affects how retail stations share the tax burden with distributors, or distributors with prime suppliers'. Furthermore, prior to 1994, the resale price of No. 2 distillate also included untaxed sales of diesel.

From 1994 on, the EIA also reports the average retail and resale prices specifically of No. 2 diesel. This distinction is irrelevant for sales through retail outlets, as only diesel fuel is sold through retail outlets. During the period of time where the series overlap (from 1994 on), the retail prices for No. 2 distillate and diesel fuel are identical. On the other hand, resale of No. 2 distillate can include transactions for on-highway diesel, heating oil, or other uses of distillate. Therefore, the series describing the resale prices of No. 2 distillate and No. 2 diesel are not perfect substitutes. The two series move in lock-step ($\rho = 0.994$), but the resale price for No. 2 distillate averages 1.4 cpg less than the resale price for diesel fuel. For these reasons, we focus our attention in this paper on the retail price of No. 2 diesel.

We have argued that how remittance affects incidence depends on its effect on tax evasion opportunities. To measure how tax remittance may affect tax collection and evasion opportunities, we obtain data on diesel tax collections from two separate sources. The most accurate measure comes from the Federal Highway Administration which reports the annual quantity by state of special fuels on which taxes were collected in Table MF-2 of the Highway Statistics Annual. Taxed special fuels are almost entirely diesel fuel. Beginning in 1983, the EIA also reports monthly data from a survey of prime suppliers, who distinguish sales of No. 2 diesel and heating oil by state. What level of the supply chain the EIA treats as the prime supplier for the purposes of reporting depends on whether the fuel is imported from another jurisdiction. For fuel distilled in the state of eventual sale to the end user, the prime supplier is the bulk terminal. For distilled fuel imported from another state or country, the prime supplier is considered to be the first distributor within the state who receives the fuel. We obtain information about the federal and state on-road diesel tax rates from 1981 to 2006 from the Federal Highway Administration Annual Highway Statistics.

We also collect data on state-level covariates. Population, per capita income and mean family size are obtained from the Census Bureau. Urbanization and educational attainment are taken from the Bureau of Economic Analysis. Information about drivers, vehicle registration, and vehicle usage are from successive issues of Highway Statistics produced by the Federal Highway Adminstration.

We recognize that it is unlikely that the choice of the point of taxation is chosen randomly. To investigate this issue, in Table 2 we present the mean differences of a variety of demographic characteristics between retailer, distributor, and supplier- remitting states. Each column in a particular panel shows a regression of the stated variable on distributor and supplier-remit dummies, as well as year fixed effects.[15] The results shown in Table 2 suggest that the point of taxation is correlated with few of the covariates. Compared with retailer-remitting states, those that tax at the supplier level tend to have a less-educated adult population and are less conservative politically. Those taxing at the distributor level also have a somewhat less educated population than retailer-remitting states, and have a smaller budget surplus, and both the upper and lower state houses have a have slightly higher portion of Democrats. Income, unemployment, population, urbanization, family size, and vehicle miles traveled per capita are all similar between the three collection regimes.

We also conduct two other exercises examining the potential endogeneity of remittance policy. First, in Table 3 we examine whether states that change the point of collection at some point in the sample are different than those who leave the point of collection unchanged. Only a state's mining share of Gross State Product and the conservative-values score of the state house of representatives are significant at the 10 percent level.

Second, we wish to consider which covariates may be contemporaneously correlated with changes in either the point of tax collection or the diesel tax. In four separate specifications, we regress the change in the distributor-remit, retailer-remit, and supplier-remit dummy variables, and the change in the state diesel tax, on a set of covariates. The results are presented in Table 4. As with the results shown in Table 2, few variables are correlated with changes in the tax regime. Population is positively related with a change in supplier remittance, though negatively correlated with a change in distributor remittance. An increase in the fraction of adults with a college degree is associated with less likelihood of moving the point of collection to the supplier

[15] Many of the variables in this table are not included in the set of covariates in the regression specifications later, as variables such as population, average family size, percent of population that are BA graduates will be slow-moving, and most of their variation will be captured by state fixed effects.

level. A greater share of high school graduates is associated with a lower likelihood of taxing at the distributor and a greater likelihood of moving the point of collection to the prime supplier. Increases in gross state product are associated with relative declines in the state diesel tax. Also, average family size and the fraction of adults with a high school degree are negatively associated with the tax rate. All in all, we find no evidence of systematic determinants of changes in tax regimes, but of course we cannot rule out decisively that there are unmeasured determinants.

5.2 Methodology

5.2.1 Point of taxation and incidence

We examine the degree to which diesel taxes are passed through to retail prices using variation across states and over time in state diesel tax rates and the point of tax collection. Ideally, we would observe the price charged by bulk terminals to wholesale distributors, and by wholesale distributors to retail stations; this would allow for a direct evaluation of the burden of taxation across different levels of the supply chain. Unfortunately, data limitations preclude this level of analysis, and so we must rely on an analysis of retail prices, which we argue reflects changes in incidence higher up the supply chain. For instance, if changing the point of tax collection raises the price that wholesalers charge retailers, then this higher cost for retailers will be reflected in the price they charge to consumers.

To be specific, we estimate a specification of monthly real tax-exclusive retail diesel prices, deflated using the consumer price index.

$$p_{it} = \beta_0 + \beta_1 \tau_{it} + \beta_2 regime_{it} + \beta_3 \tau_{it} * regime_{it} + BX_{it} + \epsilon_{it} \tag{13}$$

where $regime_{it}$ represents the indicator variables for the point-of-collection regime employed by state i in month t, τ_{it} is the diesel tax rate and X_{it} is a vector of covariates including state economic conditions, state and year*month effects, the minimum of the tax rates in neighboring states, and the portion of households who use fuel oil for home heating, interacted with heating degree days.

One extension to the primary specification given by (13) we pursue is to allow for the coefficients in the model to vary over time. It is possible that the elasticity of demand for diesel fuel changes over time in an unobservable way, which would alter the predicted degree of pass-through. Because the point of collection has on average moved up the supply chain over time, this could lead us to mistakenly attribute changes in incidence to the point of taxation that are actually due to shifts in demand elasticity. Similarly, changes in regulations or refinery capacity over time could alter the supply elasticity in a manner correlated with trends in the point of taxation. To correct for this, we will also estimate a version of (13) that allows for a time varying value of β_1 by controlling for a full set of year-tax interactions.

5.2.2 Remittance, evasion, and tax collections

We next use the data on taxed quantities from the FHWA to evaluate the impact of point of tax collection on tax evasion. If changing the point of tax collection affects evasion, then ceteris paribus tax collections should change as more or less taxable gallons are reported.

We examine the contemporaneous correlation between regime changes and the change in taxed gallons. In particular, we estimate an equation of the form

$$\Delta ln(q_{it}) = \alpha_0 + \alpha_1 \Delta ln(p_{it}) + \alpha_2 \Delta ln(1 + \tau_{it}/p_{it}) + \alpha_2 \Delta regime_{it} + A\Delta X_{it} + \rho_t + \epsilon_{it}. \quad (14)$$

where $regime_{it}$ again represents the point-of-collection regime employed by state i. We model the log of taxed gallons as a function of the log of the tax inclusive price, $ln(p+t)$. To separately identify the response of taxed gallons to the tax rate from the response to the price, we factor out the price from this expression. As stressed by Slemrod (2001), the parameter α_2 need not equal α_1. Kopczuk (2005) and Slemrod and Kopczuk (2002) point out that the size of the tax base as well as the degree of enforcement can both influence the elasticity of tax collections to the tax rate. As in the price specification, the vector of covariates in X_{it} includes state economic conditions, the tax rate in neighboring states, and the weather and its interaction with household use of fuel oil for home heating. The variable ρ_t represents common year effects.

To examine pre-existing differences between the different tax regimes, and to verify that any changes in tax collections correspond to the regime change, we will also examine graphically the coefficients β^k_{t-j} from the following regression:

$$ln(q_{it}) = \beta_0 + \sum_k \sum_{j=-2}^{2} \beta^k_{t-j} I(d^k_{i,t-j}) + \phi_t + \rho_i + \epsilon_{it}. \quad (15)$$

where k indexes the three types of transitions witnessed in the data: retailer-to-distributor collection, retailer-to-supplier, and distributor-to-supplier. $I(d^k_{i,t-j})$ is an indicator for whether the type of transition k occurred in year $t - j$. This exercise will yield the average residual tax collections in the periods before and after each type of regime transition that we observe in the data.

6 Results

6.1 Tax Incidence Results

In this section, we present estimates of the effect of the point of tax collection on retail diesel prices. In Table 5, we show the results of estimating equation (13), where the dependent variable is the real retail price, excluding taxes. In column 1 of this table, we show the results of including only the diesel tax and control variables, and excluding any information about the party responsible for tax collection. The coefficient on the diesel tax variable suggests that the net-of-tax retail price falls 0.86 cents for every ten cent-increase in the diesel tax. The interpretation of this coefficient is that nearly all (91.4 percent) of the tax burden is born by consumers, and the amount suppliers received per gallon from consumers falls little as taxes rise. Other coefficients are similar to those found in Marion and Muehlegger (2011). Prices rise as the tax rate in neighboring states increase, and prices are higher in cold months where households tend to use diesel for home heating. Lastly, economic activity is correlated with prices, as the unemployment rate has a negative association with prices, likely due to reduced demand.

The specification shown in column 2 includes indicators for whether the state collects at the distributor level or at the bulk terminal. The excluded category are states collecting the diesel tax from retail outlets. Compared to states collecting at the retail level, states in which the party responsible for remitting the tax is the prime supplier have a retail price that is 2.88 cents higher, and those taxing the wholesale distributor have a retail price that is 1.38 cents higher. Both of these coefficients are consistent with the hypothesis that retail stations are difficult for tax authorities to monitor and that the relatively small number of bulk terminals make evasion more costly for these firms.

In column 3 of Table 5, we show the results of estimating a specification including interactions between the remittance regime dummy variables and the tax rate, which allows the pass-through rate of diesel taxes to prices to depend on the point of collection. The coefficients on the interaction between diesel taxes and the collect from the distributor and terminal indicators are 0.10 and 0.21, respectively; both are statistically different from zero, although the former is only marginally so (p-value=0.073). This suggests that the pass-through rate rises as the tax collection point is moved up the supply chain. Furthermore, the pass-through rate is highest when collecting from the bulk terminal, as the coefficient on the interaction between the tax rate and the supplier collection dummy is higher than the coefficient on the similar interaction with the distributor collection dummy (p-value=0.081). This result is also consistent with the observation that the prime supplier is the easiest point in the supply chain to monitor.

It is worth noting that the sum of the main effect and the interaction in the case of taxing the bulk terminal leads to an estimated pass-through rate of greater than 100 percent. The estimates suggest that the *tax-inclusive* retail price rises by 1.089 cents for each 1-cent increase in the diesel tax. However, this is not statistically distinguishable from full pass-through (p=0.14), which is a reasonable baseline, as it is the upper bound of the pass-through rate in a competitive model without differential evasion opportunities.

Finally, the specification displayed in column 4 includes a full set of year by diesel tax interactions, which allows the rate of tax pass-through to vary over time. This is plausible due to the time trend in the point of taxation, and that factors that may influence the elasticity of supply and demand, such as environmental regulations and the demand for untaxed uses of diesel, may have shifted over time. It turns out, however, that allowing for time-varying pass-through rates has little effect on the estimated parameters of interest. The direct effect of the point of tax collection is small and indistinguishable from zero, and the interaction terms between the diesel tax and the indicators for the collection point being the terminal and the distributor are 0.16 and 0.14, respectively, very little changed from the primary specification.

6.1.1 Accounting for trends in pass-through

The above approach compares the pass-through rate in a state after a change in the point of collection with the pass-through rate prior to the shift. Therefore, unobserved characteristics affecting pass-through in a state that are fixed over time will not affect our results. However, our estimates will be biased if unobserved variables that alter rates of tax pass-through are moving over time in a way that is correlated with the change in tax collection regime. For instance, if the number of bulk terminals changes over time in a state, the tax authorities may find it more desirable to collect the tax from the prime supplier owing to the number of taxable agents. Such a change may also alter the rate of tax pass-through by changing the elasticity of supply with respect to price.[16]

To address this concern, we exploit the timing of the change in remitting party. We account for trends in pass-through relative to the date of the regime change, examining whether pass-through changed discontinuously at the date of the regime change. This is conceptually similar to a parametric regression discontinuity design, where the running variable is time, and the threshold is the date of the policy change.

We consider states that undertook a particular regime change, either shifting from retailer to distributor collection or from distributor to prime supplier.[17] We center the data such that the date of the state i's regime shift is t_i^0. We then estimate our standard pass-through specification, adding an interaction term $\tau_{it} * (t - t_i^0)$ as well as the direct effect $t - t_0^i$. This allows the estimated pass-through rate to differ in a linear fashion over time, and we can therefore examine the post-regime difference in pass-through relative to this trend.

We present the results in Table 7. Columns 1 and 2 contain estimates from estimating the pass-through equation for states moving the point of collection from the wholesale distributor to the prime supplier. Pass-through is greater after the move to the supplier level, as seen in column 1. Furthermore, the results in column 2 indicate that there is no trend in pass-through relative to the date of the regime change nor does including this interaction term alter the coefficient on the variable of interest. A similar story emerges when we examine retailer-to-distributor regime changes, as shown in columns 3 and 4. The pass-through rate is higher when the state requires the tax to be remitted by the distributor compared to when it requires the tax to be remitted by the retailer. Furthermore, this set of states do not experience a trend in incidence relative to the date of the regime change, nor does allowing for such a trend alter the primary coefficient of interest.

6.1.2 Price for resale

In this section we describe estimates of the effect of the point of collection on the wholesale price of diesel, and we examine how taxes work through to retail prices via the wholesale price when the tax is collected from the prime supplier. In column (1) of Table 6, we present estimates of our base incidence specification, with the real resale price as the dependent variable. We see that the price for resale is around two cents higher when the tax is collected from the prime supplier, and 0.7 cents higher when collected from the distributor level, compared to when the tax is collected at the retail level. On average, the tax has virtually no effect on the net of tax resale price. In the specification shown in column (2), we include the interaction between the tax and indicators for collecting from the distributor and the prime supplier. When the tax is collected from the prime supplier, an increase in the tax leads to an increase in the wholesale resale price. A ten cent per gallon tax increase leads to a 2.4 cent increase in the resale price in supplier remitting states relative to retailer remitting states. Conversely, tax changes have virtually no effect on the resale price in distributor remitting states or retailer remitting states.

[16] Another potential omitted variable is the extent of market power in this industry. We investigate controlling for wholesale market concentration in the Appendix and find that it does not affect our results. Alternatively, this exercise may interpreted as testing heterogeneity of the pass through effects with respect to the market power and we find no evidence of it.

[17] The other upstream transitions witnessed in the data are retailer-to-supplier, of which there have been five during our sample. We are unable to specifically use these in this exercise because we observe price for only two of these transitions.

This will be true if sales by prime suppliers make up the bulk of the sales used to calculate the price of diesel for resale.

We are able to show what implications this has for retail price incidence. In column (3) of Table 6, we restate the results of column (3) of Table 5, which shows that a ten cent tax increases the retail price by 2.1 cents in a supplier remitting state relative to a similar tax change in a retailer remitting state. In column (4), we show the results of estimating a similar specification, where we also include as control variables the concurrent and lagged price of diesel for resale. Controlling for resale price, the coefficient on the tax*supplier remittor interaction is now small and statistically insignificant. This suggests that the differential effect of tax on retail prices in supplier remitting states is entirely explained by the effect on the wholesale price, just as one would expect if our results are valid.

This narrows down the set of alternative explanations for our results. For the relationship between pass-through and tax collection regime to be explained by changes in unobserved variables, they must be ones that affect the resale price alone and have no independent effect on the retail price of diesel.

6.2 Tax Collection Results

We now examine how the level of taxed gallons responds to the point of taxation. As the state adjusts the point of tax collection, we interpret corresponding observed changes in tax collections as evidence of a change in tax compliance. This will provide a link between the empirical results discussed in section 6.1 and the theoretical predictions in Sections 2 and 3.

In Table 8, we present estimates of equation (14), which relates changes in taxed gallons to specific changes in the point of tax collection. The specification shown in column (1) includes only the regime dummy variables. Upstream shifts in the point of collection are associated with a higher reported tax base. A change in the point of taxation from the retailer to the distributor is associated with similar improvements in collections as retailer to supplier changes, with the former yielding a 6.7 percent improvement in collections while the latter yields a 8.2 percent improvement. When the point of remittance is moved from the distributor to the prime supplier, the estimated effect is not statistically distinguishable from zero.

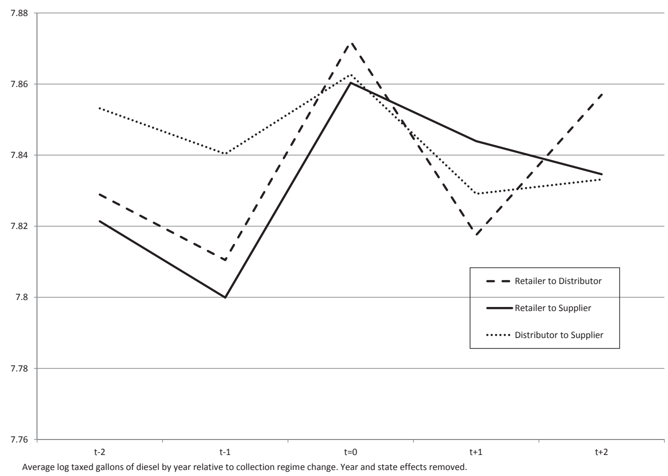
Column 2 presents the results of a specification that includes the log tax rate and interactions of the log tax rate with the remittance regime. The coefficient on log tax rate is statistically indistinguishable from zero. The coefficient on the interactions of log tax rate with supplier and retailer remittance is negative and weakly significant - taxed gallons tend to change more with taxes in supplier-remitting and distributor-remitting states than retailer-remitting states. Recall that we argued in our theoretical section that there is no inherent contradiction in having inframarginal firms in the low tax evasion sector being more responsive on the evasion margin despite having lower levels of evasion overall.

In Column 3, we display results of a specification with additional covariates, including state macroeconomic conditions as captured by log GSP and unemployment, weather, and and home heating use. The estimated effects of the three types of tax collection regime changes are virtually unchanged, which is not surprising in light of the fact that none of these variables are correlated, at least contemporaneously, with states' decisions regarding where in the supply chain to collect the tax.

Finally, the specification shown in column (4) includes a control for the lagged dependent variable. The lagged change in taxed gallons is significantly negatively correlated with the current change in taxed gallons. The data suggest that this is likely to be a reporting phenomenon, as states will at times have unusually high (low) reported tax collections in one year, followed by unusually low (high) reported tax collections the next year. Regardless, the coefficients of interest are unaltered by the inclusion of this variable.

Because they are estimated in first-differences, the regression results capture the contemporaneous response of tax collections to changes in the point of tax collection. We can further explore the timing of the response of tax collections to the change in the collection regime, as well as consider any pre- or post-change trends in tax collections. In Figure 7, we plot the average residual taxed gallons, taking out year and state effects, in each year from two years before the change in the collection regime to two years after.

Figure 7: Collection regime shifts and taxed gallons



Compared to states that move the point of collection from the distributor to the supplier, and hence are already collecting the tax above the retail level, tax collections are initially lower in states who move the point of collection away from the retail level. This is true regardless of whether the state will ultimately move the collection point to the distributor or the prime supplier. As suggested by the regression results presented in Table 8, states moving the point of collection away from the retailer experience a jump in collections in the year of the policy change. Importantly, average tax collections were similar in all three cases after the change in collection regime. Despite the fact that states that initially collected from the distributor had tax collections around 3 percent higher, the average of the post-reform coefficients for each of the three types of regime changes are within 0.7 percent of one another.

7 Conclusion

The independence between equilibrium tax-inclusive prices and the side of the market taxed is a widely accepted "law" of tax incidence and is a key principle a student of public finance learns in the study of tax theory. This paper presents the first estimates of how prices may in fact respond to the identity of the tax remitter and provides evidence that the source of this result is variation in the ability to evade taxes between the two sides of a market. This result has potentially important implications in understanding the distributional impact of taxation in markets where evasion is prevalent.

Our results are directly applicable to the current debate on whether carbon taxes should be levied on upstream energy producers or downstream energy users. The current literature weights the administrative, political and distribution advantages and disadvantages of each, but largely ignores tax incidence, effectively assuming that the incidence of a carbon tax levied on energy producers and energy users would be identical. Although it is impossible to assess opportunities for outright evasion of a hypothetical carbon tax, a major part of the debate focuses on the ability of firms to avoid a carbon tax by increasing production in unregulated jurisdictions. If those opportunities differ substantially for energy producers and energy users, incidence may be affected by the point of remittance in a very similar way to the context we examine.

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Table 1: Transitions in the point of tax collection

		To: Retailer	Distributor	Supplier
	Retailer	-	8	5
From:	Distributor	1	-	15
	Supplier	0	0	-

Table 2: Demographics and the Point of Tax Collection

Panel A	Tax-Exclusive Diesel Price ($/gal)	State Diesel Tax (cpg)	GSP per capita ($)	Unemployment Rate (%)	Manufacturing GSP Fraction	Mining GSP Fraction
Distributor Remit	2.965*	-0.829	-871.0	0.523	0.0111	0.0105
	(1.722)	(1.254)	(1170.7)	(0.369)	(0.0193)	(0.0103)
Supplier Remit	-1.612	-1.641	-1432.5	0.314	0.0398*	0.0138
	(2.469)	(1.705)	(1515.1)	(0.393)	(0.0219)	(0.0193)
Constant	133.3***	20.16***	30337.2***	4.889***	0.144***	0.0154**
	(1.596)	(1.138)	(1064.5)	(0.310)	(0.0166)	(0.00632)
Observations	6090	13536	13248	13536	13536	13536
R-Squared	0.990	0.207	0.709	0.311	0.198	0.0165

Panel B	Adult Population	Urban Pop % of Total	Average Family Size	Percentage BA graduates	Percentage HS graduates	Vehicle Miles Per Capita
Distributor Remit	-0.940	-0.0347	-0.0994	-0.796	-4.086***	0.000430
	(1.843)	(0.0549)	(0.0735)	(1.006)	(1.181)	(0.000436)
Supplier Remit	0.486	-0.0291	-0.107	-3.522***	-4.056***	0.00124
	(1.413)	(0.0697)	(0.0848)	(0.884)	(1.432)	(0.000805)
Constant	4.686***	0.750***	3.257***	23.56***	83.07***	0.0128***
	(1.718)	(0.0485)	(0.0723)	(0.741)	(0.866)	(0.000394)
Observations	13248	13248	13248	13248	13248	13248
R-Squared	0.0205	0.00524	0.138	0.333	0.462	0.196

Panel C	State Budget Surplus	Senator LCV Score	Representative LCV Score	Democrat Governor	Democrat Fraction State Senate	Democrat Fraction State House
Distributor Remit	-0.0284*	-5.872	-1.142	0.0316	0.100***	0.0804**
	(0.0147)	(7.455)	(5.586)	(0.126)	(0.0343)	(0.0334)
Supplier Remit	-0.0112	-8.150	-12.78*	0.191	0.0339	0.0190
	(0.0215)	(10.13)	(7.592)	(0.162)	(0.0392)	(0.0356)
Constant	0.113***	52.56***	48.23***	0.414***	0.476***	0.492***
	(0.0120)	(6.595)	(4.892)	(0.112)	(0.0258)	(0.0222)
Observations	12672	13248	13248	13440	13020	12984
R-Squared	0.475	0.0201	0.120	0.0539	0.132	0.105

Retailer-remittance is the omitted category. All regressions include year fixed effects. Standard errors clustered by state.

Table 3: Summary Statistics By Change in Point of Diesel Tax Collection

	Full Sample	States Not Changing POT	States Changing POT	Difference
Tax-Exclusive Diesel Price	95.97 (43.77)	97.88 (44.22)	93.20 (42.97)	-4.67*
State Diesel Tax	19.12 (5.026)	19.24 (5.278)	19.03 (4.828)	-0.21
GSP per capita	28153.9 (8784.1)	28392.8 (9560.0)	27983.3 (8181.5)	-409.5
Unemployment Rate (%)	5.307 (1.555)	5.255 (1.487)	5.346 (1.602)	0.091
Manufacturing Share of GSP	0.162 (0.0677)	0.166 (0.0640)	0.158 (0.0702)	-0.008
Mining Share of GSP	0.0235 (0.0499)	0.0103 (0.0241)	0.0333 (0.0607)	0.23*
Population (millions)	4.135 (4.377)	3.179 (2.776)	4.817 (5.120)	1.638
Urban Population Share	0.722 (0.188)	0.719 (0.194)	0.725 (0.183)	0.006
Family Size	3.184 (0.194)	3.143 (0.151)	3.213 (0.214)	0.071
Percent of Adults with BA	22.09 (4.755)	22.92 (5.483)	21.50 (4.055)	-1.42
Percent of Adults Graduating HS	79.30 (6.127)	79.12 (6.470)	79.44 (5.866)	0.31
Vehicle Miles Traveled Per Capita (000s)	13.2 (2.33)	12.9 (2.22)	13.4 (2.38)	0.5
Percent State Budget Surplus	0.0953 (0.109)	0.09 (0.105)	0.10 (0.112)	0.01
Senator LCV Score	46.96 (31.03)	51.87 (33.23)	43.45 (28.86)	-8.41
Rep LCV Score	44.58 (24.61)	53.15 (26.38)	38.47 (21.25)	-14.68**
Democrat Governor	0.457 (0.497)	0.484 (0.499)	0.437 (0.495)	-0.046
Democrat Fraction of State Senate	0.546 (0.168)	0.576 (0.183)	0.522 (0.152)	-0.054
Democrat Fraction of State House	0.546 (0.162)	0.568 (0.192)	0.528 (0.132)	-0.040

Standard errors for difference column clustered by state.

Table 4: Predictors of Tax Changes and Changes in Point of Taxation

	Dependent Variable:			
	Δ Distributor Remit	Δ Retailer Remit	Δ Supplier Remit	Δ State Diesel Tax
Retail Gasoline Price	-0.000729	-0.00316	0.00389	-0.00587
	(0.00221)	(0.00223)	(0.00298)	(0.0139)
GSP per capita	-0.00474	-0.00788	0.0126	-0.147**
	(0.00666)	(0.00605)	(0.00909)	(0.0555)
State Unemployment Rate	0.0159	-0.0101	-0.00578	0.0861
	(0.0132)	(0.00859)	(0.00958)	(0.0713)
Manufacturing Fraction GSP	0.307	-0.162	-0.145	3.722
	(0.577)	(0.410)	(0.627)	(3.047)
Mining Fraction GSP	-0.996*	0.422	0.574	8.393
	(0.533)	(0.377)	(0.715)	(6.457)
Population	-0.146*	-0.0137	0.160*	-0.548
	(0.0778)	(0.0768)	(0.0815)	(0.607)
Urban Fraction of Pop	5.901	-2.108	-3.793	-19.55
	(3.451)	(1.933)	(3.970)	(22.14)
Average Family Size	0.121*	0.0270	-0.148*	-0.973**
	(0.0652)	(0.0397)	(0.0800)	(0.416)
Fraction of Adults with BA	0.0644	0.0273	-0.0917**	-0.328
	(0.0412)	(0.0260)	(0.0370)	(0.480)
Fraction of Adults	-0.0594**	0.0268*	0.0325**	-0.449**
Graduating HS	(0.0231)	(0.0137)	(0.0148)	(0.212)
Vehicle Miles	0.00245	0.00219	-0.00464	0.435
per Capita	(0.00642)	(0.00523)	(0.00626)	(0.349)
Percent Budget Surplus	0.0458	0.0169	-0.0627	-0.0331
	(0.0430)	(0.0237)	(0.0499)	(0.504)
Senate LCV Score	-0.0000403	-0.0000276	0.0000679	-0.00271
	(0.000366)	(0.000127)	(0.000376)	(0.00292)
House LCV Score	0.000148	-0.000259	0.000111	0.00311
	(0.000337)	(0.000235)	(0.000289)	(0.00280)
Democrat Governor	-0.00216	-0.00846	0.0106	0.0839
	(0.00572)	(0.0108)	(0.00944)	(0.223)
Fraction Democrat	0.0978	-0.0818	-0.0160	-0.225
State Senate	(0.0914)	(0.0867)	(0.0603)	(0.579)
Fraction Democrat	-0.0149	-0.0855	0.100	-0.433
State House	(0.129)	(0.0725)	(0.131)	(1.196)
Observations	831	831	831	831
R-Squared	0.0525	0.0712	0.0782	0.110

Standard errors clustered by year are in parentheses. *,**,*** denote significance at the 10%, 5%, and 1% level, respectively. All dependent and independent variables are first-differenced. All specifications include year fixed effects.

Table 5: Point of Tax Collection and Incidence

	(1)	(2)	(3)	(4)
Real diesel tax	-0.086	-0.025	-0.120	-0.098
	(0.021)***	(0.022)	(0.055)**	(0.071)
Collect tax from supplier		2.875	0.445	0.824
		(0.268)***	(0.604)	(0.658)
Collect tax from distributor		1.378	0.192	-0.308
		(0.188)***	(0.626)	(0.656)
Real tax * Collect from supplier			0.209	0.162
			(0.052)***	(0.057)***
Real tax * Collect from distributor			0.100	0.139
			(0.056)*	(0.057)**
Real neighbor's tax	0.080	0.275	0.276	0.249
	(0.046)*	(0.051)***	(0.050)***	(0.051)***
Degree days	0.087	0.094	0.095	0.078
	(0.066)	(0.063)	(0.062)	(0.061)
Degree days * HH Fuel oil frac	0.468	0.460	0.460	0.459
	(0.085)***	(0.080)***	(0.079)***	(0.078)***
Unemp. Rate	-0.064	-0.128	-0.135	-0.132
	(0.061)	(0.062)**	(0.063)**	(0.062)**
Real diesel tax * year dummies				X
Observations	5435	5435	5435	5435
R-squared	0.98	0.98	0.98	0.98

Standard errors clustered by year*month are in parentheses. *,**,*** denote significance at the 10%, 5%, and 1% level, respectively. The dependent variable is the real tax exclusive retail price of number 2 diesel. Each specification includes state fixed effects and year*month effects.

Table 6: Point of Tax Collection and Wholesale Prices

	Dependent variable:			
	Resale price		Retail price	
	(1)	(2)	(3)	(4)
Real diesel tax	-0.002	-0.024	-0.120	-0.098
	(0.017)	(0.038)	(0.055)**	(0.092)
Collect tax from supplier	1.959	-0.803	0.445	0.987
	(0.259)***	(0.404)**	(0.604)	(1.785)
Collect tax from distributor	0.686	0.575	0.192	-0.296
	(0.163)***	(0.408)	(0.626)	(1.323)
Real Tax * Collect from supplier		0.240	0.209	0.028
		(0.037)***	(0.052)***	(0.164)
Real tax * Collect from distributor		0.001	0.100	0.099
		(0.039)	(0.056)*	(0.153)
Real Price for Resale				0.535
				(0.057)***
Lag Real Price for Resale				0.240
				(0.033)***
R2	0.99	0.99	0.98	0.99
N	5,427	5,427	5,435	5,349

Standard errors clustered by year-month are in parentheses. *,**,*** denote significance at the 10%, 5%, and 1% level, respectively. The price for resale is a measure of the wholesale price, as it is the price charged for diesel that will be resold to another party. The other included controls correspond to those in the specification shown in column (4) of Table 5.

Table 7: Point of Tax Collection and Incidence

	States shifting point of taxation from:			
	Distributor to supplier		Retailer to distributor	
	(1)	(2)	(3)	(4)
Real Diesel Tax	-0.149	-0.150	-0.319	-0.315
	(0.100)	(0.140)	(0.089)***	(0.085)***
Real tax * Post reform	0.227	0.229	0.677	0.677
	(0.090)**	(0.151)	(0.087)***	(0.088)***
Post reform	-1.555	-1.583	-5.363	-5.400
	(0.986)	(1.765)	(0.943)***	(1.003)***
Real tax*months relative to change		-0.00002		0.0001
		(0.001)		(0.001)
Months relative to regime change		0.070		0.161
		(0.010)***		(0.012)***
R2	0.98	0.98	0.99	0.99
N	1,004	1,004	751	751

Standard errors are in parentheses. *,**,*** denote significance at the 10%, 5%, and 1% level, respectively. The dependent variable is the real tax exclusive retail price of number 2 diesel. The other covariates are identical to those included in the specification shown in Column (3) of Table 4. Months relative to regime change is a variable equal to the number of months prior to or after the stated regime change. Specifications (1) and (2) include all observations from states that experienced a shift in the point of collection from the wholesale distributor level to the prime supplier level. Specifications (3) and (4) likewise include all observations from states that experienced a shift in the point of collection from the retail level to the wholesale distributor level.

Table 8: Point of Tax Collection and Taxed Gallons

	(1)	(2)	(3)	(4)
Collect from supplier	0.0817**	0.229**	0.201*	0.234**
	(0.0331)	(0.0983)	(0.105)	(0.0873)
Collect from distributor	0.0671**	0.188*	0.152	0.179**
	(0.0328)	(0.0954)	(0.0955)	(0.0809)
Log(1+tax rate)		0.0618	0.0970	0.0604
		(0.274)	(0.304)	(0.324)
Log(1+tax rate) * Collect from supplier		-0.323*	-0.283	-0.361**
		(0.189)	(0.199)	(0.157)
Log(1+tax rate) * Collect from distributor		-0.267	-0.192	-0.249*
		(0.184)	(0.172)	(0.142)
Log Minimum neighbor tax			-0.110*	-0.120**
			(0.0565)	(0.0594)
Log GSP			0.443***	0.561***
			(0.147)	(0.158)
Unem. Rate			-0.00986**	-0.0136**
			(0.00484)	(0.00507)
Log degree days			-0.0257	-0.0130
			(0.0381)	(0.0299)
Log degree days X HH Oil Use			0.0349	0.0379
			(0.0795)	(0.0858)
Lagged change in collections				-0.374***
				(0.0378)
Observations	980	980	940	893
R-Squared	0.0657	0.0674	0.133	0.266

Standard errors clustered by state are in parentheses. *,**,*** denote significance at the 10%, 5%, and 1% level, respectively.The dependent variable is the change in the log of the number of gallons of special fuel on which state taxes were collected. The log tax rate is defined as $ln(1 + t/p)$. The other independent variables are all first-differenced. Each specification includes year effects. If a regime change occurred mid-year, the regime change dummy is apportioned into the year of the reform and the year after the reform. For instance, shifting to taxing the supplier from the retailer in July of 2005 would cause the variable “Retailer to supplier” to take on a value of 0.5 in 2005 and 0.5 in 2006.

A Details of calculations

The independence result also holds with imperfect competition: For example, maximization of profits given by $p_r^p \cdot Q(p_r^p + t, X) - C(Q(p_r^p + t, X))$ where $C(\cdot)$ is the cost function and X is the vector of characteristics influencing a particular firm's demand (including, potentially, prices set by competitors) is equivalent to maximizing profits given by $(p_r - t) \cdot Q(p_r, X) - C(Q(p_r, X))$ with the solutions again linked as $p_r^p + t_r = p_r$. As the result, ceteris paribus, decisions of a standard firm with market power are not affected by where statutory incidence lies and, when this is so for all firms, the original equilibrium outcome remains an equilibrium when the statutory incidence shifts.

Supply is increasing in price: Taking the derivative of the supply curve with respect to the price yields

$$\frac{\partial S}{\partial p} = \frac{\partial H}{\partial \widehat{M}} q^2 + H q' \ \Rightarrow \varepsilon_S^p = \frac{\partial S}{\partial p} \cdot \frac{p}{S} = \frac{\partial H}{\partial \widehat{M}} q \cdot \frac{p}{H} + \frac{q'}{q} p = \varepsilon_N^p + \varepsilon_q^p \,,$$

where ε_S^p is the price elasticity of aggregate supply, ε_N^p is the price elasticity of the number of firms in the industry and ε_q^p is the price elasticity of output per firm. All terms are non-negative so that the supply curve is (weakly) upward sloping. Under our assumptions, the price elasticity of output per firm is independent of tax considerations. The price elasticity of the number of firms depends on the distribution of underlying characteristics and the value of the tax rate that determines which firms are marginal.

Supply is increasing in the tax rate: The effect of the tax on aggregate supply is given by

$$\frac{\partial S}{\partial t_r} = \frac{\partial H}{\partial t_r} q_r = \mathrm{E}[e|\widehat{M}, t_r] \cdot \frac{\partial H}{\partial \widehat{M}} q_r = \varepsilon_N^p \cdot \frac{\mathrm{E}[e|\widehat{M}, t_r]}{q_r} \cdot \frac{H q_r}{p}$$

so that it depends on how elastic is entry in response to price (ε_N^p), but the strength of this effect depends on the extent of tax evasion on the margin. As long as there is at least some tax evasion (which also implies that $t_r > 0$), supply (weakly) increases as t_r increases.

Wholesale price response to retail tax change: More specifically, substituting back in equation 8 yields

$$\frac{dp_w^p}{dt_r} = \frac{\varepsilon_D^p \varepsilon_S^p}{\varepsilon_S^p \varepsilon_W^p - \varepsilon_D^p \varepsilon_S^p - \varepsilon_D^P \varepsilon_W^p} - \frac{\varepsilon_N^p \varepsilon_D^p}{\varepsilon_S^p \varepsilon_W^p - \varepsilon_D^p \varepsilon_S^p - \varepsilon_D^P \varepsilon_W^p} \cdot \frac{\mathrm{E}[e|\widehat{M}, t_r]}{q_r} \tag{16}$$

This expression can be simplified by denoting $\varepsilon_Y^p \equiv \frac{\varepsilon_D^p \varepsilon_S^p}{\varepsilon_S^p - \varepsilon_D^p}$. The formula can be written as

$$\frac{dp_w^p}{dt_r} = \frac{\varepsilon_Y^p}{\varepsilon_W^p - \varepsilon_Y^p} - \frac{\varepsilon_N^p}{\varepsilon_W^p - \varepsilon_Y^p} \frac{\varepsilon_D^P}{\varepsilon_S^p - \varepsilon_D^p} \cdot \frac{\mathrm{E}[e|\widehat{M}, t_r]}{q_r}. \tag{17}$$

Response of margins to incidence shift: For completeness, recall the decisions made in each sector are determined by the margins $p_r^p - p_w^p - t_w$ (for the retail sector) and p_w^p (for the wholesale sector). Having derived the effect on p_r^p, the full characterization of the margins requires evaluating the effect on p_w^p as well. This follows simply from formulae (16) and (10) for $\frac{dp_w^p}{dt_w}$ and $\frac{dp_w^p}{dt_r}$ so that $\frac{dp_w^p}{dt_r}\Delta t_r - \frac{dp_w^p}{dt_w}\Delta t_r = \frac{\varepsilon_D^p(\varepsilon_S^p - \varepsilon_D^p)}{\varepsilon_S^p \varepsilon_W^p - \varepsilon_D^p \varepsilon_S^p - \varepsilon_D^P \varepsilon_W^p} \left(\frac{\varepsilon_{WN}^p}{\varepsilon_D^p} \frac{\mathrm{E}[e_w|\widehat{M}, t_w]}{q_w} - \frac{\varepsilon_N^p}{\varepsilon_S^p - \varepsilon_D^p} \frac{\mathrm{E}[e|\widehat{M}, t_r]}{q_r} \right) \Delta t_r$, again highlighting that it is evasion on the margin in the two sectors (interacted with the standard demand and supply elasticities) that determines the effect on all prices.

B Market Power (For Online Publication)

As a check that unobserved differences in market concentration do not drive our main results, we include a specification that conditions on wholesale market concentration in each state.[18] We construct Herfindahl indices for each state using firm-level microdata collected by the Energy Information Administration (EIA).[19] Every month, any firm with domestic refinery operations reports operational data to the EIA, including wholesale volumes in each state. From these, we calculate the HHI and 4-firm concentration ratio based on the wholesale volumes sold by each firm. For reference, the mean HHI in our sample is .22. On average, the top four firms in each market account for 74 percent of wholesale volumes.

Wholesale market concentration varies substantially over time and across states. Over the past two decades, industry consolidation increased concentration in the wholesale market approximately 20 percent, from a mean of .20 in 1994 to a mean of .24 in 2008. The most concentrated wholesale markets tend to be in the northeast - wholesale sales are most concentrated in Delaware (0.60), Vermont (0.54) and New Hampshire(0.46). Wholesale sales tend to be more concentrated in distributor-remitting states and less concentrated in supplier-remitting states (Table A1), but changes in regime and changes in diesel taxes are not strongly correlated with lagged, contemporaneous or leading changes in concentration (Table A2).

Table A3 introduces market concentration into our main specification. For reference, columns (1) and (2) present our baseline results from Table 5. Columns (3) and (4) use identical specifications, but limit the sample to the period 1994-2006 during which we can calculate wholesale market concentration. Over this period across all states, we cannot reject full pass-through of taxes to retail prices. As before, when we separate states by remittance-regime, we estimate less than full-passthough in retailer-remitting states and find that pass-through rates are signficantly higher in states that require taxes be remitted by wholesale terminal operators. In columns (5) and (6), we further condition on wholesale market concentration, first identically across regimes and then allowing for regime-specific relationships between concentration and pass-through rates. In both cases, we do not find that pass-through is strongly correlated with concentration. Moreover, our main results on pass-through and the identity of the remitting party remain unchanged.

[18]We focus on wholesale concentration rather than retail market concentration for two reasons. First, most retail stations are franchisee-owned - determining historical ownership and operational control is difficult. Second, retail stations tend to compete very locally. State-level statistics are an imperfect proxy for retail competition.

[19]We aggregate restricted EIA Form 782 and covers the universe of firms with refinery operations which cover the majority of domestic wholesale terminal sales. Our access to the data begins in 1994 and continues to the end of our sample.

Table A1: Market Power and Point of Taxation

	(1) Wholesale HHI	(2) Wholesale 4-firm CR
Distributor Remittance	0.0726**	0.00763
	(0.0300)	(0.0347)
Supplier Remittance	-0.0423***	-0.105***
	(0.0124)	(0.0334)
Constant	0.188***	0.764***
	(0.00668)	(0.0242)
Observations	7951	7951
R-Squared	0.103	0.138

Standard errors clustered by state are in parentheses. *,**,*** denote significance at the 10%, 5%, and 1% level, respectively. Specifications include year fixed effects.

Table A2: Market Power and Changes in Point of Taxation

	(1) ΔDistributor Remittance	(2) ΔRetailer Remittance	(3) ΔSupplier Remittance	(4) ΔTax Rate
Δ Wholesale HHI_{t-1}	0.287	-0.0927	-0.194	0.591
	(0.189)	(0.0673)	(0.185)	(1.016)
Δ Wholesale HHI_t	-0.163	0.0351	0.128	-1.543
	(0.251)	(0.0849)	(0.237)	(1.329)
Δ Wholesale HHI_{t+1}	0.0823	0.0680	-0.150	0.396
	(0.170)	(0.0784)	(0.167)	(1.071)
Observations	576	576	576	576
R-Squared	0.345	0.0344	0.272	0.0281

Standard errors clustered by state are in parentheses.
*,**,*** denote significance at the 10%, 5%, and 1% level, respectively. Specifications include year fixed effects. For reference, one standard deviation changes in Δ WholesaleHHI_t is 0.033.

Table A3: Retail Prices, Wholesale Concentration and Point of Taxation

	(1)	(2)	(3)	(4)	(5)	(6)
Diesel Tax	-0.0856***	-0.120**	-0.0160	-0.353	-0.445*	-0.406
	(0.0211)	(0.0550)	(0.0363)	(0.216)	(0.242)	(0.251)
Supp Remit * Diesel Tax		0.209***		0.638***	0.712***	0.524**
		(0.0524)		(0.177)	(0.199)	(0.213)
Dist Remit * Diesel Tax		0.1000*		0.308	0.375	0.340
		(0.0556)		(0.210)	(0.229)	(0.244)
Supplier Remittance		0.445		-7.557***	-8.547***	-4.556
		(0.604)		(2.316)	(2.605)	(2.880)
Distributor Remittance		0.192		-4.321	-5.213*	-3.392
		(0.626)		(2.719)	(2.975)	(3.226)
Demeaned HHI					-3.968	25.12
					(2.716)	(23.26)
Supp Remit * HHI						21.35
						(26.54)
Dist Remit * HHI						-29.46
						(23.42)
Diesel Tax * HHI					0.330	-3.429
					(0.208)	(2.809)
Supp Remit * Diesel Tax * HHI						-0.930
						(3.064)
Dist Remit * Diesel Tax * HHI						3.805
						(2.819)
Min. Neighboring Tax	0.0803*	0.276***	-0.134	-0.115	-0.0976	-0.0822
	(0.0457)	(0.0501)	(0.100)	(0.1000)	(0.103)	(0.105)
Degree Days	0.0868	0.0948	0.0591	0.0585	0.0620	0.0679
	(0.0662)	(0.0623)	(0.0773)	(0.0767)	(0.0773)	(0.0773)
Degree Days * HH Oil Frac	0.468***	0.460***	0.571***	0.568***	0.570***	0.559***
	(0.0851)	(0.0791)	(0.0912)	(0.0914)	(0.0916)	(0.0901)
Unemployment Rate	-0.0636	-0.135**	0.164**	0.263***	0.268***	0.191**
	(0.0612)	(0.0633)	(0.0760)	(0.0726)	(0.0732)	(0.0776)
Observations	5435	5435	3350	3350	3346	3346
R-Squared	0.981	0.982	0.990	0.990	0.990	0.990

*,**,*** denote significance at the 10%, 5%, and 1% level, respectively. For reference, the mean and standard deviation of HHI are .22 and .16. Specifications include state and time fixed effects.