Challenging Conventional Wisdom: Theoretical (Ir)relevance of Statutory Incidence of Ad Valorem Taxes

Konstantin Poensgen*
(Harvard University)

Lukas Rodrian†
(University of Zurich)

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Abstract

Conventional wisdom in the theoretical public finance literature suggests that the economic incidence of a tax is independent of its statutory (nominal) incidence in a frictionless, competitive economy. This paper cautions that this result is more nuanced for ad valorem taxes even in this benchmark case. Ad valorem taxes are proportional to the price (e.g., a 7% sales tax), whereas per unit or specific taxes are a fixed $ amount per unit of the good (e.g., 10 cents per liter of gasoline). First, we prove that statutory irrelevance fails in the canonical sense: shifting the statutory incidence of a constant ad valorem tax rate towards the demand side decreases the consumer price, increases the supplier price, and thus increases the equilibrium quantity. This relevance result is due to differences in the tax base when shifting the statutory incidence. The revenue-maximizing statutory incidence of a fixed ad valorem tax depends on the supply and demand elasticities. Second, we introduce a new, weaker notion of statutory irrelevance: a shift in the statutory incidence can be accompanied by a change in the tax rate that keeps equilibrium prices and allocation unchanged while holding tax revenue constant. Ad valorem taxes satisfy weak irrelevance. We derive testable formulas for economic incidence accounting for these results and provide numerical examples of the economic relevance of statutory incidence. We apply our results to payroll taxes in OECD countries. Together, our insights offer policymakers the ability to more effectively address economic incidence of tax policies.

*Konstantin Poensgen, PhD student, Harvard University, konstantinpoensgen@fas.harvard.edu
†Lukas Rodrian, PhD student, University of Zurich, lukas.rodrian@econ.uzh.ch

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1 Introduction

The economic incidence of tax policies is one of the most studied topics in public finance (e.g., Kotlikoff and Summers, 1987; Fullerton and Metcalf, 2002; Benzarti, 2024). Economic tax incidence refers to the side of the market that bears the real burden of the tax. In contrast, statutory incidence refers to the side of the market on which the tax is levied de jure (also known as nominal or legal incidence). It is widely accepted by economists that in theory—absent any frictions and in competitive equilibrium—the economic incidence of a tax is independent of its statutory incidence. This conventional wisdom is taught in any public economics course and is reflected in standard public finance textbooks:

> "In most countries, Social Security [...] is financed in large part from payroll taxes based on wages. Some of these taxes are 'paid' by employers and some by workers. This legal distinction is artificial: [...] [w]hether the employer 'pays' 80 percent or 50 percent or 20 percent of payroll taxes is immaterial to the equilibrium gross and net wages and to the determination of employment." (Salanié, 2003)

In the canonical case, the real economic incidence of a tax is considered to be fully determined by the relative demand and supply elasticities—irrespective of the statutory incidence. Empirical work demonstrates many cases when statutory incidence matters in practice (see, e.g., Benzarti, 2024, for a recent discussion on various tax "anomalies" compared to the frictionless benchmark).

This paper challenges the classical statutory irrelevance result from a theoretical perspective for the frictionless, competitive benchmark economy for one of the most common form of taxes: the ad valorem tax. Ad valorem taxes are proportionate to the price of the good or service, e.g., $(1+\tau)p$. For instance, payroll taxes or sales taxes are typically ad valorem taxes. In comparison, a per unit tax is a constant amount per unit of the good irrespective of its price, e.g., $p+t$. We argue for a more nuanced view of statutory incidence for ad valorem taxes by introducing a new distinction between strong and weak statutory irrelevance. The statutory incidence of a tax is *strongly* irrelevant for economic incidence if shifting the statutory incidence does not affect the economic equilibrium and collected revenue keeping the tax rate constant. This definition refers to the classical notion of statutory irrelevance in the literature to date. In contrast, we view the statutory incidence of a tax to be *weakly* irrelevant if shifting the statutory incidence maintains the economic equilibrium and collected revenue while allowing for simultaneous adjustments in the tax rate. While per unit taxes satisfy strong and weak irrelevance, we show that ad valorem taxes only satisfy weak irrelevance.

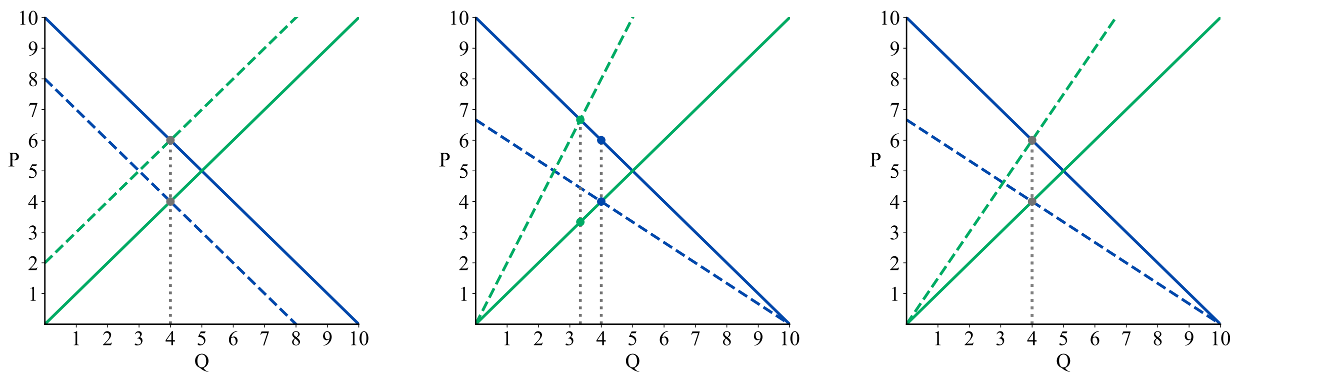
Figure 1a illustrates a stylized example of the conventional wisdom in the economics literature: per unit taxes satisfy both strong and weak irrelevance. Irrespective of whether the per unit tax is levied on the supplier, $p_S = p_D - t$, or whether it is levied on the buyer, $p_D = p_S + t$, the equilibrium is unchanged (p_S and p_D are the prices received and paid by the supply and demand side, respectively).

We demonstrate that ad valorem taxes do not satisfy strong irrelevance of statutory incidence. Figure 1b provides a stylized example of this failure, which we generalize in section 4. Consider an ad valorem tax τ_0, which is levied fully on the demand side such that $p_D^0 = (1+\tau_0)p_S^0$. Now suppose a tax reform shifts the statutory incidence from the demand to the supply side. The prices (p_D, p_S) will adjust in equilibrium to equate supply and demand at $p_S^1 = (1-\tau_0)p_D^1$. Unlike the per unit tax case, however, the price adjustment is insufficient to neutralize the statutory incidence shift, leading to a change in the real economic allocation, tax incidence, and collected tax revenue.

We derive under general conditions—downward sloping demand, upward sloping supply—that statutory incidence shifts of a constant ad valorem tax rate toward the supply side decrease the equilibrium quantity, raise buyer prices, and lower consumer prices. The effect on revenue is ex-ante unclear, but revenue increases for shifts toward the supply side when the demand elasticity exceeds -1.

Figure 1: (Ir)relevance of statutory incidence for per unit vs. ad valorem taxes

(a) Irrelevance per unit tax ($t_D = t_S$) (b) Strong relevance ad valorem tax ($\tau_D = \tau_S$) (c) Weak irrelevance ad valorem tax ($\tau_D > \tau_S$)



Notes: This figure illustrates in classic price-quantity diagrams the (ir)relevance of statutory tax incidence for per unit and ad valorem taxes. Downward-sloping, solid blue lines correspond to inverse linear demand curves. Upward-sloping, solid green lines correspond to inverse linear supply curves. Dashed blue and green lines account for taxes when levied on the supply and demand side, respectively. Panel (a) shows that for a per unit tax ($t_D = t_S$), the statutory incidence does neither affect equilibrium quantity nor prices. Panel (b) demonstrates the economic relevance of statutory tax incidence for fixed ad valorem tax rates ($\tau_D = \tau_S$). Panel (c) illustrates the case where different ad valorem tax rates on the supply side and the demand side ($\tau_D > \tau_S$) lead to the same equilibrium (the case of weak irrelevance).

The failure of the strong irrelevance theorem for ad valorem taxes is due to differences in the tax base. When the tax is levied on the demand side, the tax base is the supply price, p_S. This creates a wedge of $\tau_0 p_S$ between the demand and supply curve. When the tax is levied on the supply side, the tax base is the demand price, p_D. This creates a wedge of $\tau_0 p_D$. Since $p_S \leq p_D$ for $\tau > 0$, the distortion is smaller when τ_0 is levied on the demand side. As an important implication for tax policy, an ad valorem tax of τ_0 levied on the supply side is economically different from an ad valorem tax of τ_0 levied on the demand side.

We derive general, empirically tractable formulas for the predicted price and economic incidence changes in response to tax reforms that shift the statutory incidence. These formulas closely mirror canonical economic incidence formulas for tax rate changes and depend on relative demand and supply elasticities, the tax rate, and the pre-reform statutory incidence. The close resemblance of tax incidence formulas is driven by changes in statutory incidence for ad valorem taxes implicitly acting as effective tax rate changes. In addition, we derive general economic incidence formulas in response to tax rate changes that account for the statutory incidence. These formulas underscore that accounting for the statutory incidence is important when considering ad valorem tax rate changes.

Based on these general formulas, we provide numerical examples in the payroll tax context that simulate reforms which either shift the statutory incidence or change the tax rate. Thanks to the generality of the incidence formulas, one only requires supply and demand elasticities in addition to the tax regime parameters (statutory incidence and tax rate). In line with the well-established intuition, the numerical simulations emphasize the importance of the relative elasticities. However, the simulations also reveal the relevance of statutory incidence for expected price changes. This has implications for empirical research analyzing tax reforms in that they caution to distinguish between predicted price changes in the frictionless, competitive benchmark from the influence of optimization frictions (like salience or differential evasion opportunity). From the numerical simulations, we conclude that shifts in statutory incidence at constant tax rates can lead to meaningful changes in prices for medium and large tax rates as is commonly the case for payroll taxes.

To complete our theoretical discussions, we show that the statutory irrelevance of ad valorem taxes can be restored in the weak irrelevance sense. Conceptually, weak irrelevance is asking the question: can we implement the same equilibrium outcome after a tax change with a different statutory incidence? Figure 1c illustrates a stylized example, which we generalize in section 5. For any tax rate $\tau_S < 1$ levied on the supply side, there is an equivalent tax rate on the demand side, $\tau_D = \frac{\tau_S}{1-\tau_S}$, that leads to the same economic equilibrium. Implicitly, both tax rates lead to the same per unit tax, and we show that these two ad valorem rates also lead to the same tax revenue. Thus, we consider these taxes as equivalent from a tax collection perspective. The important policy takeaway is that shifts in statutory incidence are only neutral when they are accompanied by corresponding adjustments in the tax rate. The notion of these equivalent tax rates is closely related to the notion of the possibility to express wedges in the macroeconomics or trade literature as either on the supply or demand side.

Finally, we apply our theoretical insights to payroll taxes in OECD member countries between 2000 and 2023. First, the statutory incidence of payroll taxes between the employer (demand side) and employee (supply side) varies substantively across countries. However, there is no clear relationship between the statutory incidence and tax rates. We then show the standardized, revenue-equivalent tax rates that correspond to statutory incidences either fully on the employer or employee side. Second, we look at changes in the statutory incidence and tax rates over time. While small annual changes in both of these margins are common, there is no clear pattern in how statutory incidence changes correlate with tax rate changes.

Related literature. We contribute to two strands of the literature. First, this article relates to the theoretical work on irrelevance of statutory incidence of per unit and ad valorem taxes. We argue that two patterns in the literature contribute to the conventional wisdom among economists that the economic incidence of an ad valorem tax is independent of its statutory incidence. First, algebraic results from a per unit tax are transferred to ad valorem taxes without further proof (Dalton, 1941; Kotlikoff and Summers, 1987). We make explicit that this irrelevance only holds with a specific tax rate adjustment. Second, algebraic results for ad valorem taxes only consider the introduction of an infinitesimal tax (i.e., initial $\tau = 0$) (Fullerton and Metcalf, 2002; Salanié, 2003). As we show in our general proof, the statutory incidence for the initial introduction of an infinitesimal ad valorem tax is indeed irrelevant. The irrelevance fails, however, for any given non-zero ad valorem tax.

To the best of our knowledge, Pauwels and Schroyen (2024) form an exception in the tax theory literature showing the failure of the classical statutory irrelevance in a frictionless, competitive economy. Pauwels and Schroyen (2024) consider separate ad valorem taxes for producers and consumers. They show that a given tax rate change is quantity-maximizing if levied on the demand side rather than on the supply side. First, we deviate from Pauwels and Schroyen (2024) and more generally to this theoretical literature by introducing the notions of strong (classical) and weak irrelevance. Crucially, we show that statutory incidence of ad valorem taxes *is* irrelevant when adjusting the tax rate accordingly. Second, we provide a clear intuition for why statutory incidence matters for constant ad valorem rate, arguing that a change in the statutory incidence changes the tax base. Third, our derivations directly extend the canonical incidence analysis in the public finance literature and textbooks, generalized for per unit taxes, the introduction of small ad valorem taxes, and existing ad valorem taxes. Fourth, these incidence formulas provide general, empirically tractable formulas to guide empirical research. Fifth, we extend the frictionless environment, including, for example, behavioral terms such as tax salience or differential tax compliance.

Second, we contribute to the (primarily empirical) literature examining deviations from the irrelevance of statutory incidence. The classical view, which asserts that statutory incidence is inconsequential, rests on the assumption that all relevant information required to determine tax liability is freely and universally observed (Slemrod, 2008). In practice, however, this assumption frequently fails due to various factors, including tax salience (Chetty et al., 2009), differential opportunities for tax evasion and enforcement (Bibler et al., 2021; Hargaden and Roantree, 2019; Garriga and Tortarolo, 2024; Fox et al., 2022; Slemrod, 2019), price rigidities and social norms (Saez et al., 2012), imperfect competition (Hansen et al., 2017), and bargaining power (Claussen et al., 2024; Jiménez et al., 2024). In the case of per unit taxes (e.g., Kopczuk et al., 2016), these factors can fully account for the relevance of statutory incidence. For ad valorem taxes, however, we offer a more nuanced perspective, arguing that the resulting economic effects reveal the limitations of the canonical model. Specifically, we decompose these effects into mechanical components—those predicted by our theoretical framework—and components that arise due to the canonical model's inability to fully capture the complexity of real-world economic environments.

Benzarti (2024) highlights that empirical research challenges three key implications of the canonical tax incidence model: (1) statutory incidence has no effect on economic incidence, (2) the relative magnitudes of demand and supply elasticities serve as a sufficient statistic for tax incidence, and (3) tax incidence is symmetric for increases and decreases. Our theoretical framework can be seen as a modification of the canonical tax incidence model, providing evidence that (1) and (2) also do not hold in theory for ad valorem taxes, such as most consumption and labor taxes. We contribute to this discussion, showing that in theory (1) economic incidence depends on the statutory incidence as well as the level of the tax rate, and (2) that demand and supply elasticities only serve as a sufficient statistic depending on the context (levels of tax rate *and* statutory incidence).

The remainder of this article proceeds as follows. Section 2 introduces notation and the definitions of strong and weak statutory irrelevance. Section 3 recalls the strong irrelevance of per unit taxes. Section 4 generalizes and discusses the failure of strong irrelevance of ad valorem taxes. In Section 5, we demonstrate how weak irrelevance of ad valorem taxes can be restored. Section 6 provides an application to payroll taxes in OECD countries. Section 7 concludes.

2 Notation and definitions

Let p denote the tax-exclusive price of some good, which can be any commodity, labor, or some other service. What matters for supply and demand are the effective prices after accounting for any possible taxes; we call these the tax-inclusive prices. Let p_S denote the tax-inclusive price received by the suppliers after subtracting a possible legal tax obligation. Respectively, let p_D denote the tax-inclusive price for the demand side, which includes any possible formal tax liability. Denote $S(p_S)$ and $D(p_D)$ as aggregate supply and demand.

We express per unit taxes—also referred to as specific taxes in the literature—by t and ad valorem taxes by τ. The statutory incidence of a given tax may be split across the demand and supply side; we denote $\alpha \in [0,1]$ as the statutory share of the tax falling on the demand side. This implies the following tax-inclusive prices p_S and p_D for per unit and ad valorem taxes, respectively:

$$\begin{aligned} \text{per unit tax:} \quad & p_D = p + \alpha t \quad \text{and} \quad p_S = p - (1-\alpha)t \\ \text{ad valorem tax:} \quad & p_D = (1+\alpha\tau)p \quad \text{and} \quad p_S = [1-(1-\alpha)\tau]p, \end{aligned}$$

where p denotes the tax-exclusive price, which adjusts in equilibrium to equate supply and demand.[1]

The statutory incidence refers to side of the transaction (supply or demand) on which the tax is levied *de jure*, which has—following our argumentation in section 4.2—important implications for the base of an ad valorem tax. For the purpose of the theoretical framework, we assume that the statutory incidence coincides with the side remitting the tax (or the respective share of it) to the revenue authority. In practice, however, the statutory incidence may fall on one side, but may still be remitted to the revenue authority by the other side (e.g., payroll taxes often fall partially on the employee as expressed on payslips, but are fully remitted by the employer). Which party remits the tax can matter empirically (Slemrod, 2008), but we abstract away from this to isolate the theoretical benchmark role of statutory incidence.

[1] To gain intuition for the tax-inclusive prices, consider the following two scenarios. First, consider an ad valorem sales tax for some retail good, which falls fully on the demand side. Then, the consumer pays $p_D = (1+\tau)p_S$ for a unit of the good and the seller gets to keep p_S. Second, consider a payroll tax, which in this example falls fully on the employee (i.e., the supplier). The firm pays Lw, where L denotes hours worked and w the hourly wage. After tax, the worker only gets to keep $L(1-\tau)w$. Here, $w = p_D$ and $p_S = (1-\tau)w = (1-\tau)p_D$. Now suppose the payroll tax—levied on the tax-exclusive price—is equally split between the employer and the employee. The hourly wage might adjust to $\tilde{w}$. Assuming inelastic labor supply and demand, the firm now pays $L\tilde{w}$ to the worker and $L0.5\tau\tilde{w}$ in taxes in addition, i.e. a total wage bill of $L(1+0.5\tau)\tilde{w}$. The worker, in turn, gets to keep $L(1-0.5\tau)\tilde{w}$ of their earnings.

Strong and weak statutory irrelevance

We consider the statutory incidence of some tax to be *strongly irrelevant* for real economic outcomes and incidence whenever the tax-inclusive prices, p_S and p_D, the equilibrium quantity, $Q(p^*)$, and the tax revenue, $R(p^*)$, are unaffected by the statutory incidence, α, holding the tax rate constant. We formalize this idea in Definition 1. In our reading of the existing literature, statutory irrelevance to date implicitly refers to this notion of strong irrelevance. In contrast, we define the statutory incidence of some tax to be *weakly irrelevant* for real economic outcomes and incidence whenever the tax-inclusive prices, p_S and p_D, the equilibrium quantity, $Q(p^*)$, and the tax revenue, $R(p^*)$, are unaffected by the statutory incidence, α, whilst allowing for a corresponding adjustment in the tax rate. We establish this idea in Definition 2. The key difference is that weak irrelevance allows for changes in the tax rate when considering different supply-demand splits of the tax. Strong irrelevance of statutory incidence implies weak irrelevance of statutory incidence, but not vice versa.

Definition 1 (Strong irrelevance of statutory incidence)**.** *The statutory incidence of some tax regime* $T = \{\tau, \alpha\}$ *is strongly irrelevant if for all* $\alpha_0, \alpha_1 \in [0, 1]$ *and any* $\tau_0 \in \mathbb{R}$ *we have*

- *Constant prices:* $p_S(\tau_0, \alpha_0) = p_S(\tau_0, \alpha_1)$ *and* $p_D(\tau_0, \alpha_0) = p_D(\tau_0, \alpha_1)$
- *Constant quantity:* $Q(\tau_0, \alpha_0) = Q(\tau_0, \alpha_1)$
- *Constant revenue:* $R(\tau_0, \alpha_0) = R(\tau_0, \alpha_1)$

Definition 2 (Weak irrelevance of statutory incidence)**.** *The statutory incidence of some tax regime* $T = \{\tau, \alpha\}$ *is weakly irrelevant if for all* $\alpha_0, \alpha_1 \in [0, 1]$ *and any* $\tau_0 \in \mathbb{R}$ *there exists* $\tau_1 \in \mathbb{R}$ *such that*

- *Constant prices:* $p_S(\tau_0, \alpha_0) = p_S(\tau_1, \alpha_1)$ *and* $p_D(\tau_0, \alpha_0) = p_D(\tau_1, \alpha_1)$
- *Constant quantity:* $Q(\tau_0, \alpha_0) = Q(\tau_1, \alpha_1)$
- *Constant revenue:* $R(\tau_0, \alpha_0) = R(\tau_1, \alpha_1)$

A corollary of Definition 1 is that under strong irrelevance, the statutory incidence does not affect the economic incidence of a change in the tax rate, a common policy adjustment.

Corollary 1 (Strong irrelevance of statutory incidence for changes in tax rate)**.** *If the statutory incidence of some tax regime* $T = \{\tau, \alpha\}$ *is strongly irrelevant, for all* $\alpha_0, \alpha_1 \in [0, 1]$ *and any* $\tau_0, \tau_1 \in \mathbb{R}$*, we have*

- *Equal price changes:* $\Delta p_S(\tau_0, \tau_1; \alpha_0) = \Delta p_S(\tau_0, \tau_1; \alpha_1)$ *and* $\Delta p_D(\tau_0, \tau_1; \alpha_0) = \Delta p_D(\tau_0, \tau_1; \alpha_1)$
- *Equal quantity changes:* $\Delta Q(\tau_0, \tau_1; \alpha_0) = \Delta Q(\tau_0, \tau_1; \alpha_1)$
- *Equal revenue changes:* $\Delta R(\tau_0, \tau_1; \alpha_0) = \Delta R(\tau_0, \tau_1; \alpha_1)$

where $\Delta X(\tau_0, \tau_1; \alpha) \coloneqq X(\tau_1, \alpha) - X(\tau_0, \alpha)$.

In what follows, we frequently express formulas in terms of the tax-inclusive price elasticities of demand and supply. Formally, these are defined as

$$\varepsilon^S \coloneqq \frac{\partial S(p_S)}{\partial p_S} \frac{p_S}{S(p_S)} \quad \text{and} \quad \varepsilon^D \coloneqq \frac{\partial D(p_D)}{\partial p_D} \frac{p_D}{D(p_D)}.$$

Throughout this paper, we assume $\varepsilon^S \geq 0$ and $\varepsilon^D \leq 0$, i.e., upward sloping supply and downward sloping demand curves. In the comparative statics below, we evaluate the elasticities at the equilibrium prior to a particular perturbation of the tax regime. In what follows, whenever we present total derivatives, they should be understood as small tax policy changes.

3 Strong irrelevance of per unit taxes

This section demonstrates the well-known insight that the statutory incidence (in a frictionless, competitive environment) is irrelevant for statutory incidence. We derive these results here to draw close parallels to the ad valorem case below.

3.1 Strong irrelevance

We start by considering a per unit tax t for some $\alpha \in (0,1)$.[2] The tax-inclusive prices are $p_D = p + \alpha t$ and $p_S = p - (1-\alpha)t$. The tax-exclusive price, p, is a function of t and α, and adjusts in equilibrium for markets to clear, i.e., $S(p-(1-\alpha)t) = D(p+\alpha t)$. Proposition 1 establishes the strong statutory irrelevance of per unit taxes, which implies that their statutory incidence does not matter for economic incidence (Corollary 1).

Proposition 1. *Per unit taxes satisfy strong irrelevance of statutory incidence.*

Proof of proposition 1. Totally differentiating both sides of $S(p-(1-\alpha)t) = D(p+\alpha t)$, allowing for $d\alpha \neq 0$, and letting $dt = 0$, we obtain

$$\begin{aligned} \frac{\partial S}{\partial p_S}\left[dp + t d\alpha\right] &= \frac{\partial D}{\partial p_D}\left[dp + t d\alpha\right] \\ \Leftrightarrow \left[\frac{\partial S}{\partial p_S} - \frac{\partial D}{\partial p_D}\right]\left[dp + t d\alpha\right] &= 0. \end{aligned}$$

Hence, unless $\frac{\partial S}{\partial p_S} = \frac{\partial D}{\partial p_D} = 0$, we must have $dp = -t d\alpha$.[3] From $dp_D = dp + t d\alpha$ and $dp_S = dp + t d\alpha$, it follows $dp_S = dp_S = 0$. Finally, $dS = S'(p_S)dp_S$ and $dD = D'(p_D)dp_D$ imply $dQ^* = 0$ and $dR^* = dQ^* t + dt Q^* = 0$, satisfying Definition 1 of strong irrelevance. $\square$

3.2 Economic incidence formulas

The economic incidence of a tax is often considered to be the change in (tax-inclusive) prices in response to a change in the tax. Here, we present the common formula for the economic incidence of a per unit tax. Specifically, we consider price changes in response to a tax reform with $dt \neq 0$ and $d\alpha = 0$ for arbitrary $\alpha \in [0,1]$. Appendix A.1.1 provides a detailed derivation of the following results.

[2] We restrict the derivation to $\alpha \notin \{0,1\}$ for the comparative statics. All insights on statutory irrelevance hold for $\alpha = 0$ or $\alpha = 1$, respectively.

[3] Since $\frac{\partial S}{\partial p_S} \geq 0$ and $\frac{\partial D}{\partial p_D} \leq 0$ by assumption, the only possibility for $\left(\frac{\partial S}{\partial p_S} - \frac{\partial D}{\partial p_D}\right) = 0$ is that $\frac{\partial S}{\partial p_S} = 0$ and $\frac{\partial D}{\partial p_D} = 0$.

Totally differentiating $S(p-(1-\alpha)t) = D(p+\alpha t)$ with $d\alpha = 0$ and using $p_S = p_D - t$, one obtains

$$\frac{\partial S}{\partial p_S}\left[dp - (1-\alpha)dt\right] = \frac{\partial D}{\partial p_D}\left[dp + \alpha dt\right]$$
$$\Leftrightarrow \frac{dp}{dt} = \frac{(1-\alpha)\varepsilon^S + \alpha\varepsilon^D - \frac{\partial D}{\partial p_D}\frac{t}{D}}{\varepsilon^S - \varepsilon^D + \frac{\partial D}{\partial p_D}\frac{t}{D}}.$$

While the change in the tax-exclusive price depends on α, changes in the tax-inclusive prices, dp_S and dp_D, do not. Totally differentiating p_S and p_D and plugging in the expression for $\frac{dp}{dt}$ gives:

$$\frac{dps}{dt} = \frac{\varepsilon^D - \frac{\partial D}{\partial p_D}\frac{t}{D}}{\varepsilon^S - \varepsilon^D + \frac{\partial D}{\partial p_D}\frac{t}{D}} \tag{1}$$
$$\frac{dp_D}{dt} = \frac{\varepsilon^S}{\varepsilon^S - \varepsilon^D + \frac{\partial D}{\partial p_D}\frac{t}{D}}. \tag{2}$$

This reaffirms Proposition 1 and the resulting Corollary 1: the statutory incidence of a per unit tax is irrelevant for the economic incidence of the tax. Note also that the introduction of a small per unit tax, i.e., $t_0 = 0$, depicts the classical textbook formula:

$$\frac{dp_S}{dt} = \frac{\varepsilon^D}{\varepsilon^S - \varepsilon^D} \quad \text{and} \quad \frac{dp_D}{dt} = \frac{\varepsilon^S}{\varepsilon^S - \varepsilon^D}.$$

In the case of ad valorem taxes cases below, we will be interested in how prices change when the statutory incidence, α, changes while holding the tax rate constant. For per unit taxes, however, the strong irrelevance result implies prices are unaffected by shifts in the statutory incidence, i.e., $\frac{dp_S}{d\alpha} = 0$ and $\frac{dp_D}{d\alpha} = 0$. Accordingly, equations (1) and (2) also remain valid characterizations of price changes in response to a small tax policy reform that changes the statutory incidence and the tax rate simultaneously. Thus, from a theoretical benchmark, simultaneously changing the level and statutory incidence of a per unit tax is economically equivalent to a change in the level of the tax only. We show this result formally in Appendix A.1.2.

4 Failure of strong irrelevance of ad valorem taxes

We now turn to the case of ad valorem taxes. Recall that the tax-inclusive prices for an ad valorem tax τ are given by $p_D = (1+\alpha\tau)p$ and $p_S = [1-(1-\alpha)\tau]p$. The tax-exclusive price p adjusts in equilibrium to (τ, α) such that supply equals demand, $S([1-(1-\alpha)\tau]p) = D((1+\alpha\tau)p)$.

Section 4.1 begins by formally proving the failure of strong irrelevance for ad valorem taxes. Section 4.2 provides intuition for this result. We then derive economic incidence formulas in section 4.3 for changes in the statutory incidence and tax rate. Section 4.4 provides numerical examples demonstrating the magnitude of the statutory incidence channel. Section 4.5 provides additional theoretical results.

4.1 Formal proof

Unlike generally asserted, proposition 2 shows that ad valorem taxes do not satisfy strong statutory irrelevance (definition 1). In turn, the statutory incidence of a given ad valorem tax rate *is* relevant for real economic outcomes and the economic incidence of the tax.

Proposition 2. *Ad valorem taxes do not satisfy strong irrelevance of statutory incidence.*

Proof of proposition 2. Definition 1 requires $\frac{dp_S}{d\alpha} = \frac{dp_D}{d\alpha} = 0$. We will prove that $\frac{dp_S}{d\alpha} = 0$ and $\frac{dp_D}{d\alpha} = 0$ cannot hold simultaneously when $\tau \neq 0$.

First, consider $p_S = [1 - (1 - \alpha)\tau]p$. Totally differentiating both sides, and imposing $d\tau = 0$,

$$\frac{dp_S}{d\alpha} = [1 - (1 - \alpha)\tau]\frac{dp}{d\alpha} + \tau p.$$

Postulating $\frac{dp_S}{d\alpha} = 0$, we can re-arrange to obtain

$$\frac{dp}{p} = -\tau d\alpha \frac{1}{1 - (1 - \alpha)\tau}. \tag{3}$$

Second, consider $p_D = (1 + \alpha\tau)p$. Totally differentiating both sides, and imposing $d\tau = 0$,

$$\frac{dp_D}{d\alpha} = (1 + \alpha\tau)dp + \tau p d\alpha.$$

Again, postulating $\frac{dp_D}{d\alpha} = 0$, we can re-arrange to obtain

$$\frac{dp}{p} = -\tau d\alpha \frac{1}{1 + \alpha\tau}. \tag{4}$$

For equations (3) and (4) to hold simultaneously, we need $\tau = 0$. Thus, for any $\tau \neq 0$, definition 1 is not satisfied, and the statutory incidence of an ad valorem tax matters for economic incidence. □

4.2 Intuition

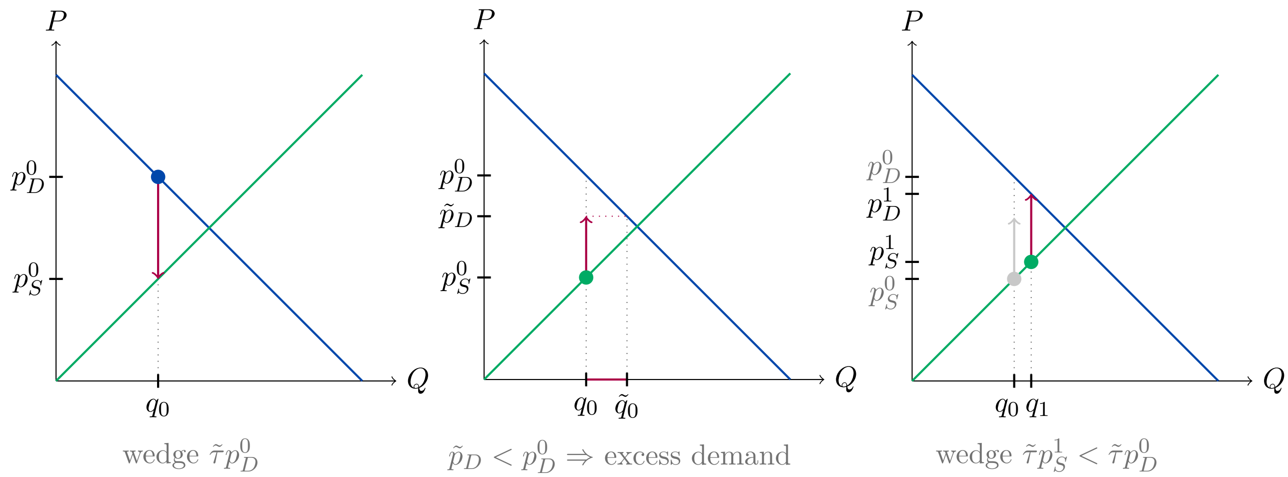
An ad valorem tax is given by the tax rate times the tax base and is thus proportional to the latter. Here, the tax base is given by the tax-exclusive price p. Strong irrelevance fails for ad valorem taxes because a shift in the statutory incidence changes the *base* without adjusting the tax rate. While the tax base, p, adjusts to a change in the statutory incidence to maintain an equilibrium (supply = demand), these changes in quantity and price do not fully offset each other.

Figure 2 illustrates this intuition for the following scenario: consider a tax that is initially levied fully on the supply side and is then shifted fully on the demand side. What happens in equilibrium?

1. Prior to the tax reform, the tax is levied fully on the supply side. Thus, $p_S^0 = (1 - \tau_0)p_D^0$. The tax creates a wedge (distortion) between the demand and supply curve equal to $\tau_0 p_D$.

2. The tax reform shifts the tax entirely on the demand side. Consider the (hypothetical) market immediately after the reform, that is, before the supplier adjusts the price. Then, $\tilde{p}_D = (1+\tau_0)p_S$. Since $p_S^0 < p_D^0$, the immediate wedge (distortion) is smaller and consumers face a lower price than before $\tilde{p}_D < p_D^0$. However, at this point, there is excess demand: $D(\tilde{p}_D) > S(p_S^0)$.
3. In response to the excess demand, the supplier will raise the price until demand equals supply. At this new equilibrium, $p_D^1 = (1+\tau_0)p_S^1$ with $p_S^1 > p_S^0$. Since we are to the left of the "no tax intersection," $p_S^1 < p_D^0$, implying that the tax, τ_0, is less distortionary at a wedge $\tau_0 p_S^1 < \tau_0 p_D^0$.

Figure 2: Intuition for failure of strong irrelevance of statutory incidence



Notes: This figure illustrates in classic price-quantity diagrams the intuition for the failure of strong irrelevance of statutory incidence for ad valorem taxes. Downward-sloping, solid blue lines depict (inverse) linear demand curves. Upward-sloping, solid green lines correspond to (inverse) linear supply curves. Panel (a) shows the equilibrium if the tax is levied fully on the supply side. Panel (b) shows the effect immediately after shifting the statutory incidence entirely on the demand side, including corresponding excess demand for consumer-facing $\tilde{p}_D$. Panel (c) shows the response to excess demand, letting the supplier price increase until demand equals supply again (note that $p_D^1 > \tilde{p}_D$).

In this illustration, the quantity increased as the tax was shifted from the supplier to the consumer. In fact, this result generalizes: for a given tax rate, τ_0, equilibrium quantity is maximized when τ_0 is levied fully on the demand side. We return to this and revenue impacts formally in section 4.5.

4.3 Economic incidence formulas

Economic incidence analysis asks how tax-inclusive prices change in response to tax rate changes. Here, we extend this form of analysis to assessing expected price changes in response to (i) changes in the statutory incidence holding constant the tax rate, (ii) changes in the tax rate holding constant the statutory incidence, and (iii) simultaneous changes in the statutory incidence and tax rate. Appendix A.2 provides detailed derivations of all results presented in this section.

Economic incidence of a change in statutory incidence

Suppose a tax reform shifts the statutory incidence by $d\alpha$ while keeping the tax rate unchanged. What will be the effective change in tax-inclusive prices p_S and p_D? Since the underlying tax-exclusive price, p, adjusts in equilibrium to changes in the statutory incidence, result 1 first summarizes how p

changes in response to the reform $d\alpha$.

Result 1 (Tax-exclusive price change due to change in statutory incidence)**.** *Consider a tax-reform that shifts the statutory incidence by $d\alpha$ without altering the ad valorem tax rate, i.e., $d\tau = 0$. Then, the tax-exclusive price changes by*

$$\frac{dp}{p} = -\tau d\alpha \, \frac{\frac{\varepsilon^S}{1-(1-\alpha)\tau} - \frac{\varepsilon^D}{1+\alpha\tau}}{\varepsilon^S - \varepsilon^D}. \tag{5}$$

Result 1 follows from totally differentiating $S([1-(1-\alpha)\tau]p) = D((1+\alpha\tau)p)$ with $d\tau = 0$, using $S = D$, the definitions of ε^S and ε^D, and the relationships between p_S, p_D, and p.

To shed light on the economic incidence of the statutory incidence shift, we next express how the tax-inclusive prices, p_S and p_D, change in response to the $d\alpha$ reform. Result 2 describes these price changes. The expressions follow from totally differentiating $p_S = [1-(1-\alpha)\tau]p$ and $p_D = (1+\alpha\tau)p$, and setting $d\tau = 0$.

Result 2 (Tax-inclusive price changes due to statutory incidence shifts)**.** *Consider a tax-reform that shifts the statutory incidence by $d\alpha$ without altering the ad valorem tax rate, i.e., $d\tau = 0$. Then, the tax-inclusive prices change by*

$$\frac{dp_S}{p_S} = \tau d\alpha \frac{\tau}{(1+\alpha\tau)[1-(1-\alpha)\tau]} \frac{-\varepsilon^D}{\varepsilon^S - \varepsilon^D} \tag{6}$$

$$\frac{dp_D}{p_D} = \tau d\alpha \frac{\tau}{(1+\alpha\tau)[1-(1-\alpha)\tau]} \frac{-\varepsilon^S}{\varepsilon^S - \varepsilon^D}. \tag{7}$$

Result 2 has important economic implications.[4] First, as is well-known for per unit taxes, the incidence is proportional to the relative elasticities, and falls more on the less elastic side. Second—which we consider worth stressing—the price change is non-zero since ad valorem taxes do not satisfy strong irrelevance of statutory incidence. Third, for $\alpha \neq 1$, a reform that only shifts the statutory incidence towards the demand side ($d\alpha > 0$ and $d\tau = 0$) increases the supplier price ($\frac{dp_S}{p_S} > 0$) and decreases the consumer price ($\frac{dp_D}{p_D} < 0$). A corollary of this is that—for a given tax rate τ_0—the equilibrium quantity is maximized when the statutory incidence falls fully on the demand side. We return to this in section 4.5 when we discuss additional results.

Economic incidence of a change in the tax rate

Now consider a tax reform that changes the tax rate by $d\tau$ while keeping the statutory incidence unchanged. What will be the effective change in the tax-inclusive prices p_S and p_D? As before, the tax-exclusive price, p, responds to maintain market clearing. Result 3 characterizes this price change.

Result 3 (Tax-exclusive price change due to change in the tax rate)**.** *Consider a tax-reform that changes the tax rate by $d\tau \neq 0$ while keeping the statutory incidence unchanged, i.e. $d\alpha = 0$. Then,*

[4] This result provides empirically testable predictions as described in Appendix B.

the tax-exclusive price changes by

$$\frac{dp}{d\tau}\frac{1}{p} = \frac{\frac{1-\alpha}{1-(1-\alpha)\tau}\varepsilon^S + \frac{\alpha}{1+\alpha\tau}\varepsilon^D}{(\varepsilon^S - \varepsilon^D)}. \tag{8}$$

This result follows from totally differentiating the equilibrium condition $S([1-(1-\alpha)\tau]p) = D((1+\alpha\tau)p)$ with $d\tau \neq 0$ and $d\alpha = 0$. Based on this change in tax-exclusive p, result 4 describes the changes in tax-inclusive prices.

Result 4 (Tax-inclusive price changes due to tax rate changes)**.** *Consider a tax-reform that changes the tax rate by $d\tau \neq 0$ while keeping the statutory incidence unchanged, i.e., $d\alpha = 0$. Then, tax-inclusive prices change by*

$$\frac{dp_S}{d\tau}\frac{1}{p_S} = \frac{1}{[1-(1-\alpha)\tau]\,(1+\alpha\tau)}\frac{\varepsilon^D}{(\varepsilon^S - \varepsilon^D)} \tag{9}$$

$$\frac{dp_D}{d\tau}\frac{1}{p_D} = \frac{1}{[1-(1-\alpha)\tau]\,(1+\alpha\tau)}\frac{\varepsilon^S}{(\varepsilon^S - \varepsilon^D)}. \tag{10}$$

Equations (9) and (10) are similar to the well-established incidence formulas of per unit taxes expressed in equations (1) and (2). In both cases, the economic incidence is proportional to the relative elasticities. Unlike the per unit tax case, however, the statutory incidence (α) matters for the economic incidence through the term $\frac{1}{[1-(1-\alpha)\tau](1+\alpha\tau)}$; this term only drops out when $\tau = 0$ reflecting the *introduction* of a small ad valorem tax. A further distinction—given the proportionate nature of an ad valorem tax—is that the economic incidence is expressed as a relative change. Finally, we note that the ratio of relative price changes, $\left[\frac{dp_S}{p_S}\right] / \left[\frac{dp_D}{p_D}\right] = \frac{\epsilon^D}{\epsilon^S}$, is constant and independent of the statutory incidence and the tax rate. This last result equally applies to the price changes in response to shifts in the statutory incidence in equations (6) and (7).

Economic incidence of simultaneous changes in the tax rate and statutory incidence

Tax policy reforms may simultaneously change the tax rate, τ, and the statutory incidence split between the supply and demand side, α. This is particularly the case for payroll taxes, which we discuss in section 6. What are the expected changes in the tax-inclusive prices p_S and p_D? Again, we first need to consider the change in the tax-exclusive price, p. Since τ and α are both set by the policymaker and do not respond to each other endogenously—i.e., $\frac{\partial\tau}{\partial\alpha} = 0$ and $\frac{\partial\alpha}{\partial\tau} = 0$—the effect of changing both τ and α is the linear combination of changing them in isolation, respectively.

Result 5 (Tax-inclusive price change due to simultaneous changes in the statutory incidence and the tax rate)**.** *Consider a tax reform that simultaneously shifts the statutory incidence by $d\alpha \neq 0$ and the tax rate by $d\tau \neq 0$. Then, the tax-exclusive price changes by*

$$\frac{dp}{p} = \underbrace{\frac{\frac{1-\alpha}{1+(1-\alpha)\tau}\varepsilon^S + \frac{\alpha}{1+\alpha\tau}\varepsilon^D}{\varepsilon^S - \varepsilon^D}d\tau}_{\textit{Effect when changing } \tau \textit{ only}} - \underbrace{\frac{\frac{1}{1+(1-\alpha)\tau}\varepsilon^S + \frac{1}{1+\alpha\tau}\varepsilon^D}{\varepsilon^S - \varepsilon^D}\tau d\alpha}_{\textit{Effect when changing } \alpha \textit{ only}}. \tag{11}$$

The effect on the tax-inclusive prices, p_S and p_D, inherits this additive separable structure.

Result 6 (Tax-inclusive price changes due to statutory incidence shifts and tax rate changes)**.** *Consider a tax reform that simultaneously shifts the statutory incidence by $d\alpha \neq 0$ and the tax rate by $d\tau \neq 0$. Then, the tax-inclusive prices change by*

$$\frac{dp_S}{p_S} = \underbrace{\frac{1}{[1-(1-\alpha)\tau]\,(1+\alpha\tau)} \frac{\varepsilon^D}{(\varepsilon^S - \varepsilon^D)}}_{\leq 0} d\tau + \underbrace{\frac{\tau^2}{(1+\alpha\tau)[1-(1-\alpha)\tau]} \frac{-\varepsilon^D}{(\varepsilon^S - \varepsilon^D)}}_{\geq 0} d\alpha \tag{12}$$

$$\frac{dp_D}{p_D} = \underbrace{\frac{1}{[1-(1-\alpha)\tau]\,(1+\alpha\tau)} \frac{\varepsilon^S}{(\varepsilon^S - \varepsilon^D)}}_{\geq 0} d\tau + \underbrace{\frac{\tau^2}{(1+\alpha\tau)[1-(1-\alpha)\tau]} \frac{-\varepsilon^S}{(\varepsilon^S - \varepsilon^D)}}_{\leq 0} d\alpha. \tag{13}$$

Equations (12) and (13) show that $d\tau$ and $d\alpha$ have opposite effects. This implies that the effects on p_S and p_D will be amplified when τ and α go in the opposite direction (e.g., an increase in the tax rate, $d\tau > 0$, with a simultaneous shift of the statutory incidence towards the supply side, $d\alpha < 0$), and are muted when they have the same signs (e.g., increase in the tax rate, $d\tau > 0$, and shift towards the demand side, $d\alpha > 0$). This further implies that shifts in statutory incidence can be neutral when they are accompanied by corresponding adjustments in the tax rate. We show this weak irrelevance result more formally in section 5.

4.4 Numerical examples of economic incidence

The previous section established two key results: (i) shifts in the statutory incidence while holding the tax rate constant will lead to changes in prices, and (ii) the statutory incidence matters for how prices change in response to changes in the tax rate. The following simulates the magnitude of these effects based on the economic incidence formulas derived in section 4.3.

While these simulations are general, we choose parameters to match the payroll tax context. In the payroll setting, p_S refers to the after-tax wage received by employees, and p_D refers to the per unit of labor costs paid by the employer. A nice feature of the economic incidence formulas is that the only unknowns are the supply and demand elasticities, ε^S and ε^D. We choose these values based on the empirical literature: $\epsilon^S \in [0.1, 0.3]$ (Chetty et al., 2011) and $\epsilon^D \in [-1, -0.01]$ (Lichter et al., 2015).

Simulating economic incidence for a change in statutory incidence

Figure 3 shows price changes, $\frac{dp_S}{p_S}$ and $\frac{dp_D}{p_D}$, in response to a tax reform that shifts the statutory incidence from the supply side ($\alpha = 0$) to the demand side ($d\alpha = 1$) while keeping the tax rate constant (see result 2). This simulation should be thought of as an upper bound to many payroll tax reforms, which tend to involve much smaller shifts in the statutory incidence.[5]

[5] Recent large changes in the statutory incidence have been implemented in Romania (2018) and Lithuania (2019). Changes such as $d\alpha = 1$ or $d\alpha = -1$ can also be found in other settings such as the introduction of digital service taxes on foreign entities, or in the case of Airbnb voluntary compliance agreements (Bibler et al., 2021). However, these changes are often motivated by differential evasion opportunities such that there will be *additional* channels to be considered.

For the interpretation of these price changes, it is worth reiterating that a shift of the statutory incidence from the supply to the demand side while keeping the nominal tax rate τ fixed effectively acts like a decrease in the tax rate under the initial statutory incidence. Panels 3a and 3b depict cases when supply is less elastic than demand. Consequently, the supply side bears a larger share of the economic incidence of the ad valorem tax. When the statutory incidence is shifted onto the demand side, the suppliers benefit proportionally more from the reduction in the effective tax rate. Panels 3c and 3d depict the opposite case when demand is less elastic than supply. The demand side now carries most of the economic incidence. In turn, the demand side benefits the most from the implicit effective tax rate reduction as the statutory incidence is shifted onto the demand side. Note that the nominal tax rate itself is unchanged in all of these simulations and all that changes is the statutory incidence.

What should we make of the magnitudes of the relative price changes? Across combinations of elasticities, the proportional price changes are small for low tax rates. For medium-to-large tax rates, however, the price changes are non-negligible. This has important implications for empirical research: when analyzing a reform with a meaningful shift in the statutory incidence and non-small tax rate, prices are expected to change even in the absence of any optimization frictions like tax salience or differential ability to evade taxes. Additionally, Figure 3 highlights the importance of the relative elasticities for what price changes are to be expected.

Simulating economic incidence for a change in tax rate

Figure 4 shows expected price changes, $\frac{dp_S}{p_S}$ and $\frac{dp_D}{p_D}$, in response to a change in the tax rate. These price changes will depend on the statutory incidence, which we keep constant in the simulations (i.e., $d\alpha = 0$; see result 4). For illustrative purposes, we set $\tau_0 = 0.4$ and consider $d\tau = 0.05$.

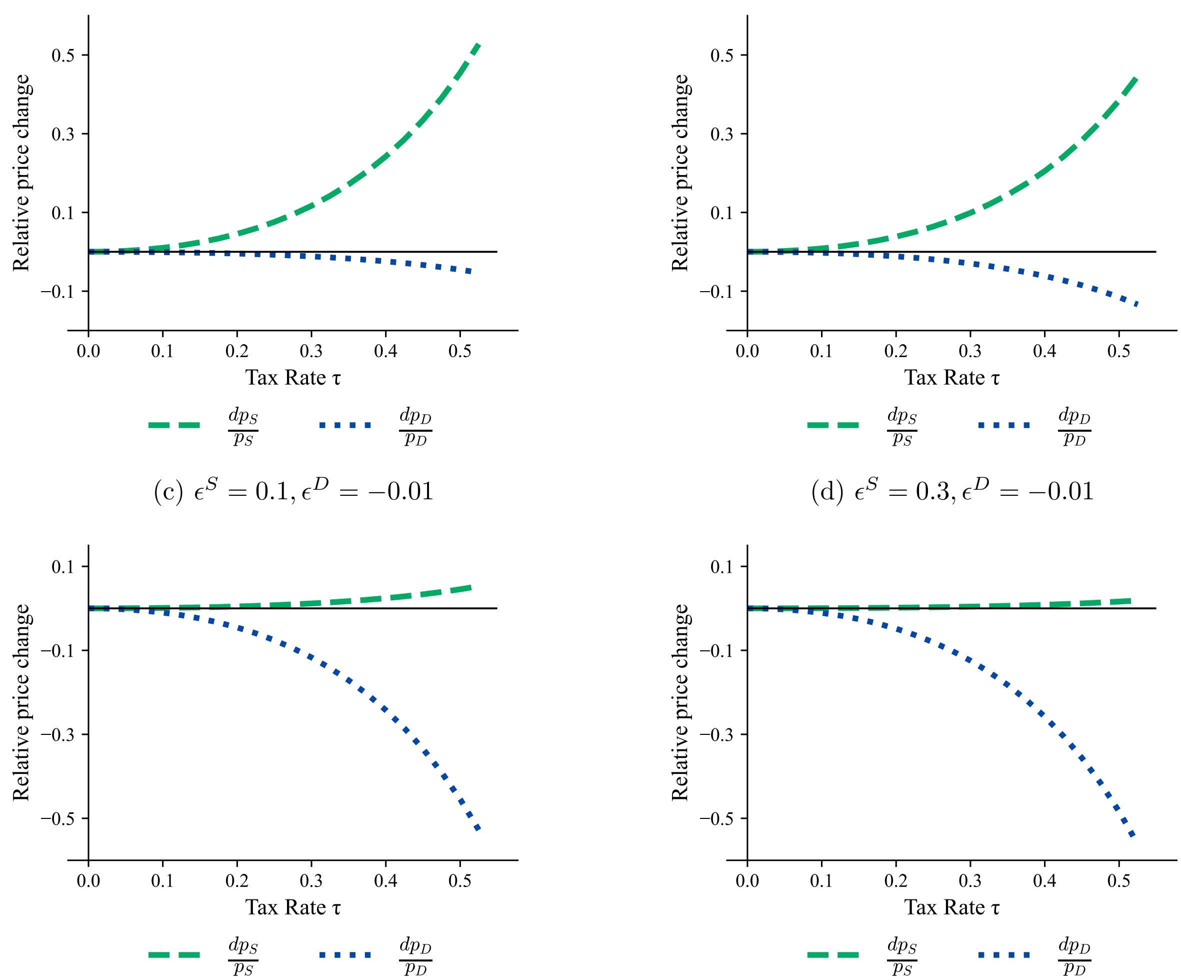
An important lesson of the above theory is that an ad valorem tax rate of τ_0 creates larger distortions when the statutory incidence falls on suppliers than when it falls on buyers. This can be seen across combinations of elasticities in Figure 4: price changes are smaller the larger the statutory incidence share of the demand side (α). As expected, the relative elasticities determine the degree to which suppliers or buyers bear the economic incidence. Panels 4a and 4b show price changes when supply is less elastic than demand. Suppliers face larger price decreases than consumers. Panels 4c and 4d illustrate the opposite case when demand is less elastic than supply. Consumer prices now increase whereas supplier prices remain relatively unchanged.

These simulations reveal that the economic incidence of a nominal change in the tax rate varies significantly between a statutory incidence of $\alpha = 0$ and of $\alpha = 1$. When considering the implementation of a tax rate change of $d\tau$, it is thus important to keep in mind the statutory incidence of the tax.

4.5 Additional results and theoretical extensions

This section provides additional results on the failure of statutory incidence irrelevance. First, we discuss how the statutory incidence of a given tax rate affects the equilibrium quantity and the tax revenue raised. Second, we consider a subsidy instead of a tax. Finally, we introduce a tax salience

Figure 3: Effect of shifting the statutory incidence from the supply to the demand side



(a) $\epsilon^S = 0.1, \epsilon^D = -1$

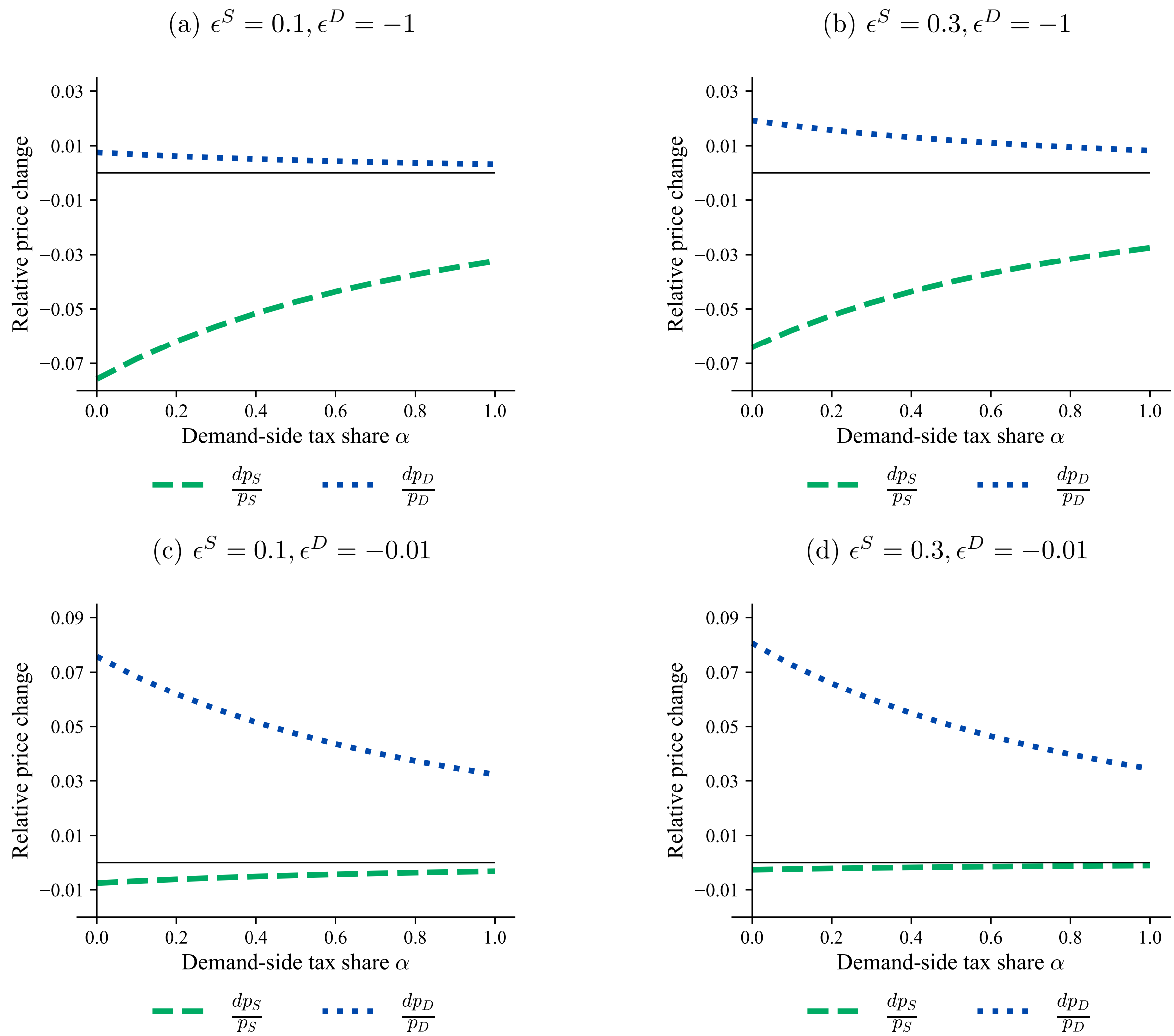
(b) $\epsilon^S = 0.3, \epsilon^D = -1$

(c) $\epsilon^S = 0.1, \epsilon^D = -0.01$

(d) $\epsilon^S = 0.3, \epsilon^D = -0.01$

Notes: This figure shows numerical examples for the effect of changing the demand-side statutory incidence from $\alpha = 0$ to $\alpha = 1$ on relative price changes. Each panel shows the effect on the relative supply-side price change in blue and on the relative demand-side change in green for different levels of the tax rate τ. Panel (a) corresponds to a supply elasticity of 0.1 and a demand elasticity of -1. Panel (b) corresponds to a supply elasticity of 0.3 and a demand elasticity of -1. Panel (c) corresponds to a supply elasticity of 0.1 and a demand elasticity of -0.01. Panel (d) corresponds to a supply elasticity of 0.3 and a demand elasticity of -0.01.

Figure 4: Numerical Examples for Effect of a Change in Tax Rate on Relative Price Changes



Notes: This figure shows numerical examples for the effect of changing the tax rate from 0.4 to 0.45 on relative price changes. Each panel shows the effect on the relative supply-side price change in blue and on the relative demand-side change in green for different levels of the demand-side tax share α. Panel (a) corresponds to a supply elasticity of 0.1 and a demand elasticity of -1. Panel (b) corresponds to a supply elasticity of 0.3 and a demand elasticity of -1. Panel (c) corresponds to a supply elasticity of 0.1 and a demand elasticity of -0.01. Panel (d) corresponds to a supply elasticity of 0.3 and a demand elasticity of -0.01.

term to deviate from the frictionless benchmark case.

Quantity and tax revenue effects of statutory incidence

In the illustrative examples provided above (Figures 1 and 2), the equilibrium quantity increased after moving the statutory incidence from the supply to the demand side. Proposition 3 generalizes this result: for a fixed tax rate, equilibrium quantity is maximized when the statutory incidence falls fully on the demand side. Following the intuition of being levied on a lower tax base (Figure 3), a tax rate of τ_0 is less distortive when levied on the demand side than on the supply side.

Proposition 3 (Quantity maximizing statutory incidence)**.** *The equilibrium quantity, $S(p_S^*) = D(p_D^*)$, of a fixed ad valorem tax rate τ_0 is maximized when the statutory incidence falls fully on the demand side, i.e., $\alpha = 1$. At $\alpha = 1$, the tax-inclusive price for the demand side, p_D, is lowest, while the tax-inclusive price for the supply side, p_S, is highest.*

Proof of proposition 3. This proof follows a perturbation argument. Assume $\alpha \in [0, 1)$ and consider a reform that shifts the incidence towards the demand side, i.e., $d\alpha > 0$. Equations (6) and (7) show that $\frac{dp_S}{p_S} \geq 0$ and $\frac{dp_D}{p_D} \leq 0$. Given upward sloping supply and downward sloping demand curves, this implies that the equilibrium quantity is increasing in α. Appendix A.2 states this more formally. $\square$

Proposition 3 has established that the equilibrium quantity is maximized when $\alpha = 1$. Yet, equation (5) shows that the tax-exclusive price p declines in α. Given these competing effects ($Q \uparrow$ and $p \downarrow$ for $d\alpha > 0$), the effect on total tax revenue is ambiguous. However, one can show that for $\varepsilon^D \geq -1$, tax revenue will be maximized with $\alpha = 0$. Intuitively, for $\varepsilon^D \geq -1$ the quantity increase is too small to offset the decline in the tax-exclusive price when $d\alpha > 0$. We formalize this in proposition 4.

Proposition 4 (Revenue maximizing statutory incidence)**.** *A change in the statutory incidence has ambiguous effects on tax revenue $R = \tau p D = \tau p S$. Specifically, without loss of generality for $d\alpha > 0$,*

$$\frac{dR}{R} = \underbrace{\frac{dp}{p}}_{\leq 0} + \underbrace{\frac{dD}{D}}_{\geq 0}. \tag{14}$$

However, for $d\alpha > 0$, tax revenue unambiguously declines if $\varepsilon^D \geq -1$ as shown (after rewriting) by

$$\frac{dR}{R} = (1 + \varepsilon^D)\frac{dp}{p} + \frac{\tau}{1 + \alpha\tau}\varepsilon^D d\alpha. \tag{15}$$

Proof of proposition 4. For the first part of the proposition, note that $R = \tau p D$ with $d\tau = 0$ implies

$$\begin{aligned} dR &= \tau D dp + \tau p dD \\ &= \tau p D \frac{dp}{p} + \tau p D \frac{dD}{D}. \end{aligned}$$

For $d\alpha \geq 0$, equation (3) shows that $\frac{dp}{p} \leq 0$; proposition 3 establishes $\frac{dD}{D} \geq 0$.

For the second part of the proposition, we begin from $R = \tau p D((1+\alpha\tau)p)$. Totally differentiating this expression with $d\tau = 0$ gives

$$
\begin{aligned}
dR &= \left[\tau D + \tau p \frac{\partial D}{dp_D}(1+\alpha\tau)\right] dp + \tau p \frac{\partial D}{dp_D} \tau p d\alpha \\
&= \left[\tau p D + \tau p D \frac{\partial D}{dp_D}\frac{p_D}{D}\right]\frac{dp}{p} + \tau p D \frac{\partial D}{\partial p_D}\frac{p_D}{D}\frac{p}{p_D} d\alpha,
\end{aligned}
$$

and re-arranging after using $R = \tau p D$ and the definition of ε^D gives (15). □

Statutory incidence and ad valorem subsidies

We consider a change in the statutory incidence of an ad valorem subsidy at rate s. The subsidy inclusive prices are given by $p_D = (1-\alpha s)p$ and $p_S = [1 + (1-\alpha)s]p$. Applying the above derivations with $s = -\tau$, all results from above follow through.

Result 7 (Subsidy-inclusive price changes due to statutory incidence shifts)**.** *Consider a subsidy-reform that shifts the statutory incidence by $d\alpha$ without altering the ad valorem subsidy rate, i.e., $d\tau = 0$. Then, the subsidy-inclusive prices change by*

$$
\frac{dp_S}{p_S} = s d\alpha \frac{s}{(1-\alpha s)[1+(1-\alpha)s]}\frac{-\varepsilon^D}{\varepsilon^S - \varepsilon^D} \tag{16}
$$

$$
\frac{dp_D}{p_D} = s d\alpha \frac{s}{(1-\alpha s)[1+(1-\alpha)s]}\frac{-\varepsilon^S}{\varepsilon^S - \varepsilon^D}. \tag{17}
$$

A shift in the statutory incidence of the subsidy towards the demand side ($d\alpha > 0$) increases the supplier price and decreases the consumer price. The equilibrium quantity is maximized when the subsidy-induced wedge is maximized, which (for fixed subsidy rate s) is achieved by maximizing the subsidy base. Since a subsidy induces an equilibrium in the region where the supply curve lies above the demand curve, $p_S \geq p_D$. Hence, analogous to proposition 3, a fixed subsidy maximizes quantity when it falls on the demand side.

Statutory incidence and salience of ad valorem taxes

This part extends the frictionless framework by introducing behavioral terms, such as reduced tax salience. Motivated by the findings in Chetty et al. (2009), suppose the tax is less salient when the legal incidence falls on the consumer. We model this by adding a behavioral parameter $\theta \in [0,1)$ in the expression of (perceived) tax-inclusive prices:

$$
\begin{aligned}
p_D &= (1+\alpha\theta\tau)p \\
p_S &= [1-(1-\alpha)\tau]p.
\end{aligned}
$$

We view this exercise as instructive because it allows to decompose observed price and incidence changes into two components: (i) the mechanic effect of the statutory incidence channel identified in this paper vs. (ii) behavioral channels due to optimization frictions. Note that θ is isomorphic to alternative interpretations such as a lower compliance rate on the consumer side (e.g., motivated by the evidence in Kopczuk et al., 2016, for diesel taxes). While we assume no friction on the supply side, the analyses can, of course, be extended to feature an analogous parameter on the supply side.

Result 8 characterizes expected price changes in the presence of this demand side friction. The effect of changing the statutory incidence continues to depend on the relative elasticities ($\varepsilon^S, \varepsilon^D$), the initial levels of the statutory incidence (α), and the tax rate (τ). In addition, the initial degree of salience (θ) and possible changes in salience after shifting the incidence influence the change in prices.

Result 8 (Tax-inclusive price changes due to statutory incidence shifts in the presence of demand-side frictions)**.** *Consider a tax-reform that shifts the statutory incidence by $d\alpha$ without altering the ad valorem tax rate, i.e., $d\tau = 0$. Then, the tax-inclusive prices change by*

$$\frac{dp_S}{p_S} = \tau d\alpha \frac{\theta\tau + 1 - \theta}{(1+\alpha\theta\tau)[1-(1-\alpha)\tau]} \frac{-\varepsilon^D}{\varepsilon^S - \varepsilon^D} + \tau d\theta \frac{\alpha}{(1+\alpha\theta\tau)} \frac{\varepsilon^D}{\varepsilon^S - \varepsilon^D} \tag{18}$$

$$\frac{dp_D}{p_D} = \tau d\alpha \frac{\theta\tau + 1 - \theta}{(1+\alpha\theta\tau)[1-(1-\alpha)\tau]} \frac{-\varepsilon^S}{\varepsilon^S - \varepsilon^D} + \tau d\theta \frac{\alpha}{(1+\alpha\theta\tau)} \frac{\varepsilon^S}{\varepsilon^S - \varepsilon^D}. \tag{19}$$

Note that setting $\theta = 1$ and $d\theta = 0$ recovers the frictionless benchmark (result 2). How is the modeled demand-side salience affecting the price changes? Note that $\frac{\theta\tau+1-\theta}{(1+\alpha\theta\tau)[1-(1-\alpha)\tau]}$ is decreasing in θ. Suppose for simplicity that $d\theta = 0$ (i.e., view θ as a policy-invariant, structural parameter). Then, price changes in response to statutory incidence shifts ($d\alpha \neq 0$) are stronger the less salient the tax, i.e., the smaller θ.

5 Restoring weak irrelevance of ad valorem taxes

Section 4 shows that ad valorem taxes do not satisfy the notion of strong irrelevance of statutory incidence (definition 1). One interpretation of this result is that an ad valorem tax of τ_0 levied fully on the supply side is not the same "tax" as an ad valorem tax of τ_0 levied fully on the demand side. From a policy perspective, arguably, what matters is (i) how the tax distorts allocations and (ii) how much revenue the tax generates. This is captured in the notion of weak statutory irrelevance (definition 2): for an ad valorem tax at rate τ_0 on the supply side, is there a rate τ_1 that achieves the exact same outcomes when levied on the demand side?

Proposition 5 demonstrates that ad valorem taxes satisfy weak statutory irrelevance. The intuition behind this result is based on the observation that changes in statutory incidence and tax rates can offset each other (see result 6). For each combination of statutory incidence and tax rate, there exist other combinations of statutory incidence *and* tax rate that result in the same equilibrium prices, quantity, and tax revenue. Both tax regimes are therefore equivalent to the same per unit tax that leads to the corresponding equilibrium.[6]

[6]What do we mean by "same per unit tax"? Consider an ad valorem tax of 20% on the supply side and suppose the consumer pays a total of \$100. Then, the supplier has to pay \$20 in tax and keeps \$80 net-of-tax. Now suppose we shift the ad valorem tax on the demand-side and change the rate to 25%. At the same supplier price, \$80, the consumer now has to pay an additional 25% of tax, or \$20, so that the tax-inclusive payment remains at \$100. This illustrates that the per unit tax is \$20 for either statutory incidence, while the ad valorem tax rate is 20% and 25%, respectively.

Proposition 5. *Ad valorem taxes satisfy weak irrelevance of statutory incidence.*

Proof of proposition 5. Consider tax schedules $\mathcal{T}_0 = (\tau_0, \alpha_0)$ and $\mathcal{T}_1 = (\tau_1, \alpha_1)$ with

$$\begin{aligned}(\tau_0, \alpha_0): \quad & p_D^0 = (1+\alpha_0\tau_0)p^0 \text{ and } p_S^0 = [1-(1-\alpha_0)\tau_0]p^0 \\ (\tau_1, \alpha_1): \quad & p_D^1 = (1+\alpha_1\tau_1)p^1 \text{ and } p_S^1 = [1-(1-\alpha_1)\tau_1]p^1.\end{aligned}$$

Suppose prices are equalized under both regimes, $p_S^0 = p_S^1$ and $p_D^0 = p_D^1$. If this holds, then $\mathcal{T}_0$ and $\mathcal{T}_1$ achieve equal equilibrium quantities. This condition is true for

$$\tau_1 = \frac{\tau_0}{1+(\alpha_0-\alpha_1)\tau_0} = \frac{\tau_0}{1-d\alpha\ \tau_0}. \tag{20}$$

It is left to show that $R_0 = \tau_0 p^0 = R_1 = \tau_1 p^1$. Indeed,

$$\begin{aligned}\tau_0 p^0 &= \tau_1 p^1 \\ \Leftrightarrow \ \tau_0 \frac{p_D^0}{1+\alpha_0\tau_0} &= \tau_1 \frac{p_D^1}{1+\alpha_1\tau_1} \\ \Leftrightarrow \ \frac{1+\alpha_0\tau_0}{1+(\alpha_0-\alpha_1)\tau_0} &= \frac{1+\alpha_0\tau_0}{1+(\alpha_0-\alpha_1)\tau_0},\end{aligned}$$

where the second line substitutes p^0 and p^1, and the third line re-arranges and uses (20) for τ_1. □

For example, suppose τ_0 is fully levied on supply side (i.e., $\tau_S = \tau_0$, $\alpha_0 = 0$). A reform that shifts the tax fully onto the demand side ($d\alpha = 1$) results in the same quantities, prices, and tax revenue when

$$\tau_D = \frac{\tau_S}{1-\tau_S}.$$

Proposition 5 shows that any change in the statutory incidence can be offset by a change in the tax rate (in the frictionless benchmark). Analogously, any change in the tax rate can be offset by a change in the statutory incidence. This result has important implications for policymakers as it extents their options to implement policies that raise or lower tax rates, or leave them unchanged despite shifts in the statutory incidence (in the frictionless benchmark).

6 Application to payroll taxes in OECD countries

Payroll taxes—or social security contributions—are a primary demonstration of the importance of statutory incidence in practice. Payroll taxes are taxes on the earnings of employees to fund various social insurance schemes, such as public pension schemes, health insurance, and disability insurance.[7] In this section, we provide a descriptive characterization of the key implications of the above points among OECD countries. First, we show how the statutory incidence of payroll taxes varies among these countries. We show how the nominal tax rate compares to a normalized, effective tax rate that

[7] The exact programs covered by payroll taxes differ from country to country.

equalizes (or “harmonizes”) the statutory incidence across countries. Second, we analyze changes to the statutory incidence and tax rates over time. We discuss reforms that shifted the statutory incidence or the tax rate, and whether these were effective tax rate increases or decreases.

The following analysis is based on data from the *OECD Taxing Wages* database. We use the average employer and employee social security tax rate for full-time employees at 100% of the average wage.

Tax rates and statutory incidence

The design of payroll taxes differs widely across OECD countries both in terms of the level and coverage of the tax as well as the statutory split between employers and employees. Payroll tax rates ranged from $\tau = 0$ to $\tau = 0.476$ among OECD countries in 2023 (Figure 5a). While the employer bears at least half of the statutory incidence in almost all countries, there remains substantial variation in the employer share (Figure 5b). In very few cases, the statutory incidence is almost entirely on the employee. The overall correlation between the tax rate and the employer share is positive but small (correlation ≈ 0.03 in 2023). In line with this result, Figure 5c does not show any clear relationship between the tax rate and the statutory incidence.

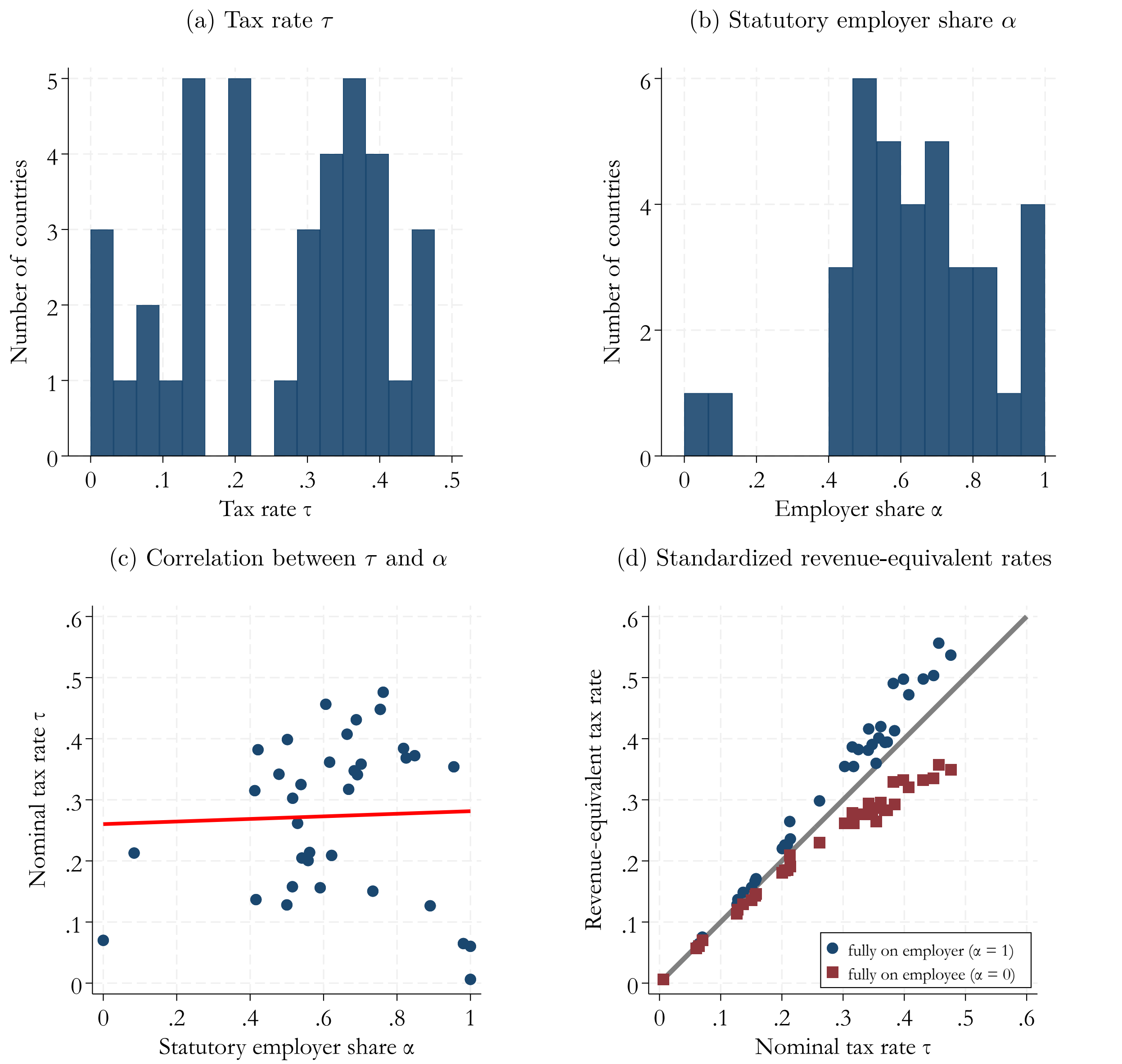
A key theoretical insight is that the effective tax rate depends on the statutory incidence. In particular, we have shown that a nominal ad valorem tax of τ_0 is always more distortive when it falls fully on the buyer ($\alpha = 0$) compared to when it falls on the consumer ($\alpha = 1$). The heterogeneity in statutory incidence across countries implies that it is hard to directly compare nominal tax rates with each other. Instead, one should standardize the tax rate by converting them to a common statutory incidence following equation (20). Figure 5d shows two such revenue-equivalent conversions: if the tax falls fully on the employer ($\alpha = 1$, blue circles) or if the tax falls fully on the employee ($\alpha = 0$, red squares). In line with the notion of “effective tax rate”, the revenue-equivalent tax rate is above the nominal rate when it falls fully on the employer, and is below the nominal rate when it falls fully on the employee.

Changes to tax rates and statutory incidence

Figure C.1 shows the evolution of payroll taxes on employers, $\alpha\tau$, and employees, $(1-\alpha)\tau$, between 2000 and 2023 for each OECD country. Rates are relatively stable in many countries for both employers and employees. In some countries, rates are changing with fairly parallel increases for both employers and employees (e.g., Japan and Korea). A few countries have seen more drastic shifts in their statutory incidence composition. Lithuania, for instance, significantly reduced the statutory incidence on employers in 2019 while raising the statutory incidence on employees.

Figure 6a shows there is no clear trend in year-to-year changes in the relationship between tax rate changes ($d\tau$) and statutory incidence changes ($d\alpha$). Excluding the 2019 reform in Lithuania, between 2001 and 2023, OECD countries implemented changes in statutory incidence ranging from $d\alpha = -0.14$ to $d\alpha = 0.08$. In the same period, tax rates were adjusted between $d\tau = -0.09$ and $d\tau = 0.06$. Figure 6b shows the longer term trends by comparing (τ, α) in 2000 and 2023. While a handful of countries implemented major changes in their statutory incidence composition over this longer period, most

Figure 5: Distribution of payroll tax rates and statutory employer share for OECD countries in 2023

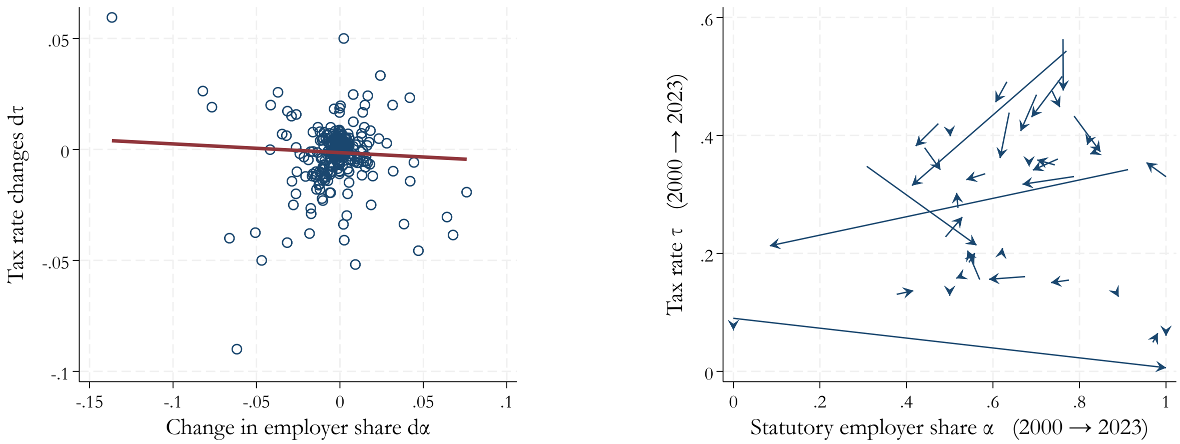


Notes: This figure shows the distribution of tax rates and the statutory incidence of payroll taxes among OECD countries in 2023. Panel (a) displays a histogram of tax rates in 2023. Panel (b) reports a corresponding histogram of statutory incidence (employer share α) in 2023. Panel (c) shows a scatter plot of nominal tax rates and statutory employer shares in 2023. Each dot corresponds to a country, along with a linear regression line in red. Panel (d) shows a scatter plot of nominal tax rates and corresponding revenue-equivalent tax rates. Each blue dot corresponds to a country-year observation with full statutory incidence on the employer side. Each red square corresponds to a country-year observation with full statutory incidence on the employee side. Based on *OECD Taxing Wages* data.

countries have experienced small changes only.

Figure 6: Tax Policy Changes for OECD Countries between 2000-2023

(a) Year-by-year changes $d\tau$ and $d\alpha$ (b) Long-term trends (2023 vs. 2000)



Notes: This figure shows tax policy changes for OECD countries between 2000 and 2023. In Panel (a), each dot represents a country-year pair with a policy change that incorporates changes in the statutory incidence ($d\alpha$) and/or the tax rate ($d\tau$). In Panel (b), each arrow corresponds to the total change in statutory incidence ($d\alpha$) and the tax rate ($d\tau$) between 2002 and 2023. Based on *OECD Taxing Wages* data.

A key implication of our theoretical analysis is that tax reforms that shift the statutory incidence without changing the nominal tax rate act like implicit effective tax rate changes. Has this ever been the case in practice? For example, the statutory incidence of a specific component in Germany's payroll taxes, the so-called "add-on premium" for health insurance, was levied fully on employees ($\alpha = 0$) before 2019. Effective in 2019, the statutory incidence was split between the employer and employee ($d\alpha = 0.5$) without explicit adjustments in the rate.[8] The move towards employers thus implicitly acted like a tax rate reduction, even though policymakers' intention was solely to redistribute the tax burden between employers and employees, without changing the overall burden. In contrast, most economists would not have expected any change in economic incidence, adhering to the conventional view that statutory incidence is irrelevant. Our exposition aims to bridge the gap between policymakers and economists, enhancing their collective understanding of the economic incidence of ad valorem taxes. At around 0.9% in 2019, the level of this payroll tax component is very low, however, and our numerical examples in Figure 3 suggest a limited proportional effect on earnings. Nevertheless, even a small proportional effect can have sizable absolute impact on absolute tax burden in the context of payroll taxes.

7 Conclusion

This paper shows theoretically that the statutory incidence of ad valorem taxes is relevant for economic incidence, absent any frictions and in competitive equilibrium. The classical (or strong) irrelevance of

[8]The add-on premium is set by each insurer individually. The average add-on premium (by the health ministry) was predicted to *decline* by 0.1 percentage points. Note that this decrease is in the opposite direction of the revenue-neutral adjustment; thus the statutory incidence shift *and* predicted average premium reduction reinforce each other.

statutory incidence only holds for per unit taxes or the introduction of an infinitesimal ad valorem tax. For the most common empirical case, a pre-existing ad valorem tax, altering the statutory incidence impacts equilibrium supply and demand prices, which in turn affect overall quantity and tax revenue.

For a given ad valorem tax rate, the equilibrium quantity is maximized when the statutory incidence falls entirely on the demand side. The revenue-maximizing statutory incidence split between the supply and demand side is ex ante ambiguous, but falls on the supply side if the demand elasticity is larger than -1. In this scenario (statutory incidence on the supply side and $\varepsilon^D \geq -1$), quantity is minimized while the tax-exclusive price is maximized, leading to the highest possible tax base and revenue. Thus, depending on the elasticities, the optimal statutory incidence for a *given* tax rate depends on the policy goal, i.e., whether to maximize quantity and minimize deadweight loss or to maximize tax revenue. However, allowing the tax rate to adjust, the same equilibrium and tax revenue can be achieved under different statutory incidences (weak irrelevance).

Our framework can be extended to incorporate, for example, behavioral frictions (tax salience) or ad valorem subsidies. In addition, our findings are both analytically tractable and empirically verifiable, equipping researchers and policymakers with valuable resources to evaluate the effects of tax policies. We present numerical examples to illustrate the potential magnitudes of changes in the statutory incidence channel in the context of payroll taxes, applying commonly used demand and supply elasticities. The predicted magnitude is non-negligible for medium-to-large tax rates. Furthermore, we demonstrate a theoretical relationship between adjustments in the tax rate and statutory incidence that preserves equilibrium, including tax revenue, at a fixed level (weak irrelevance). Consequently, once we allow the tax rate to adjust alongside statutory incidence, the notion of an optimal statutory becomes obsolete in competitive equilibrium and absent any optimization frictions.

Finally, we provide descriptive evidence on the interaction between statutory incidence and nominal payroll tax rates across OECD countries. We can detect neither a clear relationship between the absolute level of the tax rate and statutory incidence nor between changes in the tax rate and statutory incidence, suggesting that the relationship between statutory and economic incidence is usually not leveraged to ensure revenue neutrality in the context of payroll taxes.

Given the significance of our findings for both policymakers and empirical researchers studying the economic incidence of tax policies, we believe our theoretical results open two promising avenues for future research. Firstly, our derivations are empirically testable and should yield unbiased estimates of supply and demand elasticities in competitive equilibrium and absent any optimization frictions. This could allow researchers to decompose empirically observed tax anomalies into a mechanical component—consistent with our theoretical predictions—and a residual component that cannot be accounted for by a canonical model of tax incidence. Secondly, our framework may serve as a foundation for a more complete theory of tax incidence that incorporates, as proposed for example in Benzarti (2024), general equilibrium and dynamic effects, thereby bridging theory and empirics in assessing the relevance of statutory incidence of ad valorem taxes.

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Appendix

A Detailed derivations

A.1 Per unit taxes — detailed derivations

A.1.1 Economic incidence of per unit taxes

We consider the case $d\alpha = 0$ and $dt \neq 0$ for arbitrary $\alpha \in [0, 1]$. We start by totally differentiating the equilibrium condition $S(p - (1-\alpha)t) = D(p + \alpha t)$ and using $p_S = p_D - t$, which results in

$$\begin{aligned}
\frac{\partial S}{\partial p_S}\left[dp - (1-\alpha)dt\right] &= \frac{\partial D}{\partial p_D}\left[dp + \alpha dt\right] \\
\Leftrightarrow \frac{dp}{dt}\left[\frac{\partial S}{\partial p_S} - \frac{\partial D}{\partial p_D}\right] &= \frac{\partial S}{\partial p_S}(1-\alpha) + \frac{\partial D}{\partial p_D}\alpha \\
\Leftrightarrow \frac{dp}{dt} &= \frac{(1-\alpha)\varepsilon^S + \alpha\varepsilon^D - \frac{\partial D}{\partial p_D}\frac{t}{D}}{\varepsilon^S - \varepsilon^D + \frac{\partial D}{\partial p_D}\frac{t}{D}}.
\end{aligned}$$

Setting $t = 0, \alpha = 1$, we derive the classical text book result:

$$\frac{dp}{dt} = \frac{\varepsilon^D}{\varepsilon^S - \varepsilon^D}.$$

However, the effects on p_S and p_D are independent of the statutory incidence: First, consider $p_S = p - (1-\alpha)t$. Totally differentiating both sides yields:

$$\begin{aligned}
dp_S &= dp - (1-\alpha)dt \\
\Leftrightarrow \frac{dps}{dt} &= \frac{\varepsilon^D - \frac{\partial D}{\partial p_D}\frac{t}{D}}{\varepsilon^S - \varepsilon^D + \frac{\partial D}{\partial p_D}\frac{t}{D}}.
\end{aligned}$$

Similarly, we totally differentiate $p_D = p_S + t$, yielding:

$$\frac{dp_D}{dt} = \frac{\varepsilon^S}{\varepsilon^S - \varepsilon^D + \frac{\partial D}{\partial p_D}\frac{t}{D}}.$$

Both yield the classical textbook result for $t = 0$.

A.1.2 Effect of simultaneous changes in tax rate and statutory incidence

We start by totally differentiating the equilibrium condition $S(p-(1-\alpha)t) = D(p+\alpha t)$ and using $p_S = p_D - t$, which results in

$$\begin{aligned}
\frac{\partial S}{\partial p_S}\left[dp - (1-\alpha)dt + td\alpha\right] &= \frac{\partial D}{\partial p_D}\left[dp + d\alpha t + \alpha dt\right] \\
\Leftrightarrow \frac{dp}{dt}\left[\frac{\partial S}{\partial p_S} - \frac{\partial D}{\partial p_D}\right] + \frac{d\alpha t}{dt}\left[\frac{\partial S}{\partial p_S} - \frac{\partial D}{\partial p_D}\right] &= \frac{\partial S}{\partial p_S}(1-\alpha) + \frac{\partial D}{\partial p_D}\alpha \\
\Leftrightarrow \frac{dp}{dt} &= -\frac{d\alpha t}{dt} + \frac{(1-\alpha)\varepsilon^S + \alpha\varepsilon^D - \frac{\partial D}{\partial p_D}\frac{t}{D}}{\varepsilon^S - \varepsilon^D + \frac{\partial D}{\partial p_D}\frac{t}{D}}.
\end{aligned}$$

Again, the effects on p_S and p_D are independent of the statutory incidence: First, consider $p_S = p-(1-\alpha)t$. Totally differentiating both sides yields:

$$\begin{aligned}
dp_S &= dp - (1-\alpha)dt + td\alpha \\
\Leftrightarrow \frac{dps}{dt} &= \frac{\varepsilon^D - \frac{\partial D}{\partial p_D}\frac{t}{D}}{\varepsilon^S - \varepsilon^D + \frac{\partial D}{\partial p_D}\frac{t}{D}}.
\end{aligned}$$

Similarly, we totally differentiate $p_D = p_S + t$, yielding:

$$\frac{dp_D}{dt} = \frac{\varepsilon^S}{\varepsilon^S - \varepsilon^D + \frac{\partial D}{\partial p_D}\frac{t}{D}}.$$

A.2 Ad valorem taxes — detailed derivations

A.2.1 Details on the effects of a change in statutory incidence only

Derivation of result 1. We start by totally differentiating the equilibrium condition $S([1-(1-\alpha)\tau]p) = D((1+\alpha\tau)p)$, which results in

$$\begin{aligned}
\frac{\partial S}{\partial p_S}\left[[1-(1-\alpha)\tau]dp + \tau p d\alpha\right] &= \frac{\partial D}{\partial p_D}\left[(1+\alpha\tau)dp + \tau p d\alpha\right] \\
\Leftrightarrow \frac{\partial S}{\partial p_S}\left[[1-(1-\alpha)\tau]\frac{dp}{d\alpha} + \tau p\right] &= \frac{\partial D}{\partial p_D}\left[(1+\alpha\tau)\frac{dp}{d\alpha} + \tau p\right] \\
\Leftrightarrow \frac{dp}{d\alpha}\left[[1-(1-\alpha)\tau]\frac{\partial S}{\partial p_S} - [1+\alpha\tau]\frac{\partial D}{\partial p_D}\right] &= -\tau\left[\frac{\partial S}{\partial p_S}p - \frac{\partial D}{\partial p_D}p\right].
\end{aligned}$$

Using the fact that $S = D$ in equilibrium, we can write

$$\frac{dp}{d\alpha}\left[[1-(1-\alpha)\tau]\frac{\partial S}{\partial p_S}\frac{p_S}{S}\frac{1}{p_S} - [1+\alpha\tau]\frac{\partial D}{\partial p_D}\frac{p_D}{D}\frac{1}{p_D}\right] = -\tau\left[\frac{\partial S}{\partial p_S}\frac{p_S}{S}\frac{1}{p_S}p - \frac{\partial D}{\partial p_D}\frac{p_D}{D}\frac{1}{p_D}p\right],$$

which given the definition of ε^S and ε^D simplifies to

$$\frac{dp}{d\alpha}\left[\frac{1-(1-\alpha)\tau}{p_S}\varepsilon^S - \frac{1+\alpha\tau}{p_D}\varepsilon^D\right] = -\tau\left[\varepsilon^S\frac{p}{p_S} - \varepsilon^D\frac{p}{p_D}\right].$$

Using the relationship between p_D, p_S and p, this further simplifies to

$$\frac{dp}{d\alpha}\frac{1}{p}\left(\varepsilon^S - \varepsilon^D\right) = -\tau\left[\frac{\varepsilon^S}{1-(1-\alpha)\tau} - \frac{\varepsilon^D}{1+\alpha\tau}\right].$$

Re-arranging gives result 1. □

Derivation of result 2. First, let us consider $p_S = [1-(1-\alpha)\tau]p$. Totally differentiating and holding τ constant, we obtain

$$\begin{aligned} dp_S &= [1-(1-\alpha)\tau]dp + \tau p d\alpha \\ \Leftrightarrow \frac{dp_S}{p_S} &= \frac{1-(1-\alpha)\tau}{p_S}dp + \tau\frac{p}{p_S}d\alpha \\ &= \frac{dp}{p} + \tau d\alpha\frac{1}{1-(1-\alpha)\tau}. \end{aligned}$$

Plugging in (5) for $\frac{dp}{p}$, we obtain

$$\begin{aligned} \frac{dp_S}{p_S} &= \tau d\alpha\left[\frac{-\frac{\varepsilon^S}{1-(1-\alpha)\tau} + \frac{\varepsilon^D}{1+\alpha\tau}}{\varepsilon^S - \varepsilon^D} + \frac{1}{1-(1-\alpha)\tau}\right] \\ &= \tau d\alpha\left[\frac{-\varepsilon^S + \frac{1-(1-\alpha)\tau}{1+\alpha\tau}\varepsilon^D + \varepsilon^S - \varepsilon^D}{[1-(1-\alpha)\tau](\varepsilon^S - \varepsilon^D)}\right]. \end{aligned}$$

Further simplifying gives (6).

Second, let us consider $p_D = (1+\alpha\tau)p$. Totally differentiating and holding τ constant, we obtain

$$\begin{aligned} dp_D &= (1+\alpha\tau)dp + \tau p d\alpha \\ \Leftrightarrow \frac{dp_D}{p_D} &= \frac{1+\alpha\tau}{p_D}dp + \tau\frac{p}{p_D}d\alpha \\ &= \frac{dp}{p} + \frac{1}{1+\alpha\tau}\tau d\alpha \\ &= -\tau d\alpha\left[\frac{\frac{\varepsilon^S}{1-(1-\alpha)\tau} - \frac{\varepsilon^D}{1+\alpha\tau}}{\varepsilon^S - \varepsilon^D} - \frac{1}{1+\alpha\tau}\right] \\ &= -\tau d\alpha\left[\frac{\frac{1+\alpha\tau}{1-(1-\alpha)\tau}\varepsilon^S - \varepsilon^D - \varepsilon^S + \varepsilon^D}{(1+\alpha\tau)(\varepsilon^S - \varepsilon^D)}\right]. \end{aligned}$$

Further simplifying gives (7). □

Extended proof of proposition 3. This proof uses a perturbation argument. Assume $\alpha \in [0, 1)$ and consider a reform that shifts the incidence towards the demand side, i.e., $d\alpha > 0$. Equations (6) and (7) show that $\frac{dp_S}{p_S} \geq 0$ and $\frac{dp_D}{p_D} \leq 0$. Given upward sloping supply and downward sloping demand curves, this implies that the equilibrium quantity is increasing in α.

More formally, let us first totally differentiate $D((1 + \alpha\tau)p)$, holding τ fixed and using (1),

$$
\begin{aligned}
dD^* &= \frac{\partial D}{\partial p_D}\left[(1+\alpha\tau)dp + \tau p d\alpha\right] \\
&\propto \frac{\partial D}{\partial p_D}\left[(1+\alpha\tau)\frac{dp}{p} + \tau d\alpha\right] \\
&= \frac{\partial D}{\partial p_D}\left[\tau\alpha\left(1 - \frac{\frac{1+\alpha\tau}{1-(1-\alpha)\tau}\varepsilon^S - \varepsilon^D}{\varepsilon^S - \varepsilon^D}\right)\right] \\
&= d\alpha\left(-\frac{\partial D}{\partial p_D}\right)\frac{\tau^2}{1-(1-\alpha)\tau}\frac{-\varepsilon^S}{\varepsilon^S - \varepsilon^D} \\
&= d\alpha\frac{\tau}{(1+\alpha\tau)}\frac{\tau}{[1-(1-\alpha)\tau]}\frac{Q^*}{p}\frac{\varepsilon^S * (-\varepsilon^D)}{\varepsilon^S - \varepsilon^D} \\
&\geq 0.
\end{aligned}
$$

Next, we consider $S([1 - (1 - \alpha)\tau]p)$, which gives

$$
\begin{aligned}
dS^* &= \frac{\partial S}{\partial p_S}\left[[1-(1-\alpha)\tau]dp + \tau p d\alpha\right] \\
&\propto \frac{\partial S}{\partial p_S}\left[[1-(1-\alpha)\tau]\frac{dp}{p} + \tau d\alpha\right] \\
&= \frac{\partial S}{\partial p_S}\left[\tau d\alpha\left(1 - \frac{\varepsilon^S - \frac{1-(1-\alpha)\tau}{1+\alpha\tau}\varepsilon^D}{\varepsilon^S - \varepsilon^D}\right)\right] \\
&= \tau^2 d\alpha\frac{\partial S}{\partial p_S}\frac{1}{1+\alpha\tau}\frac{-\varepsilon^D}{\varepsilon^S - \varepsilon^D} \\
&= d\alpha\frac{\tau}{(1+\alpha\tau)}\frac{\tau}{[1-(1-\alpha)\tau]}\frac{Q^*}{p}\frac{\varepsilon^S * (-\varepsilon^D)}{\varepsilon^S - \varepsilon^D} \\
&\geq 0.
\end{aligned}
$$

□

A.2.2 Details on change in tax rate only

Derivation of result 3. We start by totally differentiating the equilibrium condition $S([1-(1-\alpha)\tau]p) = D((1 + \alpha\tau)p)$ with $d\alpha = 0$ & $d\tau \neq 0$, allowing for endogenous response in p (market clearing), which results in

$$\begin{aligned}
\frac{\partial S}{\partial p_S}\left[1-(1-\alpha)\tau\right]dp-(1-\alpha)pd\tau] &= \frac{\partial D}{\partial p_D}\left[(1+\alpha\tau)dp+\alpha pd\tau\right] \\
\Leftrightarrow \frac{\partial S}{\partial p_S}\left[1-(1-\alpha)\tau\right]\frac{dp}{d\tau}-(1-\alpha)p\bigg] &= \frac{\partial D}{\partial p_D}\left[(1+\alpha\tau)\frac{dp}{d\tau}+\alpha p\right] \\
\Leftrightarrow \frac{\partial S}{\partial p_S}\left[\frac{p_S}{p}\frac{dp}{d\tau}-(1-\alpha)p\right] &= \frac{\partial D}{\partial p_D}\left[\frac{p_D}{p}\frac{dp}{d\tau}+\alpha p\right] \\
\Leftrightarrow \frac{dp}{p}\frac{1}{d\tau}\left[\frac{\partial S}{\partial p_S}p_S-\frac{\partial D}{\partial p_D}p_D\right] &= (1-\alpha)\frac{\partial S}{\partial p_S}p+\alpha\frac{\partial D}{\partial p_D}p.
\end{aligned}$$

Using the fact that $S=D$ in equilibrium, and the definition of ε^S and ε^D simplifies to

$$\frac{dp}{p}\frac{1}{d\tau}\left(\varepsilon^S-\varepsilon^D\right)=(1-\alpha)\varepsilon^S\frac{p}{p_S}+\alpha\varepsilon^D\frac{p}{p_D}.$$

Using the relationship between p_D, p_S and p, this further simplifies to

$$\frac{dp}{d\tau}\frac{1}{p}=\frac{\frac{1-\alpha}{1-(1-\alpha)\tau}\varepsilon^S+\frac{\alpha}{1+\alpha\tau}\varepsilon^D}{(\varepsilon^S-\varepsilon^D)}.$$

□

Derivation of result 4. First, we derive the tax-inclusive prices. Let us consider $p_S=[1-(1-\alpha)\tau]p$. Totally differentiating and holding α constant, we obtain

$$\begin{aligned}
dp_S &= [1-(1-\alpha)\tau]dp-(1-\alpha)pd\tau \\
\Leftrightarrow \frac{dp_S}{d\tau}\frac{1}{p_S} &= \frac{1-(1-\alpha)\tau}{p_S}\frac{dp}{d\tau}-(1-\alpha)\frac{p}{p_S} \\
&= \frac{dp}{d\tau}\frac{1}{p}-\frac{1-\alpha}{1-(1-\alpha)\tau} \\
&= \frac{\frac{1-\alpha}{1-(1-\alpha)\tau}\varepsilon^S+\frac{\alpha}{1+\alpha\tau}\varepsilon^D}{(\varepsilon^S-\varepsilon^D)}-\frac{1-\alpha}{1-(1-\alpha)\tau} \\
&= \frac{1}{[1-(1-\alpha)\tau]\,(1+\alpha\tau)}\frac{\varepsilon^D}{(\varepsilon^S-\varepsilon^D)}.
\end{aligned}$$

Second, we consider $p_D=[1+\alpha\tau]p$. Totally differentiating and holding α constant, we obtain

$$
\begin{aligned}
dp_D &= [1+\alpha\tau]dp + \alpha p d\tau \\
\Leftrightarrow \frac{dp_D}{d\tau}\frac{1}{p_D} &= \frac{1D\alpha\tau}{p_D}\frac{dp}{d\tau} + \alpha\frac{p}{p_D} \\
&= \frac{dp}{d\tau}\frac{1}{p} + \frac{\alpha}{1+\alpha\tau} \\
&= \frac{\frac{1-\alpha}{1-(1-\alpha)\tau}\varepsilon^S + \frac{\alpha}{1+\alpha\tau}\varepsilon^D}{(\varepsilon^S - \varepsilon^D)} + \frac{\alpha}{1+\alpha\tau} \\
&= \frac{1}{[1-(1-\alpha)\tau]\,(1+\alpha\tau)}\frac{\varepsilon^S}{(\varepsilon^S-\varepsilon^D)}.
\end{aligned}
$$

□

A.2.3 Details on simultaneous changes in tax rate and statutory incidence of ad valorem taxes

Derivation of result 5. We consider the case $d\alpha = 0$ & $d\tau = 0$. We start by totally differentiating the equilibrium condition $S([1-(1-\alpha)\tau]p) = D((1+\alpha\tau)p)$, allowing for endogenous response in p (market clearing).

$$
\begin{aligned}
&\frac{\partial S}{\partial p_S}\left[[1-(1-\alpha)\tau]dp - (1-\alpha)pd\tau + \tau p d\alpha\right] = \frac{\partial D}{\partial p_D}\left[(1+\alpha\tau)dp + \alpha p d\tau + \tau p d\alpha\right] \\
&\Leftrightarrow \frac{dp}{p}\left[\frac{\partial S}{\partial p_S}[1-(1-\alpha)\tau] - \frac{\partial D}{\partial p_D}(1+\alpha\tau)\right] = \left[\frac{\partial D}{\partial p_D}\alpha + \frac{\partial S}{\partial p_S}(1-\alpha)\right]d\tau + \left[\frac{\partial D}{\partial p_D} - \frac{\partial S}{\partial p_S}\right]\tau d\alpha \\
&\Leftrightarrow \frac{dp}{p}\left[\frac{\partial S}{\partial p_S}\frac{p_S}{p} - \frac{\partial D}{\partial p_D}\frac{p_D}{p}\right] = \left[\frac{\partial D}{\partial p_D}\alpha + \frac{\partial S}{\partial p_S}(1-\alpha)\right]d\tau + \left[\frac{\partial D}{\partial p_D} - \frac{\partial S}{\partial p_S}\right]\tau d\alpha \\
&\Leftrightarrow \frac{dp}{p}\left[\varepsilon^S - \varepsilon^D\right] = \left[\frac{\partial D}{\partial p_D}\frac{p}{D}\alpha + \frac{\partial S}{\partial p_S}\frac{p}{S}(1-\alpha)\right]d\tau + \left[\frac{\partial D}{\partial p_D}\frac{p}{D} - \frac{\partial S}{\partial p_S}\frac{p}{S}\right]\tau d\alpha \\
&\Leftrightarrow \frac{dp}{p}\left[\varepsilon^S - \varepsilon^D\right] = \left[\frac{\alpha}{1+\alpha\tau}\varepsilon^D + \frac{1-\alpha}{1+(1-\alpha)\tau}\varepsilon^S\right]d\tau + \left[\frac{1}{1+\alpha\tau}\varepsilon^D + \frac{1}{1+(1-\alpha)\tau}\varepsilon^S\right]\tau
\end{aligned}
$$

$$
\frac{dp}{p} = \underbrace{\frac{\frac{\alpha}{1+\alpha\tau}\varepsilon^D + \frac{1-\alpha}{1+(1-\alpha)\tau}\varepsilon^S}{\varepsilon^S - \varepsilon^D}d\tau}_{\text{Effect when changing } \tau \text{ only}} - \underbrace{\frac{\frac{1}{1+(1-\alpha)\tau}\varepsilon^S - \frac{1}{1+\alpha\tau}\varepsilon^D}{\varepsilon^S - \varepsilon^D}\tau d\alpha}_{\text{Effect when changing } \alpha \text{ only}}
$$

□

Derivation of result 6. Next, we derive the tax-inclusive prices. First, let us consider $p_S = [1-(1-\alpha)\tau]p$. Totally differentiating, we obtain

$$
\begin{aligned}
&dp_S = [1-(1-\alpha)\tau]dp - (1-\alpha)pd\tau + \tau pd\alpha \\
\Leftrightarrow\ &\frac{dp_S}{p_S} = \frac{dp}{p} - \frac{1-\alpha}{[1-(1-\alpha)\tau]}d\tau + \frac{\tau}{1-(1-\alpha)\tau}d\alpha \\
\Leftrightarrow\ &\frac{dp_S}{p_S} = \frac{1}{[1-(1-\alpha)\tau]\,(1+\alpha\tau)}\frac{\varepsilon^D}{(\varepsilon^S-\varepsilon^D)}d\tau + \frac{\tau^2}{(1+\alpha\tau)[1-(1-\alpha)\tau]}\frac{-\varepsilon^D}{(\varepsilon^S-\varepsilon^D)}d\alpha
\end{aligned}
$$

Second, we consider $p_D = [1+\alpha\tau]p$. Totally differentiating, we obtain

$$
\begin{aligned}
&dp_D = [1+\alpha\tau]dp + \alpha pd\tau + \tau pd\alpha \\
\Leftrightarrow\ &\frac{dp_D}{p_D} = \frac{dp}{p} + \frac{\alpha}{[1+\alpha\tau]}d\tau + \frac{\tau}{1+\alpha\tau}d\alpha \\
\Leftrightarrow\ &\frac{dp_D}{p_D} = \frac{1}{[1-(1-\alpha)\tau]\,(1+\alpha\tau)}\frac{\varepsilon^S}{(\varepsilon^S-\varepsilon^D)}d\tau - \frac{\tau^2}{(1+\alpha\tau)[1-(1-\alpha)\tau]}\frac{-\varepsilon^S}{(\varepsilon^S-\varepsilon^D)}d\alpha
\end{aligned}
$$

$\square$

A.3 Closed form illustration of ad valorem relevance result

The previous derivations suggest post-tax wages for employees, $\tilde{w}$, are higher when the statutory incidence falls on the employer, while the employer's post-tax labor cost per unit, $\hat{w}$, are lower simultaneously. We illustrate this here for an economy with a unit mass of identical households and a representative firm, assuming simple functional forms for the households' utility and the firm's production function.

Optimization problems. Specifically, assume households solve the following optimization problem.

$$\max_{l} \tilde{w}l - \frac{l^{1+\frac{1}{\sigma}}}{1+\frac{1}{\sigma}}$$

This gives an aggregate labor supply of $L^S(\tilde{w}) = \tilde{w}^\sigma$. Further, assume the representative firm demands labor according to the following profit maximization problem.

$$\max_{L} L^{1-\beta} - \hat{w}L$$

This results in an aggregate labor demand of $L^D(\hat{w}) = (1-\beta)^{\frac{1}{\beta}}\hat{w}^{-\frac{1}{\beta}}$.

Statutory incidence on the employee. We first consider the case of $\alpha = 0$. Then, $\tilde{w} = (1-\tau)w$ and $\hat{w} = w$. In equilibrium, the wage rate w adjusts such that $L^D = L^S$. Solving for this, we obtain

$$\begin{aligned}
w &= (1-\beta)^{\frac{1}{1+\sigma\beta}}(1-\tau)^{-\frac{\sigma\beta}{1+\sigma\beta}} \\
\tilde{w} &= (1-\beta)^{\frac{1}{1+\sigma\beta}}(1-\tau)^{\frac{1}{1+\sigma\beta}} \\
\hat{w} &= w
\end{aligned}$$

Statutory incidence on the employer. Next, we consider the case of $\alpha = 1$. Then, $\tilde{w} = w$ and $\hat{w} = (1+\tau)w$. Again, the wage rate w adjusts such that $L^D = L^S$. Thus, we obtain

$$\begin{aligned}
w &= (1-\beta)^{\frac{1}{1+\sigma\beta}}(1+\tau)^{-\frac{1}{1+\sigma\beta}} \\
\tilde{w} &= w \\
\hat{w} &= (1-\beta)^{\frac{1}{1+\sigma\beta}}(1+\tau)^{\frac{\sigma\beta}{1+\sigma\beta}}
\end{aligned}$$

Comparison of statutory incidence regimes. Given the results above, we confirm that $\tilde{w}_{\alpha=0} < \tilde{w}_{\alpha=1}$ and $\hat{w}_{\alpha=0} > \hat{w}_{\alpha=1}$ for any $\tau > 0$ independent of σ and β. That is, workers earn more post-taxes per unit of labor supplied when the statutory incidence falls on the employer. Employers, on the other hand, face lower post-tax labor costs per unit when the statutory incidence falls on the employee. Moreover, since the amount of labor employed in equilibrium is increasing in $\tilde{w}$, employment and output are higher when the nominal incidence falls on the employer.

A.4 Ad valorem taxes extensions — detailed derivations

A.4.1 Details on change in statutory incidence of ad valorem subsidies

Derivation of result 7. We start by totally differentiating the equilibrium condition $S([1+(1-\alpha)\tau]p) = D((1-\alpha\tau)p)$, which results in

$$\begin{aligned}
\frac{\partial S}{\partial p_S}\left[[1+(1-\alpha)\tau]dp - \tau p d\alpha\right] &= \frac{\partial D}{\partial p_D}\left[(1-\alpha\tau)dp - \tau p d\alpha\right] \\
\Leftrightarrow \frac{\partial S}{\partial p_S}\left[[1+(1-\alpha)\tau]\frac{dp}{d\alpha} - \tau p\right] &= \frac{\partial D}{\partial p_D}\left[(1-\alpha\tau)\frac{dp}{d\alpha} - \tau p\right] \\
\Leftrightarrow \frac{dp}{d\alpha}\left[[1+(1-\alpha)\tau]\frac{\partial S}{\partial p_S} - (1-\alpha\tau)\frac{\partial D}{\partial p_D}\right] &= \tau\left[\frac{\partial S}{\partial p_S}p - \frac{\partial D}{\partial p_D}p\right].
\end{aligned}$$

Using the fact that $S = D$ in equilibrium, we can write

$$\frac{dp}{d\alpha}\left[[1+(1-\alpha)\tau]\frac{\partial S}{\partial p_S}\frac{p_S}{S}\frac{1}{p_S} - (1-\alpha\tau)\frac{\partial D}{\partial p_D}\frac{p_D}{D}\frac{1}{p_D}\right] = \tau\left[\frac{\partial S}{\partial p_S}\frac{p_S}{S}\frac{1}{p_S}p - \frac{\partial D}{\partial p_D}\frac{p_D}{D}\frac{1}{p_D}p\right],$$

which given the definition of ε^S and ε^D simplifies to

$$\frac{dp}{d\alpha}\left[\frac{1+(1-\alpha)\tau}{p_S}\varepsilon^S - \frac{1-\alpha\tau}{p_D}\varepsilon^D\right] = \tau\left[\varepsilon^S\frac{p}{p_S} - \varepsilon^D\frac{p}{p_D}\right].$$

Using the relationship between p_D, p_S and p, this further simplifies to

$$\begin{aligned}
\frac{dp}{d\alpha}\frac{1}{p}\left(\varepsilon^S - \varepsilon^D\right) &= \tau\left[\frac{\varepsilon^S}{1+(1-\alpha)\tau} - \frac{\varepsilon^D}{1-\alpha\tau}\right] \\
\Leftrightarrow \frac{dp}{p} &= d\alpha\frac{\tau\left[\frac{\varepsilon^S}{1+(1-\alpha)\tau} - \frac{\varepsilon^D}{1-\alpha\tau}\right]}{(\varepsilon^S - \varepsilon^D)}.
\end{aligned}$$

Next, let us consider $p_S = [1+(1-\alpha)\tau]p$. Totally differentiating and holding τ constant, we obtain

$$\begin{aligned}
dp_S &= [1+(1-\alpha)\tau]dp - \tau p d\alpha \\
\Leftrightarrow \frac{dp_S}{p_S} &= \frac{1+(1-\alpha)\tau}{p_S}dp - \tau\frac{p}{p_S}d\alpha \\
&= \frac{dp}{p} - \tau d\alpha\frac{1}{1+(1-\alpha)\tau}.
\end{aligned}$$

Plugging in for $\frac{dp}{p}$, we obtain

$$\begin{aligned}
\frac{dp_S}{p_S} &= \tau d\alpha\left[\frac{\frac{\varepsilon^S}{1+(1-\alpha)\tau} - \frac{\varepsilon^D}{1-\alpha\tau}}{\varepsilon^S - \varepsilon^D} - \frac{1}{1+(1-\alpha)\tau}\right] \\
&= \tau d\alpha\left[\frac{\varepsilon^S - \frac{1+(1-\alpha)\tau}{1-\alpha\tau}\varepsilon^D - \varepsilon^S + \varepsilon^D}{[1+(1-\alpha)\tau](\varepsilon^S - \varepsilon^D)}\right].
\end{aligned}$$

Further simplifying gives (16).

Next, let us consider $p_D = (1-\alpha\tau)p$. Totally differentiating and holding τ constant, we obtain

$$\begin{aligned}
dp_D &= (1-\alpha\tau)dp - \tau p d\alpha \\
\Leftrightarrow \frac{dp_D}{p_D} &= \frac{1-\alpha\tau}{p_D}dp - \tau\frac{p}{p_D}d\alpha \\
&= \frac{dp}{p} - \frac{1}{1-\alpha\tau}\tau d\alpha \\
&= \tau d\alpha\left[\frac{\frac{\varepsilon^S}{1+(1-\alpha)\tau} - \frac{\varepsilon^D}{1-\alpha\tau}}{\varepsilon^S - \varepsilon^D} - \frac{1}{1-\alpha\tau}\right] \\
&= \tau d\alpha\left[\frac{\frac{1-\alpha\tau}{1+(1-\alpha)\tau}\varepsilon^S - \varepsilon^D - \varepsilon^S + \varepsilon^D}{(1-\alpha\tau)(\varepsilon^S - \varepsilon^D)}\right].
\end{aligned}$$

Further simplifying gives (17). □

A.4.2 Details on change in statutory incidence of ad valorem taxes with imperfect salience

Derivation of result 8. We start by totally differentiating the equilibrium condition $S([1-(1-\alpha)\tau]p) = D((1+\alpha\theta\tau)p)$, which results in

$$\begin{aligned}
\frac{\partial S}{\partial p_S}\left[[1-(1-\alpha)\tau]dp + \tau p d\alpha\right] &= \frac{\partial D}{\partial p_D}\left[(1+\alpha\theta\tau)dp + \theta\tau p d\alpha + \alpha\tau p d\theta\right] \\
\Leftrightarrow \frac{\partial S}{\partial p_S}\left[[1-(1-\alpha)\tau]\frac{dp}{d\alpha} + \tau p\right] &= \frac{\partial D}{\partial p_D}\left[(1+\alpha\theta\tau)\frac{dp}{d\alpha} + \theta\tau p + \alpha\tau p\frac{d\theta}{d\alpha}\right] \\
\Leftrightarrow \frac{dp}{d\alpha}\left[[1-(1-\alpha)\tau]\frac{\partial S}{\partial p_S} - [1+\alpha\theta\tau]\frac{\partial D}{\partial p_D}\right] &= -\tau\left[\frac{\partial S}{\partial p_S}p - \frac{\partial D}{\partial p_D}p\left(\theta + \alpha\frac{d\theta}{d\alpha}\right)\right].
\end{aligned}$$

Using the fact that $S = D$ in equilibrium, we can write

$$\frac{dp}{d\alpha}\left[[1-(1-\alpha)\tau]\frac{\partial S}{\partial p_S}\frac{p_S}{S}\frac{1}{p_S} - [1+\alpha\theta\tau]\frac{\partial D}{\partial p_D}\frac{p_D}{D}\frac{1}{p_D}\right] = -\tau\left[\frac{\partial S}{\partial p_S}\frac{p_S}{S}\frac{1}{p_S}p - \frac{\partial D}{\partial p_D}\frac{p_D}{D}\frac{1}{p_D}p\left(\theta + \alpha\frac{d\theta}{d\alpha}\right)\right],$$

which given the definition of ε^S and ε^D simplifies to

$$\frac{dp}{d\alpha}\left[\frac{1-(1-\alpha)\tau}{p_S}\varepsilon^S - \frac{1+\alpha\theta\tau}{p_D}\varepsilon^D\right] = -\tau\left[\varepsilon^S\frac{p}{p_S} - \varepsilon^D\frac{p}{p_D}\left(\theta + \alpha\frac{d\theta}{d\alpha}\right)\right].$$

Using the relationship between p_D, p_S and p, this further simplifies to

$$\begin{aligned}
\frac{dp}{d\alpha}\frac{1}{p}\left(\varepsilon^S - \varepsilon^D\right) &= -\tau\left[\frac{\varepsilon^S}{1-(1-\alpha)\tau} - \frac{\varepsilon^D}{1+\alpha\theta\tau}\left(\theta + \alpha\frac{d\theta}{d\alpha}\right)\right] \\
\Leftrightarrow \frac{dp}{p} &= d\alpha\frac{-\tau\left[\frac{\varepsilon^S}{1-(1-\alpha)\tau} - \frac{\varepsilon^D}{1+\alpha\theta\tau}\left(\theta + \alpha\frac{d\theta}{d\alpha}\right)\right]}{(\varepsilon^S - \varepsilon^D)}.
\end{aligned}$$

Next, let us consider $p_S = [1-(1-\alpha)\tau]p$. Totally differentiating and holding τ constant, we obtain

$$\begin{aligned} dp_S &= [1-(1-\alpha)\tau]dp + \tau p d\alpha \\ \Leftrightarrow \frac{dp_S}{p_S} &= \frac{1-(1-\alpha)\tau}{p_S}dp + \tau\frac{p}{p_S}d\alpha \\ &= \frac{dp}{p} + \tau d\alpha \frac{1}{1-(1-\alpha)\tau}. \end{aligned}$$

Plugging in for $\frac{dp}{p}$, we obtain

$$\begin{aligned} \frac{dp_S}{d\alpha}\frac{1}{p_S} &= \tau\left[\frac{-\frac{\varepsilon^S}{1-(1-\alpha)\tau} + \frac{\varepsilon^D}{1+\alpha\theta\tau}\left(\theta+\alpha\frac{d\theta}{d\alpha}\right)}{\varepsilon^S-\varepsilon^D} + \frac{1}{1-(1-\alpha)\tau}\right] \\ &= \tau\left[\frac{-\varepsilon^S + \frac{1-(1-\alpha)\tau}{1+\alpha\theta\tau}\varepsilon^D\left(\theta+\alpha\frac{d\theta}{d\alpha}\right) + \varepsilon^S - \varepsilon^D}{[1-(1-\alpha)\tau](\varepsilon^S-\varepsilon^D)}\right]. \end{aligned}$$

Further simplifying gives (18). Under full salience ($\theta = 1$ and $\frac{d\theta}{d\alpha} = 0$), we obtain result (6).

Next, let us consider $p_D = (1+\alpha\theta\tau)p$. Totally differentiating and holding τ constant, we obtain

$$\begin{aligned} dp_D &= (1+\alpha\theta\tau)dp + \theta\tau p d\alpha + \alpha\tau p d\theta \\ \Leftrightarrow \frac{dp_D}{p_D} &= \frac{1+\alpha\theta\tau}{p_D}dp + \theta\tau\frac{p}{p_D}d\alpha + \alpha\tau\frac{p}{p_D}d\theta \\ \Leftrightarrow \frac{dp_D}{d\alpha}\frac{1}{p_D} &= \frac{dp}{d\alpha}\frac{1}{p} + \frac{1}{1+\alpha\theta\tau}\theta\tau + \alpha\tau\frac{1}{1+\alpha\theta\tau}\frac{d\theta}{d\alpha} \\ &= -\tau\left[\frac{\frac{\varepsilon^S}{1-(1-\alpha)\tau} - \frac{\varepsilon^D}{1+\alpha\theta\tau}\left(\theta+\alpha\frac{d\theta}{d\alpha}\right)}{\varepsilon^S-\varepsilon^D} - \frac{1}{1+\alpha\theta\tau}\left(\theta+\alpha\frac{d\theta}{d\alpha}\right)\right] \\ &= -\tau\left[\frac{\frac{1+\alpha\theta\tau}{1-(1-\alpha)\tau}\varepsilon^S - \varepsilon^S\left(\theta+\alpha\frac{d\theta}{d\alpha}\right)}{(1+\alpha\theta\tau)(\varepsilon^S-\varepsilon^D)}\right]. \end{aligned}$$

Further simplifying gives (19). Under full salience ($\theta = 1$ and $\frac{d\theta}{d\alpha} = 0$), we obtain result (7). □

B Testable Predictions

Our results yield empirically testable predictions. Taking our derivations seriously, and letting t index time, equations (12) and (13) imply the following empirical specification of a shift in the statutory incidence

$$\left(\frac{dp_S}{p_S}\right)_t = \beta_1^S x_{1t} + \beta_2^S x_{2t} \tag{21}$$

$$\left(\frac{dp_D}{p_D}\right)_t = \beta_1^D x_{1t} + \beta_2^D x_{2t}, \tag{22}$$

where

$$\begin{aligned}
\left(\frac{dP}{P}\right)_t &= \frac{P_t - P_{t-1}}{P_{t-1}} \\
x_{1t} &= \frac{1}{[1-(1-\alpha_{t-1}\tau_{t-1})](1+\alpha_{t-1}\tau_{t-1})} d\tau_t \\
x_{2t} &= \frac{\tau_{t-1}^2}{[1-(1-\alpha_{t-1}\tau_{t-1})](1+\alpha_{t-1}\tau_{t-1})} d\alpha_t.
\end{aligned}$$

The simple theoretical framework above would imply

1. $\beta_1^S = -\beta_2^S = \frac{\varepsilon^D}{\varepsilon^S + \varepsilon^D}$
2. $\beta_1^D = -\beta_2^D = \frac{\varepsilon^S}{\varepsilon^S + \varepsilon^D}$
3. and the derived elasticities $\hat{\varepsilon}^S$ and $\hat{\varepsilon}^D$ are identical when inferred from estimating equation (21) or (22).

In contrast, the classical view of statutory irrelevance would suggest $\beta_2^S = \beta_2^D = 0$.

In practice, however, there are numerous reasons why the derived relationships may not hold. First, policy changes, $d\tau_t$ and $d\alpha_t$, are likely endogenous and may correlate with other factors that shift demand and thus p_S and p_D, like optimization frictions like tax salience, or evasion. Second, we do no model a contribution-benefit linkage, which exists for many payroll taxes like pension contributions. This is different however for some payroll taxes. Health insurance benefits are independent of an individual's payroll tax contributions in many countries. Third, changes in statutory incidence, in the absence behavioral, informational, or market frictions, are often implemented across entire populations in empirical settings. An example is nationwide adjustments to statutory incidence and payroll tax rates in OECD countries, described in Figure 6.

C Payroll taxes in OECD countries

Figure C.1: Payroll tax rates of employer and employee in OECD countries

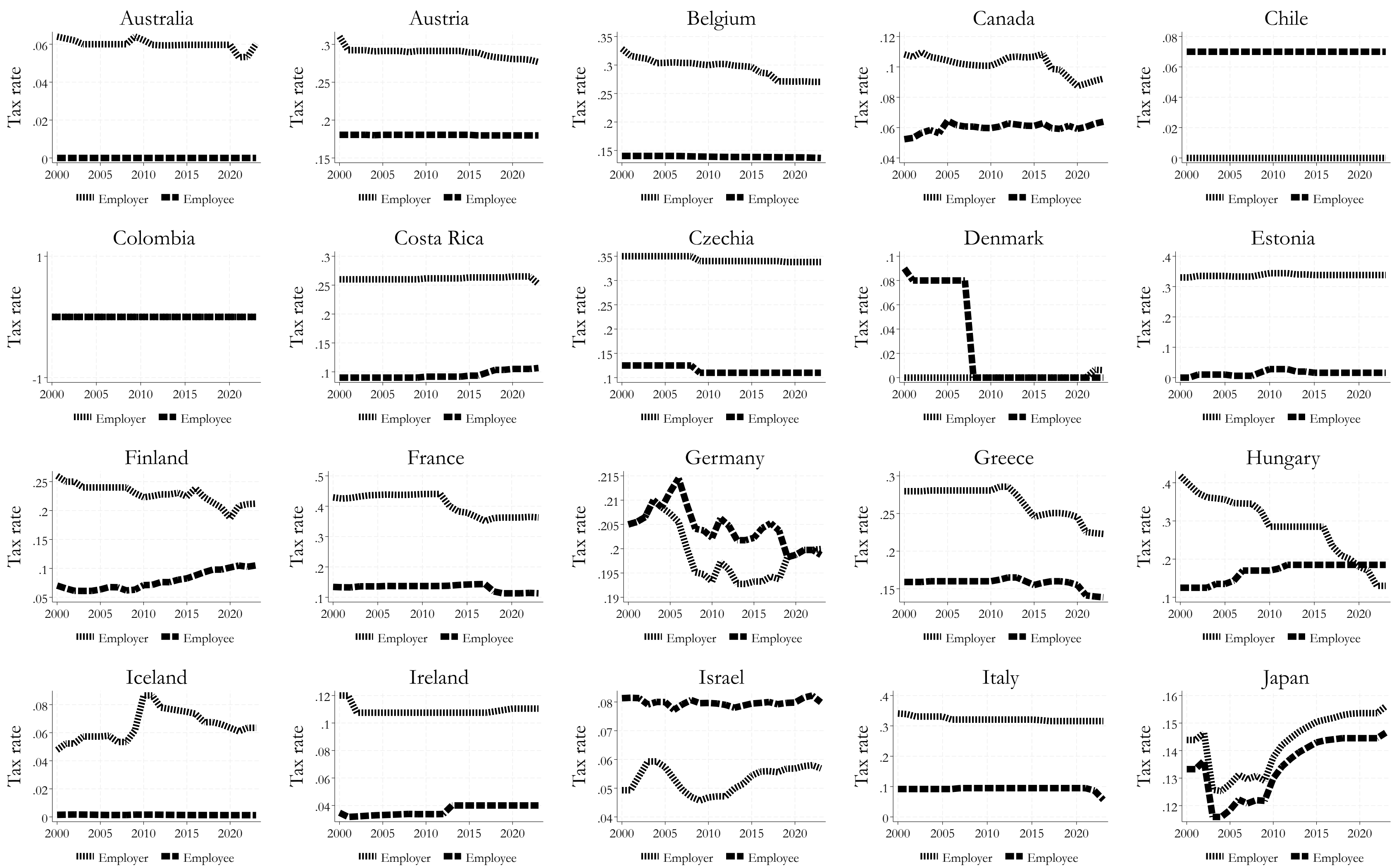
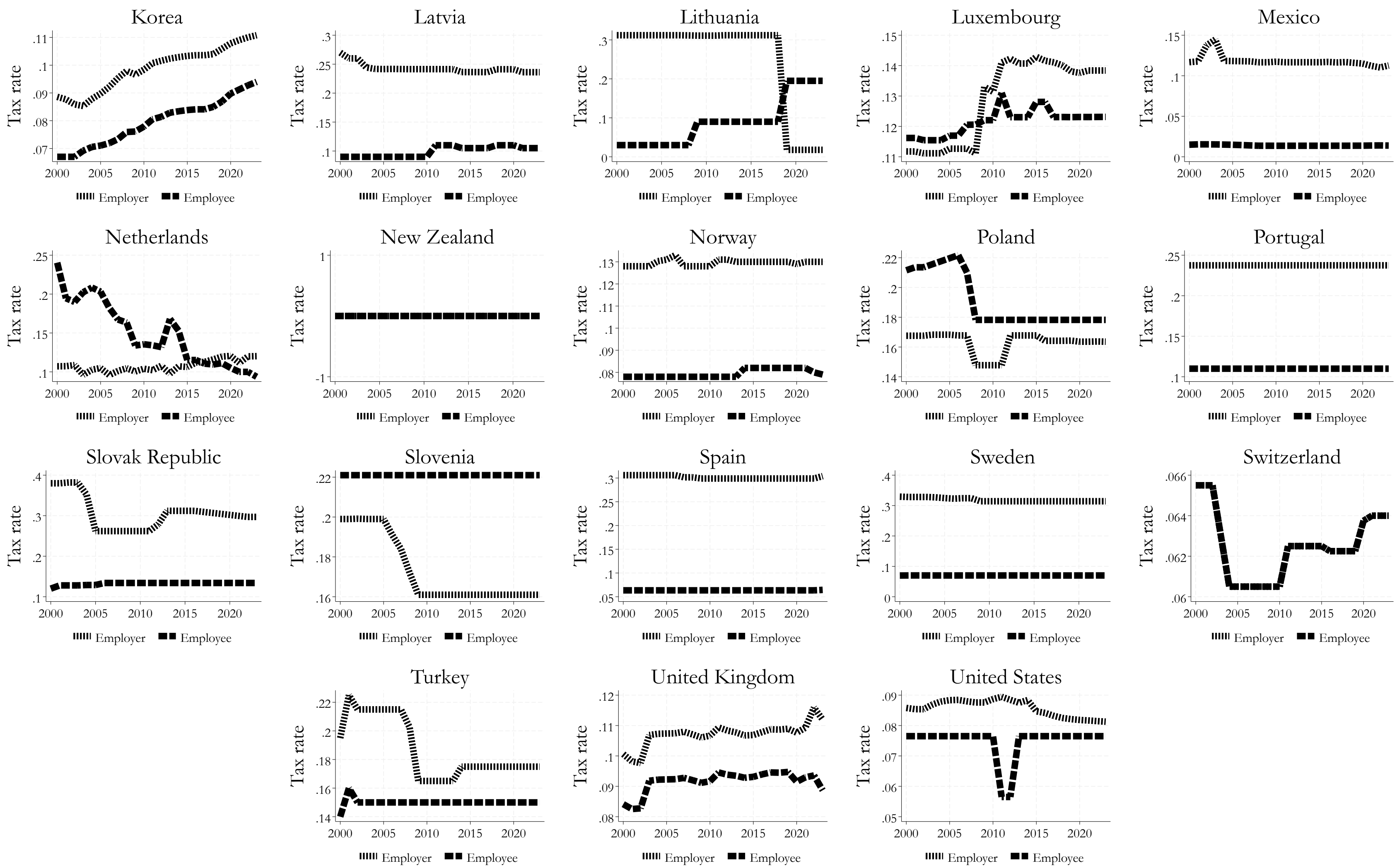


Figure C.1: Payroll tax rates of employer and employee in OECD countries



Notes: This figure shows the evolution of statutory employer and employee tax rates from 2000 to 2023 by all 38 OECD countries. The vertically dashed line corresponds to the employer side. The squared dashed line corresponds to the employee side. Based on *OECD Taxing Wages* data.