The legal incidence of ad valorem taxes matters

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The legal incidence of ad valorem taxes matters*

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Abstract

It is well known that, for a specific tax, its economic incidence does not depend on which side of the market has the legal obligation to pay the tax. In this paper, we show that, for an ad valorem tax, this legal incidence does matter for the economic incidence. In particular, when a government imposes an ad valorem tax rate on the sale of a commodity, the resulting reduction in the market equilibrium level of sales will be larger when sellers are obliged to pay the tax than when buyers are obliged to pay the tax.

Keywords: economic incidence, legal incidence, statutory incidence, ad valorem taxes, invariance theorem

JEL Codes: H22

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1 Introduction

When a government imposes an indirect tax on the sale of a commodity, it has to specify which side of the market—the demand side and/or the supply side—has the legal obligation to pay the tax to the government. An important result of the theory of taxation states that, for specific taxes,[1] it does not matter which side of the market has the obligation to pay the tax. Shifting this obligation from one market side to the other has no important economic consequences. The market equilibrium, the consumer and producer surplus and the total tax revenue will remain the same. The only important decision of the government concerns the total amount of the tax per unit of the commodity. We call this result the invariance result for specific taxes. See, e.g., the textbook treatment by (Nechyba, 2011, pp. 672-674) , or the survey on tax incidence by (Kotlikoff and Summers, 1987, pp. 1045-1047). A simple proof is also provided in Section 3 below.

Does a similar result also hold for ad valorem taxes? Such a result can be formulated as follows: if each of the two market sides faces its own ad valorem tax rate, then the economic incidence of these tax rates only depends on their sum, and not on their particular values. We call this result the invariance result for ad valorem tax rates. Browsing the economic literature on this topic, one finds a strong belief that this result is correct. We now briefly review some treatments of this issue in the literature.

In their survey chapter, (Kotlikoff and Summers, 1987, p. 1046) write that "[t]his principle, that the incidence of a tax does not depend on which side of the market it is levied, carries over to much more general contexts. ... [S]hifting the tax assessment between consumers and producers has no real effects. The real equilibrium is invariant to whom the government requires mail in the tax payment".

(Gruber, 2019, pp. 589-590) states that "[t]he second rule of tax incidence is that the side of the market on which the tax is imposed is irrelevant to the distribution of the tax burdens: tax incidence is identical whether the tax is levied on producers or consumers". Although the example he gives is in terms of a specific tax on a product market, he continues with an example of a per unit payroll tax on the labour market and states that the conclusions also go through under an ad valorem payroll tax.

Also (Salanié, 2011, p. 16) illustrates economic incidence in the context of a competitive labour market. After noting that some payroll taxes are paid by employers and some by workers, he writes that "[t]his legal distinction is artificial. [...] Whether 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."

[1] Also known as excise taxes or per-unit taxes.

In his analysis of gross receipt taxes, and in particular the Ohio commercial activity tax, (Lawson, 2018, p. 208) first reviews some of the results of incidence analysis, writing that "[o]ne interesting and, to many noneconomists, surprising fact about the economic incidence of a tax is that the sharing of the tax burden among these various stakeholders is invariant to the legal incidence", and illustrates this with an example of a 5% ad valorem tax.

(Goolsbee et al., 2020, ch 3) explain the invariance result for excise taxes in their microeconomics text, and extend it to ad valorem payroll taxes by concluding that "the analyses we've just completed suggest that [changes to the equal split of the 15.3% Social Security and Medicare tax on wages between employers and employees in the US] wouldn't make any difference. In a competitive market, the wage would adjust to the same level regardless of which side of the market is legally bound to pay the tax" (p 81).

The issue of which side of the market bears the legal obligation to remit a tax is central in Slemrod (2008). Slemrod sketches a competitive labour market model where both workers and employers have to pay a tax based on the wage level. He then extends the model with an evasion technology on either side of the market, and the idea is that the party who is responsible for remittance may make use of this technology to reduce his or her tax liability. A main conclusion of his analysis is that, in the absence of any avoidance or evasion opportunities, changing the tax rates of workers and employers will not impact on the economic incidence as long as the sum of the two rates is kept constant.

These different examples of public economics discourse give indeed the impression of the existence of a general invariance theorem regarding the economic effects of shifting the legal obligation to pay ad valorem taxes between buyers and sellers.[2] But as (Slemrod and Gillitzer, 2014a, p. 21) and (Slemrod and Gillitzer, 2014b, p. 96) point out, this invariance theorem is a folk theorem in that the assumptions are never made explicit. In the present paper we hope to clarify this issue by showing that a general invariance theorem for ad valorem taxes does not hold. In particular, we will investigate when and how shifting the legal obligation to pay an ad valorem tax between buyers and sellers will affect the equilibrium market outcome and the surpluses of these buyers and sellers.

The following example illustrates that a clarification is not only of academic interest, but that it can also be informative for the public debate. In Flanders, the northern region of Belgium, there exists an ad valorem tax (a registration tax) on the sale of houses. The

[2](Picard and Toulemonde, 2001, p. 464) and (Slemrod, 2008, p. 255) attribute the 'Theorem of the Invariance of Tax Incidence' to Dalton (1954). While Dalton does not state any formal theorem, he writes in Chapter VII ('The incidence of taxation'): "It makes no essential difference whether the tax is legally imposed on buyers or sellers, though this may affect the length of time which will elapse before the process of shifting the direct money burden, or part of it, from one side to the other is completed." ((Dalton, 1954, p. 38). This statement of the invariance result is already present in the 3rd edition (p. 54) of Dalton's *Principles of Public Finance* that came out in 1936).

buyer of a house is obliged to pay this tax to the government. Several years ago, there were proposals to replace this tax by a system where the buyer and the seller each pay one half of this tax. The expectation was that in this way the burden of the tax would be shared more equally between buyers and sellers. A more extreme version of the proposal was to shift the full tax to the seller. At first sight, such proposals may look reasonable. However, we will show that shifting the obligation to pay this tax from the buyers to the sellers does have unintended economic consequences. Such a shift will not benefit the buyers. In fact, it will reduce their surplus. This example also clearly illustrates a basic insight of tax incidence, viz., that a taxpayer's welfare need not increase when his tax obligation is reduced. See, e.g., Fullerton and Metcalf (2002), and Salanié (2011).

Our analysis also clarifies the importance of how social security contributions by employers and employees determine the equilibrium on the labour market. Under the invariance theorem for ad valorem taxes, the relative size of these contributions has no real economic consequences, and is purely symbolic. We will show that this view is not correct.

In our analysis we introduce two tax rates, one for each side of the market. This approach allows us to compare exactly the effects on the market equilibrium of changing the tax rate of one or both market sides. We use inverse demand and supply functions, which greatly simplifies the derivation of comparative statics results. We first show that there exists an overall measure for the tax pressure on the market to which these two taxes give rise, and that this overall measure fully determines the equilibrium consumer price, producer price, quantity bought and sold, and the associated surpluses to consumers and producers. We then determine the rate at which one tax can be substituted for the other without changing the overall tax pressure. We show that this marginal rate of substitution is not constant, *and is never equal to one*. It then immediately follows that the choice of the market side responsible for paying an ad valorem tax does have important economic consequences. Although our focus is on a competitive market, our main result—that of a non-unitary marginal rate of substitution between the two ad valorem tax rates—also applies markets with less than perfect competition.

The paper is structured as follows. In the next section we recall some simple but important relationships which hold in the context of ad valorem taxes. In Section 3, we study how ad valorem taxes affect the competitive market equilibrium. In Section 4, we use this analysis to study the economic effects of shifting the responsibility for paying an ad valorem tax between the demand and the supply side of the market. Section 5 concludes.

2 Ad valorem taxes—some important relationships

Consider the market of a particular commodity. Let p_c denote the consumer price of the commodity, i.e., the total per unit price of the commodity paid by a consumer, possibly including a tax paid by the consumer to the government. Similarly, let p_p denote the producer price of the commodity, i.e., the net price received by a selling firm, after the firm has—possibly—paid a tax to the government. Finally, let p denote the amount of money paid by a consumer to a selling firm for one unit of the commodity. We call this price the transaction price.

We consider a situation where both buyers and sellers are required to pay an ad valorem tax. When the buyer pays the seller a transaction price p, he also has to pay a tax $t_c p$ to the government, with $t_c \geq 0$. The consumer price is then $p_c = (1 + t_c)p$. When the seller receives a transaction price p from the buyer, he has to pay a tax $t_p p$ to the government, with $0 \leq t_p < 1$. The producer price then equals $p_p = (1 - t_p)p$.[3]

It is clear that this tax system drives a wedge between the consumer price p_c and the producer price p_p. The absolute size of this wedge is given by

$$p_c - p_p = (t_c + t_p)p. \tag{1}$$

This difference equals the total tax per unit of the commodity, paid by the buyer and the seller. Expressed as a fraction of the transaction price p, this wedge equals $t_c + t_p$. We consider $t_c + t_p$ as a *nominal* tax pressure measure. The invariance result for ad valorem taxes that we referred to in the introduction, suggests that any combination (t_p, t_c) giving rise to the same nominal tax pressure results in the same economic incidence.

We can also define a relative wedge as the ratio of the consumer price to the producer price, viz.,

$$\sigma(t_p, t_c) \stackrel{\text{def}}{=} \frac{1 + t_c}{1 - t_p} = \frac{p_c}{p_p}. \tag{2}$$

This wedge σ is an increasing function of both t_c and t_p, and for all values $t_c \in [0, \infty)$ and $t_p \in [0, 1)$, the inequality $\sigma \geq 1$ holds. Moreover, $\sigma = 1$ if and only if $t_c = t_p = 0$. As will become clear in the following sections, σ plays an essential role in our analysis. We will show that the economic incidence of (t_p, t_c) *only* depends on σ. It also follows that σ is a good measure of the *effective* tax pressure resulting from (t_p, t_c). In section 4, we will define two other effective tax pressure measures, based on σ.

[3]The remittance of the tax liability of the consumer, $t_c p$, to the government may, and often will, go via the seller. E.g., the sales tax ($t_c p$) and commercial activity tax ($t_p p$) in Ohio, are both transferred to the government by the seller (see (Lawson, 2018, pp. 208-9)).

3 Market equilibria and economic welfare in the presence of ad valorem taxes

When imposing an ad valorem tax on the sale of a commodity, the government has to choose a combination of tax rates (t_p, t_c), with $t_c \in [0, \infty)$ and $t_p \in [0, 1)$. We want to study the economic effects of such a decision. We will do this in two stages. In the present section, we study how the competitive market equilibrium and all its welfare economic properties only depend on the value of σ . In section 4, we study how the choice of the tax rates t_c and t_p affects the value of σ . Combining these two stages allows us to determine the effect of the choice of the tax rates on the market equilibrium, and on the welfare generated by the market.

Let the inverse aggregate demand and supply functions on a market be given by $p_c = d(X)$ and $p_p = s(X)$, respectively.[4] The inverse demand function $d(X)$ gives, for every possible value of aggregate sales X, the maximum price p_c consumers are willing to pay for one extra unit of the commodity. The inverse supply function $s(X)$ gives, for every possible value of aggregate sales X, the minimum price p_p at which firms are willing to sell one extra unit of the commodity.

In the presence of ad valorem taxes (t_p, t_c), and at a given aggregate level of sales X, consumers are willing to buy an extra unit at a maximal transaction price of $\frac{d(X)}{1+t_c}$. Producers, on the other hand, are only willing to supply an extra unit if the transaction price is at least as large as $\frac{s(X)}{1-t_p}$. Therefore, the market will be in equilibrium when X^* units are bought and sold at a transaction price $p^* = \frac{d(X^*)}{1+t_c} = \frac{s(X^*)}{1-t_p}$. Using (2), this condition can be written as

$$\frac{d(X^*)}{s(X^*)} = \sigma. \tag{3}$$

In equilibrium, the consumer price $d(X^*)$ exceeds the producer price $s(X^*)$ by $(\sigma-1)\times 100\%$. If there are no taxes, $\sigma = 1$ and (3) simply states that $d(X^*) = s(X^*)$.

This equilibrium is illustrated in Figure 1. For simplicity we take the functions $d(X)$ and $s(X)$ to be linear—these are drawn as the solid lines. The functions $d(X)/(1 + t_c)$ and $s(X)/(1-t_p)$, drawn as dashed lines, intersect at the equilibrium sales $X^*$and at the price p^*. The vertical distance between $d(X^*)$ and $d(X^*)/(1+t_c)$ equals $t_c d(X^*)/(1+t_c) = t_c p^*$. This is the tax per unit paid by a consumer in the market equilibrium. Similarly, the vertical distance between $s(X^*)/(1 - t_p)$ and $s(X^*)$ equals $t_p s(X^*)/(1 - t_p) = t_p p^*$. This is the tax per unit paid by a firm in the market equilibrium. It then follows that in equilibrium

[4]The graph of $p_c = d(X)$ corresponds to the horizontal sum of the individual marginal willingness to pay functions, while the graph of $p_p = s(X)$ is the horizontal sum of the individual firms' marginal cost functions (the part exceeding the respective average cost function).

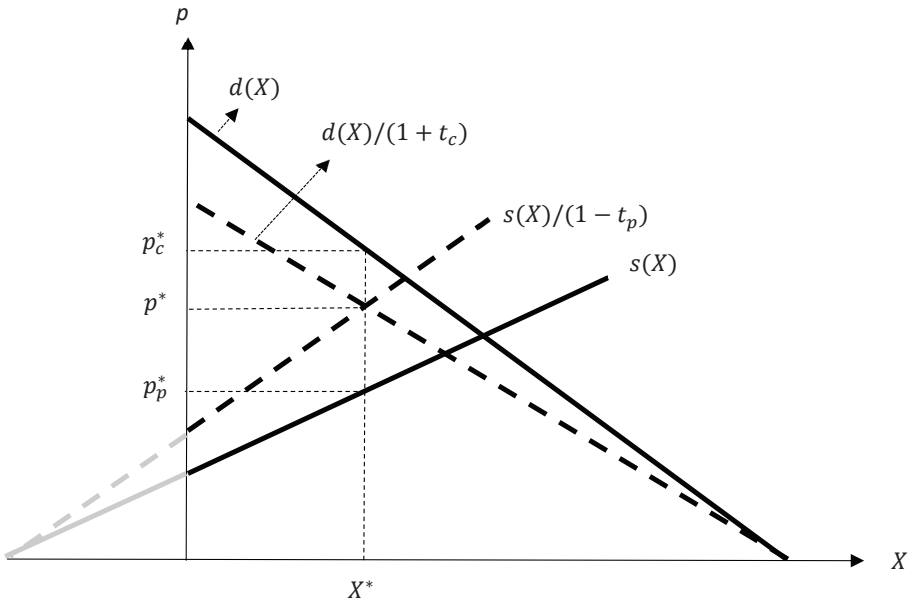

Figure 1: Market equilibrium with ad valorem taxes (t_p, t_c)

$p^*(t_c + t_p) = d(X^*) - s(X^*)$. Hence, the vertical distance between $d(X^*)$ and $s(X^*)$ equals the total tax per unit, $p^*(t_c + t_p)$. This is consistent with relation (1).[5]

To gain a better understanding of the implications of condition (3), assume that the government decides to impose a tax of 25% on the transaction price of a commodity. If the tax liability is allocated to consumers, $(t_p, t_c) = (0, 0.25)$, with $\sigma = 1.25$, the resulting maximum transaction price consumers are willing to pay for an extra unit is $p = \frac{d(X)}{1.25}$. Firms are willing to supply this unit for a price at least as large as $s(X)$. In a market equilibrium X^*, we must have that $\frac{d(X^*)}{1.25} = s(X^*)$, or $\frac{d(X^*)}{s(X^*)} = 1.25$. On the other hand, if producers are held accountable for paying the tax, we have $(t_p, t_c) = (0.25, 0)$, with $\sigma = 1.33$. Consumers are now willing to pay up to $d(X)$ for an extra unit, whereas producers are willing to sell this unit at a transaction price at least equal to $\frac{s(X)}{1-t_p}$. The new market equilibrium thus requires that $d(X^{**}) = \frac{s(X^{**})}{1-t_p}$, or $\frac{d(X^{**})}{s(X^{**})} = 1.33$. Therefore, shifting the obligation to pay 25% tax on the transaction price from consumers to producers has the same effect as raising the consumer tax rate from 25% to 33%. Clearly, this implies that $X^{**} < X^*$. In fact, it is easily checked that $(t_p, t_c) = (0.20, 0)$ would also implement X^*. In other words, $t_c = 0.25$ is

[5]In case of a monopoly market structure where $s(X)$ corresponds to the monopolist's marginal cost curve that exceeds the average cost curve, the equilibrium condition is $[d'(X^*)X^* + d(X^*]/(1+t_c) = s(X^*)/(1-t_p)$ or $[d'(X^*)X^* + d(X^*] = \sigma s(X^*)$, showing that (t_p, t_c) only affect X^* through σ. In the same vein, the first order conditions for a Cournot equilibrium will be characterised by marginal revenue equalling the product of σ with the marginal cost for each firm.

the relative markup on $s(X^*)$ to arrive at $d(X^*)$, while $t_p = 0.20$ is the relative markdown on $d(X^*)$ to arrive at $s(X^*)$. Because in a distorted equilibrium $d(X^*) > s(X^*)$, the markdown is smaller than the markup.

It is instructive to compare equilibrium condition (3) with the corresponding condition for a pair of specific taxes (T_p, T_c). In this case, the maximal transaction price that consumers are willing to pay for an additional unit is $d(X) - T_c$, while the minimal transaction price at which producers are willing to sell this unit is $s(X) + T_p$. In the competitive market equilibrium we require that $d(X^*) - T_c = p^* = s(X^*) + T_p$, or that

$$d(X^*) - s(X^*) = T_c + T_p. \tag{4}$$

This condition confirms that any (T_c, T_p)-combination resulting in the same aggregate tax $T_c + T_p$ leads to the same equilibrium. This is the invariance theorem for specific taxes mentioned in the introduction.

We now return to the equilibrium condition (3). Let us define the function $\varphi(\sigma)$ giving, for every possible value of σ, the corresponding value X^* that solves the equation $d(X) = \sigma s(X)$. By differentiating the identity $d(\varphi(\sigma)) \equiv \sigma s(\varphi(\sigma))$ with respect to σ, it is easy to see that the derivative of φ with respect to σ is negative. An increase of σ will cause a decrease of the equilibrium value X^*. In terms of Figure 1, an increase in σ shifts the equilibrium value X^* to the left. The elasticity of $\varphi(\sigma)$ with respect to σ is given by

$$\frac{\mathrm{d}\varphi(\sigma)}{\mathrm{d}\sigma}\frac{\sigma}{\varphi(\sigma)} = \varepsilon_M \stackrel{\text{def}}{=} -\left[\frac{1}{|\varepsilon_d|} + \frac{1}{\varepsilon_s}\right]^{-1} < 0, \tag{5}$$

where we define ε_M, the market elasticity, as the harmonic mean of the price elasticities of demand (ε_d) and supply (ε_s). Clearly, ε_M is negative, and becomes more negative when the demand and supply functions become more price elastic.

It then immediately follows that the elasticity of the consumer price $d(\varphi(\sigma))$ with respect to σ is given by

$$\frac{\mathrm{d}d(X^*)}{\mathrm{d}\sigma}\frac{\sigma}{X^*} = \frac{\varepsilon_M}{\varepsilon_d} = \frac{1}{1 + \frac{|\varepsilon_d|}{\varepsilon_s}} \in (0, 1). \tag{6}$$

The elasticity of the producer price $s(\varphi(\sigma))$ with respect to σ is equal to

$$\frac{\mathrm{d}s(X^*)}{\mathrm{d}\sigma}\frac{\sigma}{X^*} = \frac{\varepsilon_M}{\varepsilon_s} = -\frac{1}{1 + \frac{\varepsilon_s}{|\varepsilon_d|}} \in (-1, 0). \tag{7}$$

The more price elastic the demand (supply) compared with the market elasticity, the less the consumer (producer) price is affected by an increase in σ.

The consumer and producer surplus at a value σ are given by

$$CS(\sigma) = \int_0^{\varphi(\sigma)} [d(x) - d(\varphi(\sigma)] \, \mathrm{d}x, \tag{8}$$

and

$$PS(\sigma) = \int_0^{\varphi(\sigma)} [s(\varphi(\sigma)) - s(x)] \, \mathrm{d}x. \tag{9}$$

The derivatives of $CS(\sigma)$ and of $PS(\sigma)$ with respect to σ are therefore

$$\frac{\mathrm{d}CS(\sigma)}{\mathrm{d}\sigma} = \frac{p_c^* X^*}{\sigma} \frac{\varepsilon_M}{|\varepsilon_d|} < 0, \tag{10}$$

and

$$\frac{\mathrm{d}PS(\sigma)}{\mathrm{d}\sigma} = \frac{p_p^* X^*}{\sigma} \frac{\varepsilon_M}{\varepsilon_s} < 0, \tag{11}$$

where p_c^* (p_p^*) is the equilibrium consumer (producer) price. Both consumers and producers suffer from the increase in σ, and the marginal burden on an agent is proportional to the relative price inelasticity of that agent's market behaviour. Comparing the absolute values of (10) and (11) shows that an increase in the relative tax wedge σ hurts consumers more than producers if $\frac{|\varepsilon_d|}{\varepsilon_s} < \frac{p_c^*}{p_p^*} = \sigma$.

The total tax per unit is given by $(t_c + t_p)\, p^*$ which can also be written as $(\sigma - 1) s(\varphi(\sigma))$. This is an increasing function of σ.[6] Total tax revenue, defined as $R(\sigma) \stackrel{\text{def}}{=} (\sigma - 1)\, s(\varphi(\sigma))\varphi(\sigma)$, can increase or decrease with σ. An increase of σ increases the tax per unit $(\sigma - 1)s(\varphi(\sigma))$, but decreases the quantity $\varphi(\sigma)$. It is easy to show that $|\varepsilon_d| < 1$ is sufficient for the derivative $R'(\sigma)$ to be positive.

Expressions (5)-(11) generalise the expressions given by, e.g., (Kotlikoff and Summers, 1987, p. 1046) for specific taxes on the demand side, or (Salanié, 2011, p. 18) for infinitesimal ad valorem taxes on labour demand. It is important to note that, in a competitive market, any tax mix (t_p, t_c) that results in the same relative tax wedge σ will result in the same volume of sales and in the same consumer and producer surplus. In that sense, σ is a correct measure of effective tax pressure.

[6] This follows from $\frac{\mathrm{d}(\sigma-1)s(\varphi(\sigma))}{\mathrm{d}\sigma} = s(\varphi) \times \left[1 + \frac{\sigma-1}{\sigma} \frac{\varepsilon_M}{\varepsilon_s}\right]$. Since $\frac{\sigma-1}{\sigma} \in [0, 1)$ and $\frac{\varepsilon_M}{\varepsilon_s} \in (-1, 0)$ the square bracket term is positive.

4 Shifting tax obligations between buyers and sellers

In Section 3 we found that knowledge of the function $\varphi(\sigma)$ allows us to predict the effects of a change of σ on the equilibrium level of sales X^*, and on all the important welfare economic variables. Comparing the effects of changes in t_c and t_p on the market equilibrium sales $\varphi(\sigma)$, we see that

$$\frac{\partial\varphi(\frac{1+t_c}{1-t_p})}{\partial t_p} = \frac{\mathrm{d}\varphi(\sigma)}{\mathrm{d}\sigma}\frac{\sigma}{1-t_p} < \frac{\partial\varphi(\frac{1+t_c}{1-t_p})}{\partial t_c} = \frac{\mathrm{d}\varphi(\sigma)}{\mathrm{d}\sigma}\frac{1}{1-t_p} < 0. \tag{12}$$

This inequality shows clearly that the effect of a marginal change in t_p on the equilibrium sales X^* exceeds (is more negative than) the effect of a marginal change in t_c on X^*. This stronger effect of t_p on $\varphi(\sigma)$ also leads to stronger effects on all the important welfare economic variables which depend on $\varphi(\sigma)$. Inequality (12) also makes it clear why this is so: the partial derivative of σ with respect to t_p exceeds the partial derivative of σ with respect to t_c.

From the definition of $\sigma = \frac{1+t_c}{1-t_p}$, it follows that all combinations (t_p, t_c) that give rise to the same value of σ satisfy

$$t_c = \sigma - 1 - \sigma t_p. \tag{13}$$

This is the equation of the level curve of the function $\sigma(t_p, t_c)$, corresponding to the value σ. The graph of such a level curve is a downward sloping straight line in the (t_p, t_c)-space. Figure 2 shows the field of level curves. The curves all emanate from the point $(1, -1)$ and their σ-levels increase in North-East direction. A level curve with value σ has intercept $\sigma - 1$ on the vertical axis and $\frac{\sigma-1}{\sigma}$ on the horizontal axis. We can define the marginal rate of substitution of t_c for t_p as

$$-\frac{\mathrm{d}t_c}{\mathrm{d}t_p}|_{\mathrm{d}\sigma=0} = \frac{\partial\sigma/\partial t_p}{\partial\sigma/\partial t_c} = \sigma. \tag{14}$$

It is constant along a level curve, it is always larger than 1, and it increases as we move to higher level curves.

In Section 2 we defined $t_c + t_p$ as a measure of nominal tax pressure. We can now define three measures of effective tax pressure. A first measure is the value of σ, or $\frac{p_c^*}{p_p^*}$, itself. Clearly, the higher the value of σ, the lower equilibrium sales, and the lower the consumer and producer surplus. A drawback of this measure is that it does not have the dimension of a percentage. A second possible measure is $\sigma - 1$, the intercept of the level curve of σ on the vertical axis, or the value of t_c that would realise the value of σ when $t_p = 0$. This measure equals $\frac{p_c^* - p_p^*}{p_p^*}$ and thus has the interpretation of the tax wedge expressed as a percentage of

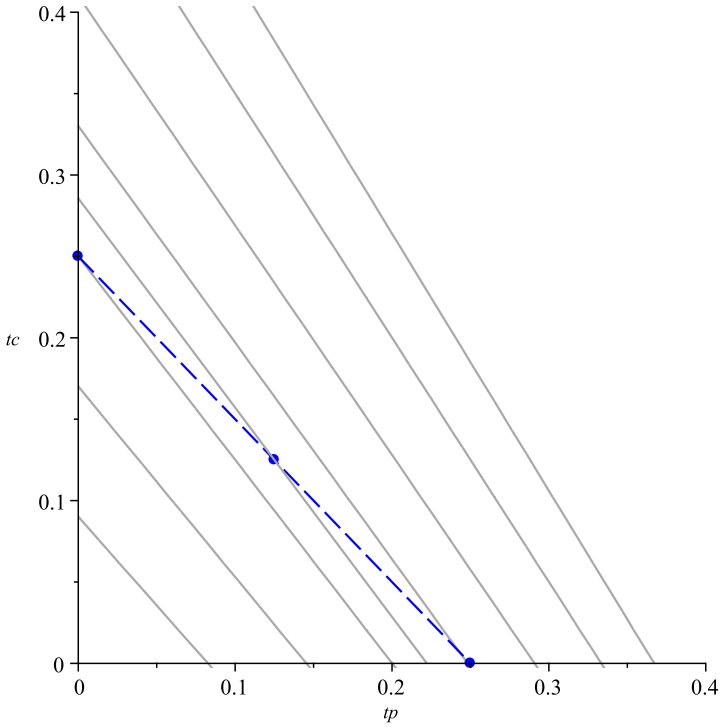

Figure 2: Fanning out level curves for σ (solid lines) and the level curve corresponding to a nominal tax pressure of 25% (dashed line)

the producer price. A third measure is $\frac{\sigma-1}{\sigma}$, the intercept of the level curve of σ on the horizontal axis, or the value of t_p that would realise the value of σ when $t_c = 0$. This measure equals $\frac{p_c^* - p_p^*}{p_c^*}$ and is therefore the wedge expressed as a percentage of the consumer demand price. All three measures are increasing in σ.

Let us return to the numerical example of Section 3. Start from a situation where $(t_p, t_c) = (0, 0.25)$ so that only consumers are required to pay a tax. The locus of all tax combinations leading to the same nominal tax pressure is given by $t_p + t_c = 0.25$. The marginal rate of substitution implied by this line is 1. See the dashed line in Figure 2. Now consider tax combinations (t_p, t_c) along this line, moving from point $(0, 0.25)$ to point $(0.25, 0)$. It is clear that such a move leads to increasing values of σ, and thus also of $\sigma - 1$ and $\frac{\sigma-1}{\sigma}$. Initially, $\sigma = 1.25$, $\sigma - 1 = 0.25$, and $\frac{\sigma-1}{\sigma} = 0.20$. At point $(0.125, 0.125)$ we have $\sigma \simeq 1.29$, $\sigma - 1 \simeq 0.29$, and $\frac{\sigma-1}{\sigma} \simeq 0.22$. And at the final point $(0, 0.25)$ we have $\sigma \simeq 1.33$, $\sigma - 1 \simeq 0.33$, and $\frac{\sigma-1}{\sigma} = 0.25$. It is clear that the shift in tax obligation from consumers to producers does not change the nominal tax pressure, but it does increase the values of all the three measures of effective tax pressure. Surprisingly, moving from $(0, 0.25)$ to $(0.125, 0.125)$ and further to $(0.25, 0)$ does not benefit consumers!

All these measures are summarised in Table 1. The final column in this table gives

the increase in σ relative to $\sigma = 1$. Thus, reallocating a 25% ad valorem tax rate from the buyers' to the sellers' side reduces the equilibrium volume with about $6.7 \times |\varepsilon_M|$ per cent (see (5), raises the consumer price by about $6.7 \times \frac{\varepsilon_M}{\varepsilon_d}$ per cent (see (6)), and lowers consumer surplus relative to consumer expenditure by the same percentage (see (10)).

Table 1: Consequences of reallocating a nominal tax pressure of 25% from consumers to producers

(t_p, t_c)	σ	$\sigma - 1^a$	$\frac{\sigma-1}{\sigma}{}^b$	$\Delta \log \sigma^c$
$(0, .25)$	1.25	.25	.20	\
$(.125, .125)$	1.29	.29	.22	3.2%
$(.25, 0)$	1.33	.33	.25	6.7%

[a] The effective tax rate as measured on the vertical axis of Figure 2.
[b] The effective tax rate as measured on the horizontal axis of Figure 2.
[c] The increase in σ, relative to $\sigma = 1.25$: $\frac{\sigma-1.25}{1.25} \times 100$.

More generally, a tax reform $(\Delta t_p, \Delta t_c)$ will increase (decrease) the value of σ and therefore reduce (increase) the value of X^* if and only if

$$\sigma \Delta t_p + \Delta t_c > (<) 0.$$

It is only when $\sigma \Delta t_p + \Delta t_c = 0$ that the reform will keep σ, and thus X^* and the surpluses, constant—this is a move along a level curve. But what happens to the transaction price in this case? Suppose $\Delta t_p < 0$ and $\Delta t_c = -\sigma \Delta t_p > 0$. It then follows from Figure 2 that the nominal tax pressure increases: $\Delta t_c + \Delta t_p > 0$. Since $d(X^*) - s(X^*) = (t_c + t_p)p^*$ and since the left hand side is constant, the transaction price p^* must fall to offset the increase in the nominal tax pressure. To sum up, the equilibrium transaction price decreases, the nominal tax pressure $t_c + t_p$ increases, but the after tax consumer and producer prices remain unchanged.

Referring back to Salanié's (2011) example of a payroll tax on a competitive labour market, mentioned in the introduction, our analysis teaches that the distribution of this tax between the employers and workers *does* bear on the equilibrium gross and net wages and the determination of employment. Our analysis also suggests that the proposal of spreading the Flemish registration duty equally over the buyer and the seller is not a good idea. This would increase the value of σ, and decrease the surplus not only of the sellers, but also of the buyers.

5 Concluding remarks

In the case of an ad valorem tax, the choice of the market side responsible for paying the tax does have important economic consequences. Most importantly, any shift from a tax on buyers to a tax on sellers decreases the equilibrium level of sales in the market, thereby reducing both consumer and producer surplus. This result contradicts the invariance result for ad valorem taxes stated in many public finance textbooks.

It remains true, of course, that our analysis ignores the total resource costs of administering a given tax structure. This cost may vary depending on the remittance system and on the opportunities for avoidance and evasion. Taking these considerations into account can change the conclusions of our analysis. See, e.g., the work by Slemrod (2008), Slemrod and Gillitzer (2014a), Slemrod and Gillitzer (2014b) and Hargaden and Roantree (2019). Clearly, their insights and conclusions remain very relevant.

In their recent survey of the literature on commodity taxation, (Christiansen and Smith, 2021, p. 65) point to an expanding field of empirical research on tax incidence, with results that do not always match with the theory. We hope that by clarifying the consequences of the statutory incidence of ad valorem taxes for their economic incidence, our analysis facilitates the interpretation of empirical results.

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