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Is Sales Tax Included in the Price? Consumer Inattention and Price Competition

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Abstract: Sales tax is generally not included in the advertised price quoted to consumers in the United States. In contrast, value added taxes (VAT) are embedded into the price in most other countries. This article investigates how the two different pricing structures and consumers' decision-making process affect the intensity of price competition. The two pricing structures yield identical market outcomes with fast-computing consumers who are willing and able to recompute the exact sales tax each time there is a price change. With slow-computing consumers, prices and profits are higher when sellers quote and compete in prices without sales tax. In this case, a model extension with two-stage decision making shows that the entire tax burden is shifted to the consumers when they completely ignore sales tax during their initial search.

JEL classification: D43, H29, L13, M3

Key words: price competition, price comparisons, sales tax, value added tax, fast and slow-computing consumers, mental accounting, inattention, consumer decision making

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1. Introduction

The last stage in the supply chain of any product or service is the final sale to the consumer. Governments levy a tax on this final transaction which could be a fixed amount (unit tax) or expressed as a percentage of the price (ad-valorem tax). This tax is called "sales tax" in the United States and value-added tax (VAT) in most other countries.[1] To avoid switching between terms, for the purpose of this article, the term "tax" refers to the ad-valorem tax calculated as a percentage of the unit price received by the seller.

Sales tax is generally not included in the advertised price quoted to consumers in the United States. That is, the tax is added to the price only during the final payment checkout stage. In contrast, value added taxes (VAT) are embedded into the price in most other countries. The question asked and analyzed in this article is whether the two pricing structures could have different consequences for the intensity of price competition among retailers. The organization of the main analysis is displayed in Figure 1.

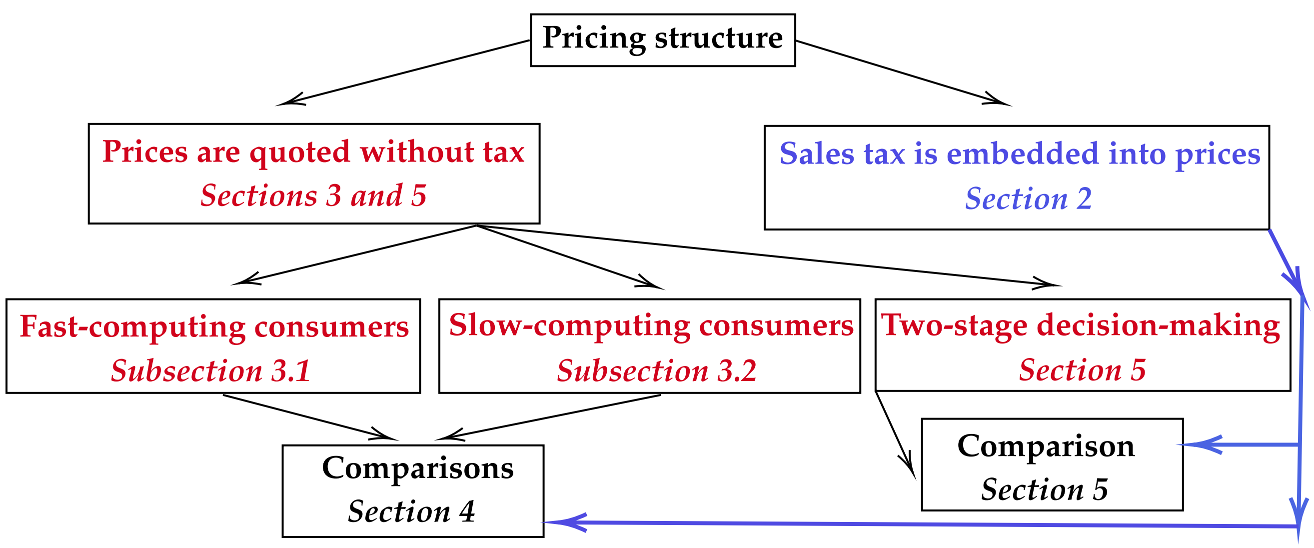

Figure 1: A comparison of sales tax-inclusive and tax-exclusive pricing structures.

[1] A value-added tax (VAT) is a more comprehensive tax system because it also covers the sales of intermediate goods. That is, VAT is imposed on each stage in the supply chain (component production, assembly, distribution, and final sale) but each firm receives a credit for VAT paid on its own purchases. However, for the purpose of this article, VAT refers to the tax paid only on the last stage in the supply chain which is the final sale to consumers (end users). For comparisons of VAT with retail sales tax (RST) see Zodrow (1999) and Martinez-Vazquez, Wallace, and Wheeler (2007).

In the United States, California has the highest sales tax at 7.25-percent, followed by Indiana, Mississippi, Rhode Island, and Tennessee at 7-percent. Alaska, Delaware, Montana, New Hampshire, and Oregon (referred to as the NOMAD states) do not impose statewide sales tax. Some cities and counties add their own "local" taxes. VAT rates in the European Union (EU) are significantly higher than sales tax in the United States. All EU countries are required to levy at least 15-percent, and the average VAT rate is 21.1-percent.[2]

Using a simple model of imperfectly-competitive sellers, I analyze price competition under the two pricing structures. With fast-computing consumers who are able and willing to recompute the exact sales tax each time a price is updated, both pricing structures yield identical market outcomes and equally-intense price competition. That is, price competition is not affected by whether sellers advertise, quote, and compete in tax-inclusive prices or whether sellers quote and compete in prices without sales tax. This is not surprising given the fact that fully-rational sellers are aware of the fact that changing their price will also change the sales tax for their brand and hence will influence fully-rational consumers' choice of which brand to purchase.

The model then shifts to analyzing slow-computing consumers who are aware of the sales tax but take the tax amount as given when they compare prices and select which brand to buy. Sellers then compete in prices to attract customers, taking into account that consumers view the sales tax as given and will not recompute the exact tax amount if the seller changes the price. After these consumers select a brand (or from which seller to buy), consumers pay the price plus sales tax and take delivery of the product or service.

The assumption of slow-computing consumers could be explained by consumers' desire to lower their "mental accounting" cost, Thaler (1985). That is, consumers do not bother to recompute the exact sales tax if sellers change prices when consumers decide which brand to buy. In that sense, consumers perceive the selection of a brand when

[2]For the EU see https://europa.eu/youreurope/business/taxation/vat/vat-rules-rates/index_en.htm and https://taxfoundation.org/data/all/eu/value-added-tax-2023-vat-rates-europe/. For the United States see https://taxfoundation.org/data/all/state/2024-sales-taxes/.

prices are quoted without sales tax separately from the stage when consumers pay the price plus sales tax. Alternatively, consumers may perceive their choice of which brand to buy by "framing" their total expenditure in a way that separates the price from the exact sales tax, Tversky and Kahneman (1981).

The last section modifies the model to consumers who first select one seller (a store) according to sellers' advertised prices and location while totally ignoring sales tax. After reaching the store the travel cost becomes sunk. At the second stage consumers learn about the tax-inclusive prices which leave them with the option to regret their initial choice and spend additional resources to travel to the competing store. As with the previous analysis, price competition is more intense when sellers compete in tax-inclusive prices. But the result is much stronger because in this scenario the consumers bear the entire tax burden when sellers compete in prices without quoting the sales tax.

To my best knowledge there is no literature that develops a theory for analyzing and comparing the intensity of price competition under the two pricing structures (competition in tax-inclusive prices versus competition in prices that are separated from sales tax). The closest paper is Kroft et al. (2024) who analyze the effect of sales tax salience on the distribution of the tax burden between consumers and producers under imperfect competition. However, in Kroft et al. (2024) there is no direct competition among brands (or among retailers/stores) because consumers are assumed to buy all brands. In contrast, the model in this paper analyzes consumers who select only one brand (or one store) and sellers who directly compete in prices against each other to attract customers. As it turns out, these two models generate different results. In Kroft et al. (2024), greater attention to taxes can increase the incidence on consumers under certain conditions. In my model, full attention to sales tax (fast-computing consumers) shifts most of the tax burden on to the sellers. The reason is that full attention to sales taxes intensifies price competition among sellers which induces sellers to absorb a greater portion of the burden of sales taxes (to avoid losing customers to a competing seller).

Chetty, Looney, and Kroft (2009) compare the effects of displaying tax-inclusive prices versus prices before tax. They find that demand for a brand is lower when sellers post tax-inclusive prices relative to when sellers post prices without sales tax. The authors concluded that survey respondents ignored taxes when prices without sales taxes were posted. In a lab experiment, Feldman and Ruffle (2015) find that subjects who were presented with prices without tax spend more than subjects who faced tax-inclusive prices and this is despite the fact that the final checkout prices were the same for all subjects. Similarly, Bradley and Feldman (2020) empirically investigate the consequences of a 2012 requirement that US air carriers incorporate all mandatory taxes and fees in their advertised fare. They find that this requirement resulted in a significant reduction in airline ticket revenue along higher-tax routes.

The empirical and experimental findings described above in which demand is lower when consumers face tax-inclusive prices (as opposed to tax-exclusive prices) is consistent with the main result of this paper which shows that equilibrium prices are lower when sellers compete in tax-inclusive prices. However, the reasoning is slightly different. In Chetty, Looney, and Kroft (2009), Feldman and Ruffle (2015), and Bradley and Feldman (2020), consumers demand less when they face tax-inclusive prices. In the theoretical model analyzed in this paper, sellers compete more intensively with tax-inclusive prices than with prices without tax.

Empirical research on how sales tax or VAT affect prices and sales in general includes Besley and Rosen (1999) who analyze how sales tax affects prices, Carbonnier (2007) who studies two VAT reforms in France, Cashin and Unayama (2016) who analyze VAT rate increase in Japan, Agarwal, Marwell, and McGranahan (2017) who analyze the effects of sales tax holidays on spending, Baker, Johnson, and Kueng (2021) using high-frequency data on 48 US states, and Buettner and Madzharova (2021) who study European VAT rate changes. Goldin (2015) and Farhi and Gabaix (2020) analyze how the theory of optimal taxation could be modified to incorporate possible behavioral biases including misconceptions of taxes and limited attention.

Consumer inattention (or partial attention) with respect to sales tax charges (which is analyzed in this paper) is similar to the inattention with respect to shipping costs. Hossain and Morgan (2006) conduct a field experiment on eBay and find that charging a high shipping fee and starting the auction at a low opening price lead to a higher number of bidders and higher revenue for the seller. Based on experiments using online auction platforms in Taiwan and Ireland, and eBay in the United States, Brown, Hossain, and Morgan (2010) find that sellers are better off disclosing shipping costs if they are low. However, increasing shipping charges boosts revenues when these charges are hidden.

The vast literature on how salience, inattention, framing, and context effects influence consumer choice includes Gabaix and Laibson (2006), Dahremöller and Fels (2015), Bordalo, Gennaioli, and Shleifer (2013, 2022), and references therein. Papers that integrate these behavioral aspects with price competition include Ellison (2005), Azar (2008), Cunningham (2011), Piccione and Spiegler (2012), and Bordalo, Gennaioli, and Shleifer (2016).

In view of Figure 1, the article is organized as follows. Section 2 derives equilibrium prices when sellers advertise, quote, and compete in tax-inclusive prices (commonly practiced in many countries and throughout Europe). Section 3 analyzes price competition when sellers advertise, quote, and compete in prices without sales tax (commonly practiced in the United States). This section also derives the conditions on consumers' decision-making under which the two pricing structures yield different equilibrium market outcomes. Section 4 compares the two pricing structures. Section 5 modifies the model by introducing two-stage decision-making and the option for consumers to regret their initial choice of a seller. Section 6 concludes. Algebraic derivations are relegated to the appendix.

2. Price competition with sales tax embedded into the price.

This section constructs the benchmark model of an imperfectly-competitive retail sector. It characterizes equilibrium outcomes assuming that sellers advertise, quote, and compete in prices inclusive of sales tax. This practice is observed in many countries and throughout Europe but not in the United States.

Consider a product or a service provided by two sellers labeled A and B (could also be firms or producers). The unit costs of seller A and seller B are denoted by $c_A \geq 0$ and $c_B \geq 0$, respectively. Let τ ($0 \leq \tau < 1$) denote the sales tax rate (or VAT on the final sale) which is computed as a fraction (percentage) of the unit price received by the sellers. Denote by p_A and p_B the "producer" prices received by sellers A and B, respectively. Also let q_A and q_B denote the "consumer" (tax-inclusive) prices of brands A and B, respectively. Therefore, with this ad-valorem sales tax,

$$q_A = p_A(1+\tau), \quad q_B = p_B(1+\tau) \quad \text{or} \quad p_A = \frac{q_A}{1+\tau}, \quad p_B = \frac{q_B}{1+\tau}. \tag{1}$$

Thus, q_A and q_B are tax-inclusive prices paid by the consumers whereas p_A and p_B are the net-of-tax prices received by sellers A and B, respectively. The difference in prices $q_A - p_A = \tau p_A$ and $q_B - p_B = \tau p_B$ are the government revenue per unit of sale of brands A and B, respectively.

Consumers' basic valuations for brand A and brand B are denoted by V_A and V_B, respectively. The analysis is based on the following assumptions.

ASSUMPTION 1. *(a) Other things equal, consumers value brand A not less than they value brand B. Formally, define $\Delta V \equiv V_A - V_B$. Then, $\Delta V \geq 0$.*

(b) Brand A is at least as costly to produce as brand B. Formally, define $\Delta c \equiv c_A - c_B$. Then, $\Delta c \geq 0$.

(c) The difference in brand valuations (ΔV) is sufficiently larger than the difference in production cost (Δc). Formally, $\Delta V \geq 2\Delta c$.

The purpose of Assumptions 1(a) and 1(b) is to allow for potential asymmetries between the two brands which would make the main results more general rather than restricted to just symmetric price equilibria. These assumptions do not rule out symmetric equilibria. V_A and V_B could also be interpreted as the objective quality characteristics of brand A and brand B, in which case the quality of brand A is at least as high as the quality of brand B.

Assumption 1(c) is needed to make brand A more profitable to produce than Brand B. This assumption guarantees that brand A will have a higher market share than brand B.

This assumption does not rule out symmetric outcomes (equal market shares) for cases where $\Delta V = \Delta c = 0$.

There are $N > 0$ consumers uniformly indexed by x on the unit interval $[0, 1]$ according to increased preference for brand B relative to brand A. Each consumer buys one unit of the product/service either from seller A or seller B. Figure 2 illustrates a possible allocation of consumers according to their choice of whether to purchase brand A or brand B.

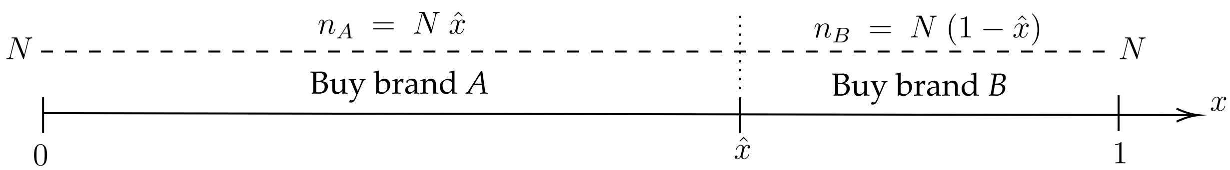

Figure 2: Consumers' choice whether to buy brand A or B.

Note: $\widehat{x}$ is an endogenously-determined function of prices q_A and q_B according to (3). The figure is based on $V_A > V_B$ (hence, in equilibrium, $\widehat{x} > \frac{1}{2}$).

Formally, the utility of a consumer indexed by x, $0 \le x \le 1$, is[3]

$$U(x) = \begin{cases} V_A - \overbrace{p_A(1+\tau)}^{q_A} - \mu x & \text{if buys brand } A \\ V_B - \underbrace{p_B(1+\tau)}_{q_B} - \mu(1-x) & \text{if buys brand } B. \end{cases} \tag{2}$$

The parameter μ measures the degree of sellers' market power. It will be shown that higher values μ correspond to higher equilibrium prices and profits earned by the two sellers.

Let $\widehat{x}$ index consumers who are indifferent between buying brand A and B at given market prices. The utility function (2) implies that $\widehat{x}$ is implicitly determined from $V_A -$

[3] This utility function reflects fast-computing consumers who choose whether to purchase brand A or brand B by comparing the tax-inclusive prices (even when prices are quoted separately from the tax). Subsection 3.2 slightly modifies the utility function to reflect slow-computing consumers whose search for a brand is partially separated from the exact final sales tax charge. Section 5 further modifies this utility function to reflect consumers who totally ignore the sales tax when they select a brand.

$p_A(1+\tau) - \mu\widehat{x} = V_B - p_B(1+\tau) - \mu(1-\widehat{x})$. Hence,

$$\widehat{x} = \frac{1}{2} + \frac{\Delta V + (p_B - p_A)(1+\tau)}{2\mu} = \frac{1}{2} + \frac{\Delta V + q_B - q_A}{2\mu}, \tag{3}$$

where p_A and p_B were substituted for q_A and q_B using (1). The following assumption is needed to obtain strictly positive equilibrium prices and profits.

ASSUMPTION 2. *Sellers' degree of market power is sufficiently large. Formally,* $\mu > \Delta V$.

Another way of interpreting Assumption 2 is that the difference in brand quality is bounded by the degree of sellers' market power ($\Delta V = V_A - V_B < \mu$).

In view of Figure 2, the numbers of consumers buying from seller A and seller B are $n_A = N\widehat{x}$ and $n_B = N(1-\widehat{x})$, respectively. The market share equation (3) implies that n_A increases with V_A and p_B (the price of the competing brand) and decreases with V_B and p_A (own price). Similarly, n_B increases with V_B and p_A (the price of the competing brand) and decreases with V_A and p_B.

Seller A and seller B set their tax-inclusive prices q_A and q_B, respectively, to maximize profit

$$\max_{q_A} \pi_A = (p_A - c_A)N\widehat{x} = \left(\frac{q_A}{1+\tau} - c_A\right) N \left(\frac{1}{2} + \frac{\Delta V + q_B - q_A}{2\mu}\right) \tag{4}$$
$$\max_{q_B} \pi_B = (p_B - c_B)N(1-\widehat{x}) = \left(\frac{q_B}{1+\tau} - c_B\right) N \left(\frac{1}{2} - \frac{\Delta V + q_B - q_A}{2\mu}\right),$$

where q_A and q_B were substituted for p_A and p_B using (1) and $\widehat{x}$ was substituted from (3). Appendix A derives the following equilibrium consumer and producer prices.

$$q_A^{\mathrm{I}} = \mu + \frac{\Delta V + (2c_A + c_B)(1+\tau)}{3}, \quad q_B^{\mathrm{I}} = \mu + \frac{-\Delta V + (c_A + 2c_B)(1+\tau)}{3}, \tag{5}$$
$$p_A^{\mathrm{I}} = \frac{q_A^{\mathrm{I}}}{(1+\tau)}, \quad \text{and} \quad p_B^{\mathrm{I}} = \frac{q_B^{\mathrm{I}}}{1+\tau},$$

where the superscript "I" denotes the benchmark equilibrium where sellers advertise and compete in tax-inclusive prices q_A and q_B. Assumption 2 ensures that $q_A^{\mathrm{I}} > 0$ and $q_B^{\mathrm{I}} > 0$. Substituting q_A^{I} and q_B^{I} from (5) into (3) and (4) yields the equilibrium market shares and profits

$$\widehat{x}^{\mathrm{I}} = \frac{1}{2} + \frac{\Delta V - \Delta c(1+\tau)}{6\mu}, \quad \pi_A^{\mathrm{I}} = N\frac{[3\mu + \Delta V - \Delta c(1+\tau)]^2}{18\mu(1+\tau)},$$
$$\pi_B^{\mathrm{I}} = N\frac{[3\mu - \Delta V + \Delta c(1+\tau)])^2}{18\mu(1+\tau)}. \quad (6)$$

Note that $0 < \widehat{x}^{\mathrm{I}} < 1$ by Assumption 1(c) and Assumption 2. The equilibrium values (5) and (6) show that a larger quality gap ΔV corresponds to (i) a higher price of brand A and a lower price for brand B, (ii) larger market share of brand A relative to brand B, and (iii) higher profit of seller A and lower profit of seller B. In addition, equilibrium prices and profits increase when sellers gain stronger market power (an increase in the parameter μ).

The following result summarizes the consequences of competition with tax-inclusive prices. Appendix A derives the following results.

Result 1. *When sellers compete in tax-inclusive prices,*

(a) Consumer prices q_A^{I} and q_B^{I} rise with the tax rate τ implying that consumers absorb some of the tax burden. In contrast,

(b) Producer prices p_A^{I} and p_B^{I} decline with the tax rate τ implying that sellers also absorb some of the tax burden.

Result 1 is illustrated in Figure 3. At this stage, the reader should focus only on prices labeled "I" that denotes equilibrium prices when sellers compete in tax-inclusive prices. There are two sets of prices, one for brand A and one for brand B. Equilibrium prices of brand A are higher than prices of brand B because brand A has a higher quality ($\Delta V = V_A - V_B > 0$).

The solid (blue) lines q_A^{I} and q_B^{I} in Figure 3 illustrate that consumer prices rise moderately with the tax rate τ indicating that consumers absorb only a small fraction of the tax burden. In contrast, sellers absorb most of the tax increase as shown in Figure 3 by the solid (black) lines p_A^{I} and p_B^{I}. These prices decline steeply with higher tax rates τ which imply that that competition in tax-inclusive prices is very intense. Result 1 would become very important in Section 4 and Section 5 that compare this equilibrium with an

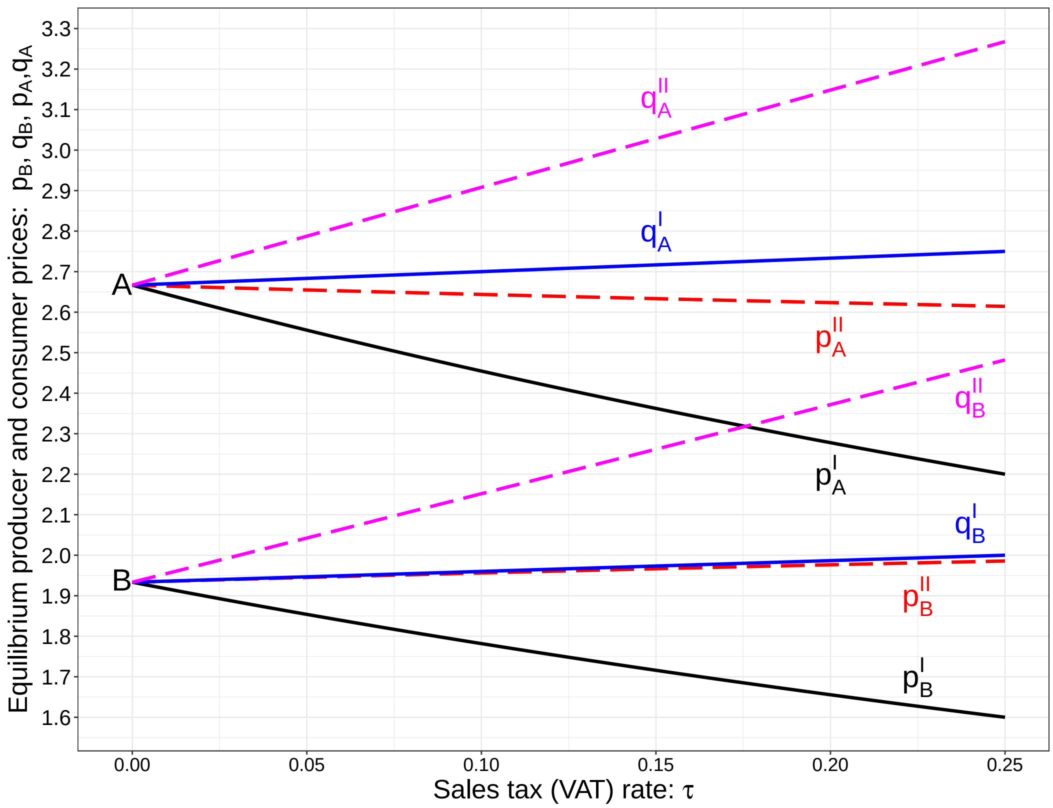

Figure 3: Equilibrium producer and consumer prices of brand A or B.

Notes: Equilibrium I: The prices when sellers compete in tax-inclusive prices are drawn from (5). Consumer prices q_A^{I}, q_B^{I} are drawn in solid blue lines. Producer prices p_A^{I}, p_B^{I} are drawn in solid black lines. Equilibrium II: The prices with slow-competing consumers when prices are separated from sales tax are drawn from (12). Consumer prices q_A^{II}, q_B^{II} are drawn in dashed purple lines. Producer prices p_A^{II}, p_B^{II} are drawn in dashed red lines. The figure is drawn based on $\tau = 0.1$, $\mu = 2$, $\Delta V = 1$, $c_A = 0.4$, $c_B = 0.2$, and $\tau = 0, \ldots, 0.25$ (zero to 25-percent sales tax).

equilibrium when sellers separate the sales tax from the advertised price that they quote to consumers, in which case price competition is weaker.

3. Price competition with sales tax separated from the price

This section investigates the polar case of Section 2. The model is modified to analyze sellers who advertise, quote, and compete in prices without sales tax. This type of price competition is commonly observed in the United States.

3.1 Fast-computing consumers: An equivalence result

Fast-fast computing consumers are those who are able and willing to compute the exact sales tax amount each time they observe a different price. Consequently, sellers take into account that a change in their price will be followed by an immediate recalculation of the sales tax amount before consumers select whether to purchase brand A or brand B.

With sales tax separated from price, the sellers' profit-maximization problems (4) should be modified and expressed as functions of the producer prices p_A and p_B instead of tax-inclusive consumer prices q_A and q_B. Therefore, seller A and seller B set their prices p_A and p_B, respectively, to solve

$$\max_{p_A} \pi_A = (p_A - c_A)N\widehat{x} = (p_A - c_A)N\left[\frac{1}{2} + \frac{\Delta V + (p_B - p_A)(1+\tau)}{2\mu}\right] \tag{7}$$
$$\max_{p_B} \pi_B = (p_B - c_B)N(1-\widehat{x}) = (p_B - c_B)N\left[\frac{1}{2} - \frac{\Delta V + (p_B - p_A)(1+\tau)}{2\mu}\right],$$

where $\widehat{x}$ was substituted from (3). Appendix B derives the following Result.

Result 2. *Equilibrium prices (5) and profits (6) remain the same regardless of whether sellers advertise, quote, and compete in prices without sales tax or whether sellers advertise, quote, and compete in tax-inclusive prices. Formally, the profit-maximization problems (4) and (7) yield identical solutions and market outcomes.*

3.2 Slow-computing consumers: A nonequivalence result

Result 2 established market outcome equivalence between price competition with sellers competing in tax-inclusive prices (q_A and q_B) and price competition with sellers competing in prices that are separated from sales tax (p_A and p_B). This "equivalence" result raises the question whether the two types of pricing structures always yield identical outcomes.

The analysis conducted in this subsection modifies consumers' ability or willingness to recompute the exact sales tax each time they encounter a different price before they choose which brand to purchase. It is shown that this modification of consumer and hence seller behavior makes the intensity of price competition depend on whether prices are quoted with or without sales tax.

Consider sellers who advertise, quote, and compete in prices separately from sales tax. Therefore, this subsection replicates the analysis in Subsection 3.1 based on the following modification.

ASSUMPTION 3. *(a) Consumers' selection between brand A and brand B is based on the advertised producer prices p_A and p_B while they view sales taxes VAT_A and VAT_B as given constants.*

(b) Sellers take consumers' behavior as given and choose their prices accordingly.

With slow-computing consumers, the utility function (2) of a consumer indexed by x ($0 \leq x \leq 1$) is now modified to

$$U(x) = \begin{cases} V_A - p_A - \mathrm{VAT}_A - \mu x & \text{if buys brand } A \\ V_B - p_B - \mathrm{VAT}_B - \mu(1-x) & \text{if buys brand } B, \end{cases} \tag{8}$$

where VAT_A and VAT_B are the amounts of sales tax (or value added tax) on each brand. The small difference between the utility function (8) and (2) is that now, although consumers are aware of the sales tax, consumers do not bother to recompute the exact tax amounts even if sellers change prices while they are still searching which brand to buy. Instead, consumers take VAT_A and VAT_B as given constants for the purpose of selecting which brand to buy.[4]

In view of Figure 2, the utility function (8) implies that $\widehat{x}$ is implicitly determined from $V_A - p_A - \mathrm{VAT}_A - \mu\widehat{x} = V_B - p_B - \mathrm{VAT}_B - \mu(1-\widehat{x})$. Hence,

$$\widehat{x} = \frac{1}{2} + \frac{\Delta V + p_B - p_A + \mathrm{VAT}_B - \mathrm{VAT}_A}{2\mu}. \tag{9}$$

With sales tax separated from prices, the sellers' profit maximization problems (7) now

[4] In this respect, the model slightly deviates for the experiment by Chetty, Looney, and Kroft (2009) who found that respondents ignored taxes when calculating the total price of a basket of goods. Here, consumers do not completely ignore sales taxes, but instead do not recompute the tax even if sellers change prices. Section 5 further modifies the utility function to capture consumers who completely ignore sales tax during their initial brand selection.

become

$$\max_{p_A} \pi_A = (p_A - c_A)N\widehat{x} = (p_A - c_A)N\left(\frac{1}{2} + \frac{\Delta V + p_B - p_A + \mathrm{VAT}_B - \mathrm{VAT}_A}{2\mu}\right) \tag{10}$$
$$\max_{p_B} \pi_B = (p_B - c_B)N(1-\widehat{x}) = (p_B - c_B)N\left(\frac{1}{2} - \frac{\Delta V + p_B - p_A + \mathrm{VAT}_B - \mathrm{VAT}_A}{2\mu}\right),$$

where $\widehat{x}$ was substituted from (9). Note that the profit maximization problems (10) are very similar to (7) except that consumers (and hence sellers) view sales taxes as constants in the sense that they do not recomputed VAT_A and VAT_B even if sellers change their prices.

Appendix C derives the following equilibrium seller prices as functions of sales taxes,

$$p_A = \mu + \frac{\Delta V + \mathrm{VAT}_B - \mathrm{VAT}_A + 2c_A + c_B}{3}, \tag{11}$$
$$p_B = \mu + \frac{-\Delta V + \mathrm{VAT}_A - \mathrm{VAT}_B + c_A + 2c_B}{3}.$$

However, we are not done because, in equilibrium, sales taxes depend on the equilibrium producer prices. Therefore, substituting $\mathrm{VAT}_A = \tau p_A$ and $\mathrm{VAT}_B = \tau p_B$ into (11) and solving this system of two equations yields the equilibrium producer and consumer prices

$$p_A^{\mathrm{II}} = \mu + \frac{\Delta V + c_A(2+\tau) + c_B(1+\tau)}{2\tau+3}, \quad p_B^{\mathrm{II}} = \mu + \frac{-\Delta V + c_A(1+\tau) + c_B(2+\tau)}{2\tau+3}, \tag{12}$$
$$q_A^{\mathrm{II}} = (1+\tau)p_A^{\mathrm{II}}, \quad \text{and} \quad q_B^{\mathrm{II}} = (1+\tau)p_B^{\mathrm{II}},$$

where superscript "II" denotes equilibrium values when consumers are slow to compute and sellers compete in prices without the tax.

Appendix C derives following result which summarizes the consequences of competition in prices without sales tax.

Result 3. *With slow-computing consumers, when sellers compete in prices without sales tax,*

(a) Both consumer prices q_A^{II} and q_B^{II} rise with the tax rate τ. Therefore, consumers absorb some or most of the increase in the tax burden.

(b) The seller of the high-quality brand absorbs part of a tax increase by setting a lower price. The

seller of the low-quality brand increases its price. Formally, p_A^{II} decreases and p_B^{II} increases with the tax rate τ.

Result 3 is illustrated in Figure 3 with prices denoted by "II". Result 3(a) is illustrated by the steep upward-sloping dashed purple lines q_A^{II} and q_B^{II} which show that consumers absorb almost the entire tax burden. Result 3(b) is illustrated by the almost-flat dashed red lines p_A^{II} and p_B^{II}. The producer price of the high-quality brand p_A^{II} is slightly decreasing with higher tax rates τ. The price of the low-quality brand is p_B^{II} is slightly rising with τ. Therefore, most of the burden of higher tax rates is borne by the consumer. Result 3 would become very important in Section 4 which compares this equilibrium with equilibrium prices when sellers compete in tax-inclusive prices because it reveals why competition is weaker when sellers compete in prices that are separated from sales tax.

Recalling that $\mathrm{VAT}_A = \tau p_A^{\mathrm{II}}$ and $\mathrm{VAT}_B = \tau p_B^{\mathrm{II}}$, the equilibrium market shares (9) and profits (10) are then

$$\widehat{x}^{\mathrm{II}} = \frac{1}{2} + \frac{\Delta V - \Delta c(1+\tau)}{2\mu(2\tau+3)}, \quad \pi_A^{\mathrm{II}} = N\frac{[\mu(2\tau+3) + \Delta V - \Delta c(1+\tau)]^2}{2\mu(2\tau+3)^2},$$
$$\pi_B^{\mathrm{II}} = N\frac{[\mu(2\tau+3) - \Delta V + \Delta c(1+\tau)]^2}{2\mu(2\tau+3)^2}. \quad (13)$$

Note that $0 \le \widehat{x}^{\mathrm{II}} \le 1$ by Assumption 1(c) and $0 \le \tau < 1$.

4. Comparing market outcomes under the two pricing structures

Section 2 analyzed seller competition in tax-inclusive prices. Section 3 analyzed price competition between sellers who advertise and compete in prices that are separated from sales tax. Subsection 3.1 derived an equivalence result showing that market outcomes remain the same regardless of whether sellers compete in prices that are separated from sales tax or with tax-inclusive prices. In contrast, Subsection 3.2 showed that the two pricing structures do not yield the same market outcome with slow-computing consumers. This section compares the two pricing structures when they generate different market outcomes (Section 2 versus Subsection 3.2).

The goal of this comparison is to find which pricing structure yields more intense competition (or weaker competition) between the two sellers. Comparing the equilibrium producer prices (12) with (5) yields

$$p_A^{\mathrm{II}} - p_A^{\mathrm{I}} = \tau \frac{3\mu(2\tau+3) + \Delta V - \Delta c(1+\tau)}{3(1+\tau)(2\tau+3)} > 0, \qquad (14)$$
$$p_B^{\mathrm{II}} - p_B^{\mathrm{I}} = \tau \frac{3\mu(2\tau+3) - \Delta V + \Delta c(1+\tau)}{3(1+\tau)(2\tau+3)} > 0,$$

where the inequality signs follow from Assumption 1(c) and Assumption 2. Equations (14) imply the main result.

Result 4. *Suppose the sales tax rate satisfies $\tau > 0$. Then, with slow-computing consumers,*

(a) Competition is more intense and prices are lower when sellers compete in tax-inclusive prices compared with competition in prices that are separated from sales tax. Formally, $p_A^{\mathrm{I}} < p_A^{\mathrm{II}}$ and $p_B^{\mathrm{I}} < p_B^{\mathrm{II}}$, and hence $q_A^{\mathrm{I}} < q_A^{\mathrm{II}}$ and $q_B^{\mathrm{I}} < q_B^{\mathrm{II}}$. Therefore,

(b) Price competition is weaker, consumers are worse off, and sellers earn higher profits when they compete in prices that are separated from sales tax relative to competition in tax-inclusive prices.

Result 4 is illustrated in Figure 3 which plots two sets of prices (brand A and brand B). The gap between the steep upward-sloping q_A^{II} (dashed purple line) and the moderately upward sloping q_A^{I} (solid blue line) is shown to increase with τ. The same applies to the expanding gap between q_B^{II} and q_B^{I}. Similarly, The gap between the moderately downward-sloping p_A^{II} (dashed red line) and the steeper downward-sloping p_A^{I} (solid black line) is shown also to increase with τ. This implies that competition is weaker when sellers compete in prices that are separated from sales tax.

5. Two-stage decision-making: A model with (no) regret

So far, the analysis was deliberately vague about the interpretation of brands A and B. One common interpretation views A and B as different brands with qualities V_A and V_B, respectively. The second common interpretation views A and B as different sellers with physical stores at different locations. The analysis in this section applies to the second interpretation (separate stores at different locations). This is needed because consumer "regret" must involve some sunk cost. That is, consumers reevaluate their choice of a seller after they bear some travel cost that cannot be recovered. Similar to Figure 2, Figure 4 illustrates a market where seller A is located at point $x = 0$ and seller B at $x = 1$. Therefore, the distance between the stores is one unit of distance (such as one mile). As before, all consumers are located uniformly between the two sellers.

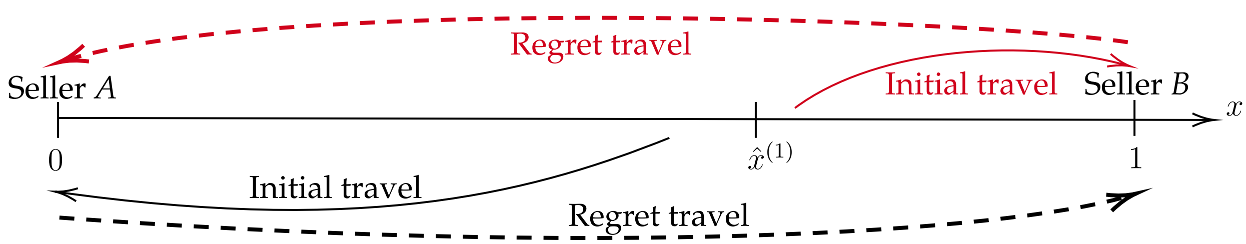

Figure 4: Consumers' choice whether to buy brand A or B with possible regrets.

Note: $\widehat{x}^{(1)}$ is an endogenously-determined function of producer prices p_A and p_B according to (17). The figure is based on $V_A > V_B$ (hence, $\widehat{x}^{(1)} > \frac{1}{2}$ in equilibrium).

Consider now a slightly different consumer decision-making process:

First stage (1): The consumer completely ignores sales taxes when she selects whether to buy from seller A or seller B. Thus, the initial selection is based on observing producer prices p_A and p_B and the distance to sellers A and B. At this stage, in view of the utility functions (2) or (8), the consumer travels to the store of her choice and bears the transportation cost μx if travels to seller A and $\mu(1-x)$ if travels to seller B.

Second stage (2): After arriving at the store of her choice, the consumer views her initial travel expense as a sunk cost. Then, before paying at the store, the consumer learns about the tax-inclusive prices q_A and q_B. At this stage, the consumer may adhere to her initial choice or regret and travel a full distance $\mu \cdot 1$ to the competing store on the other side of town, as illustrated in Figure 4.

With the above-described two-stage consumer decision-making, the utility function (8) for the first stage is now simplified to

$$U_x^{(1)} = \begin{cases} V_A - p_A - \mu x & \text{travels to seller } A \\ V_B - p_B - \mu(1-x) & \text{travels to seller } B, \end{cases} \tag{15}$$

where superscript "(1)" denotes the first stage. However, the utility function (15) no longer applies in the second stage after consumers travel either to seller A or seller B. This is because their cost of travel cannot be recovered. Therefore, in view of Figure 4, the utility of a consumer located at x in the second stage is

$$\begin{aligned} U_{AA}^{(2)}(x) &= V_A - q_A & &\text{travels to } A \text{ and buys from } A \\ U_{AB}^{(2)}(x) &= V_B - q_B - \mu \cdot 1 & &\text{travels to } A \text{ and then travels to buy from } B \\ U_{BB}^{(2)}(x) &= V_B - q_B & &\text{travels to } B \text{ and buys from } B \\ U_{BA}^{(2)}(x) &= V_A - q_A - \mu \cdot 1 & &\text{travels to } B \text{ and then travels to buy from } A. \end{aligned} \tag{16}$$

Note that the initial travel costs μx (from x to seller A) and $\mu(1-x)$ (from x to seller B) do not appear in (16) because sunk costs become irrelevant after the consumer travels to a store. However, as shown in Figure 4, consumers have yet to decide whether to travel to the other side of town at the cost of $\mu \cdot 1$.

In the first stage, the utility function (15) implies that consumers who are indifferent between brand A and brand B, denoted by $\widehat{x}^{(1)}$, are determined from $V_A - p_A - \mu\widehat{x}^{(1)} = V_B - p_B - \mu(1-\widehat{x}^{(1)})$. Hence,

$$\widehat{x}^{(1)} = \frac{1}{2} + \frac{\Delta V + p_B - p_A}{2\mu}. \tag{17}$$

Note that (17) is a special case of (9) except that now $\text{VAT}_A = \text{VAT}_B = 0$. In fact, the sellers' profit maximization problems (10) need not be repeated here because they still apply to the case in which $\text{VAT}_A = \text{VAT}_B = 0$. Under this restriction, the derivations in Appendix C still apply and the equilibrium prices (11) now become

$$p_A^{\text{III}} = \mu + \frac{\Delta V + 2c_A + c_B}{3}, \quad p_B^{\text{III}} = \mu + \frac{-\Delta V + c_A + 2c_B}{3}. \tag{18}$$

The corresponding consumer prices are $q_A^{\mathrm{III}} = p_A^{\mathrm{III}}(1+\tau)$ and $q_B^{\mathrm{III}} = p_B^{\mathrm{III}}(1+\tau)$.

Moving on to the second stage, the following result shows that when sellers set their prices according to (18), consumers do not find it beneficial to exercise their regret option and buy from the competing seller.

Result 5. *Suppose buyers ignore sales taxes during the first stage when they select a seller. Then, under the equilibrium prices (18), consumers stick to their initial choice of a seller. Hence, after traveling to a seller, under the prices (18) buyers do not benefit from traveling to the competing seller for the sake of making the purchase.*

Loosely speaking, even if buyers regret their choice of a seller after they realize the tax-inclusive prices, the gap between the stores' tax-inclusive prices is not sufficiently wide to compensate for the cost of travel to the competing seller.

To prove Result 5, it has to be shown that buyers do not benefit from regretting their initial choice of buying from seller A or seller B. Formally, using the second-stage utilities (16), the indifferent consumers (17), and the prices (18), it has to be verified that $U_{AA}^{(2)}(x) \geq U_{AB}^{(2)}(x)$ for all $x \leq \widehat{x}^{(1)}$ and $U_{BB}^{(2)}(x) \geq U_{BA}^{(2)}(x)$ for all $x \geq \widehat{x}^{(1)}$. These are shown in Appendix D.

Finally, similar to the price comparisons made in (14), comparing the equilibrium producer prices (18) with (5) yields

$$p_A^{\mathrm{III}} - p_A^{\mathrm{I}} = \frac{\tau(\Delta V + 3\mu)}{3(1+\tau)} > 0, \quad p_B^{\mathrm{III}} - p_B^{\mathrm{I}} = \frac{\tau(3\mu - \Delta v)}{3(1+\tau)} > 0, \tag{19}$$

by Assumption 2. Equations (18) and (19) imply the last result.

Result 6. *With two-stage consumer decision-making in which consumers ignore sales tax during the first stage,*

(a) Competition is more intense and prices are lower when sellers compete in tax-inclusive prices compared with competition when sales tax is separated from price. Formally, $p_A^{\mathrm{I}} < p_A^{\mathrm{III}}$ and $p_B^{\mathrm{I}} < p_B^{\mathrm{III}}$, and hence $q_A^{\mathrm{I}} < q_A^{\mathrm{III}}$ and $q_B^{\mathrm{I}} < q_B^{\mathrm{III}}$. Therefore,

(b) Price competition is weaker, consumers are worse off, and sellers earn higher profits when they compete in prices that are separated from sales tax relative to competition in tax-inclusive prices.

(c) Consumers bear the entire tax burden when sellers compete in prices that are separated from sales tax.

Results 6(a) and 6(b) duplicate Result 4 for the case of two-stage consumer decision-making. However, Result 6(c) is totally new. It shows that under two-stage decision-making when consumers totally ignore sales tax while searching for a seller, sellers do not change their price even if sales tax increases. This finding follows directly from (18) which shows that producer prices are independent of the tax rate τ. In terms of Figure 3, the dashed (red) lines p_A^{II} and p_B^{II} would be replaced by totally flat p_A^{III} and p_B^{III}. This would make the consumer prices q_A and q_B rise more steeply because consumers now absorb the entire tax burden.

6. Conclusion and Takeaway

The main finding of this article is that price competition in tax-inclusive prices is more intense than competition in prices that are separated from sales tax. Competition in tax-inclusive prices is commonly observed outside the United States and throughout Europe whereas competition in prices that are separated from sales tax is commonly observed in the United States.

Consumers may not be able to process information as fast as spreadsheets. Spreadsheets are designed so that changes made on the producer's price column result in immediate updating of the tax-inclusive price column. But consumers may not be willing or able to process information that fast. This article analyzes scenarios where consumers may be slow to update their estimation of the tax burden each time they observe a different price. Sellers, in turn, take this consumer behavior into account when adjusting their price in an imperfectly-competitive market. That explains why price competition when prices are quoted separately from sales tax yields different a market outcome than competition in tax-inclusive prices. In the latter case, the computation of sales tax are performed by the seller and not by the consumer which facilitates consumer decision making with respect to their selection of which store to buy from.

Stronger results are obtained in Section 5 which separates consumers' decision-making into two stages. In the first stage consumers completely ignore sales tax (if sellers quote prices without sales tax). In this scenario, the entire tax burden is shifted on to the consumers and sellers maintain the same price regardless of the tax rate.

The main takeaway from this analysis is that sellers (producers or merchants) in the United States do not have a *collective incentive* to change the existing practice of quoting prices without sales tax. This is because, overall, consumers end up paying more when sellers compete in prices that are separated from sales tax.

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References

Agarwal, Sumit, Nathan Marwell, and Leslie McGranahan. 2017. "Consumption responses to temporary tax incentives: Evidence from state sales tax holidays." *American Economic Journal: Economic Policy* 9 (4):1–27.

Azar, Ofer. 2008. "The effect of relative thinking on firm strategy and market outcomes: A location differentiation model with endogenous transportation costs." *Journal of Economic Psychology* 29 (5):684–697.

Baker, Scott, Stephanie Johnson, and Lorenz Kueng. 2021. "Shopping for lower sales tax rates." *American Economic Journal: Macroeconomics* 13 (3):209–250.

Besley, Timothy and Harvey Rosen. 1999. "Sales taxes and prices: An empirical analysis." *National Tax Journal* 52 (2):157–178.

Bordalo, Pedro, Nicola Gennaioli, and Andrei Shleifer. 2013. "Salience and consumer choice." *Journal of Political Economy* 121 (5):803–843.

———. 2016. "Competition for attention." *Review of Economic Studies* 83 (2):481–513.

———. 2022. "Salience." *Annual Review of Economics* 14:521–544.

Bradley, Sebastien and Naomi Feldman. 2020. "Hidden baggage: Behavioral responses to changes in airline ticket tax disclosure." *American Economic Journal: Economic Policy* 12 (4):58–87.

Brown, Jennifer, Tanjim Hossain, and John Morgan. 2010. "Shrouded attributes and information suppression: Evidence from the field." *Quarterly Journal of Economics* 125 (2):859–876.

Buettner, Thiess and Boryana Madzharova. 2021. "Unit sales and price effects of preannounced consumption tax reforms: Micro-level evidence from European VAT." *American Economic Journal: Economic Policy* 13 (3):103–134.

Carbonnier, Clément. 2007. "Who pays sales taxes? Evidence from French VAT reforms, 1987–1999." *Journal of Public Economics* 91 (5-6):1219–1229.

Cashin, David and Takashi Unayama. 2016. "Measuring intertemporal substitution in consumption: Evidence from a VAT increase in Japan." *Review of Economics and Statistics* 98 (2):285–297.

Chetty, Raj, Adam Looney, and Kory Kroft. 2009. "Salience and taxation: Theory and evidence." *American Economic Review* 99 (4):1145–1177.

Cunningham, Tom. 2011. "Comparisons and choice." Unpublished.

Dahremöller, Carsten and Markus Fels. 2015. "Product lines, product design, and limited attention." *Journal of Economic Behavior and Organization* 119:437–456.

Ellison, Glenn. 2005. "A model of add-on pricing." *Quarterly Journal of Economics* 120 (2):585–637.

Farhi, Emmanuel and Xavier Gabaix. 2020. "Optimal taxation with behavioral agents." *American Economic Review* 110 (1):298–336.

Feldman, Naomi and Bradley Ruffle. 2015. "The impact of including, adding, and subtracting a tax on demand." *American Economic Journal: Economic Policy* 7 (1):95–118.

Gabaix, Xavier and David Laibson. 2006. "Shrouded attributes, consumer myopia, and information suppression in competitive markets." *Quarterly Journal of Economics* 121 (2):505–540.

Goldin, Jacob. 2015. "Optimal tax salience." *Journal of Public Economics* 131:115–123.

Hossain, Tanjim and John Morgan. 2006. "... plus shipping and handling: Revenue (non) equivalence in field experiments on eBay." *The BE Journal of Economic Analysis & Policy* 6 (2). Article 3.

Kroft, Kory, Jean-William Laliberté, René Leal-Vizcaíno, and Matthew Notowidigdo. 2024. "Salience and taxation with imperfect competition." *Review of Economic Studies* 91 (1):403–437.

Martinez-Vazquez, Jorge, Sally Wallace, and Laura Wheeler. 2007. "Overview and comparison of the value added tax and the retail sales tax." Fiscal Research Center Policy Brief, June 2007, number 156. Andrew Young School of Policy Studies, Georgia State University.

Piccione, Michele and Ran Spiegler. 2012. "Price competition under limited comparability." *Quarterly Journal of Economics* 127 (1):97–135.

Thaler, Richard. 1985. "Mental accounting and consumer choice." *Marketing science* 4 (3):199–214.

Tversky, Amos and Daniel Kahneman. 1981. "The framing of decisions and the psychology of choice." *Science* 211 (4481):453–458.

Zodrow, George. 1999. "The sales tax, the VAT, and taxes in between—or, is the only good NRST a "VAT in drag"?" *National Tax Journal* 52 (3):429–442.

Appendix A Derivations of (5) and Result 1

The first-order conditions of (4) are

$$\begin{aligned} 0 = \frac{\partial \pi_A}{\partial q_A} &= N\frac{c_A(1+\tau) + q_B - 2q_A + \Delta V + \mu}{2\mu(1+\tau)} \\ 0 = \frac{\partial \pi_B}{\partial q_B} &= N\frac{c_B(1+\tau) + q_A - 2q_B - \Delta V + \mu}{2\mu(1+\tau)}. \end{aligned} \tag{A.1}$$

The second-order conditions are $\frac{\partial^2 \pi_A}{\partial (q_A)^2} = \frac{\partial^2 \pi_B}{\partial (q_B)^2} = -\frac{N}{\mu(1+\tau)} < 0$. Solving the system of two equations (A.1) for q_A and q_B yields (5). The equilibrium producer prices p_A and p_B are then obtained from (1).

Results 1(a)(b) follow from differentiation of (5) with respect to τ

$$\begin{aligned} \frac{\partial q_A^{\mathrm{I}}}{\partial \tau} &= \frac{2c_A + c_B}{3} > 0, \quad \frac{\partial q_B^{\mathrm{I}}}{\partial \tau} = \frac{c_A + 2c_B}{3} > 0, \\ \frac{\partial p_A^{\mathrm{I}}}{\partial \tau} &= -\frac{\Delta V + 3\mu}{3(1+\tau)^2} < 0, \quad \frac{\partial p_B^{\mathrm{I}}}{\partial \tau} = \frac{\Delta V - 3\mu}{3(1+\tau)^2} < 0. \end{aligned} \tag{A.2}$$

The last inequality sign follows from Assumption 2.

Appendix B Derivation of Result 2

The first-order conditions of (7) are

$$0 = \frac{\partial \pi_A}{\partial p_A} = N\frac{(c_A - 2p_A + p_B)(1+\tau) + \Delta V + \mu}{2\mu} \tag{B.1}$$
$$0 = \frac{\partial \pi_B}{\partial p_B} = N\frac{(c_B + p_A - 2p_B)(1+\tau) - \Delta V + \mu}{2\mu}.$$

The second-order conditions are $\frac{\partial^2 \pi_A}{\partial (p_A)^2} = \frac{\partial^2 \pi_B}{\partial (p_B)^2} = -\frac{N(1+\tau)}{\mu} < 0$. Solving the system of two equations (B.1) for p_A and p_B yields (5). Therefore, both profit-maximization problems (4) and (7) yield identical market outcomes.

Appendix C Derivations of (11), (12), (13) and Result 3

The first-order conditions of (10) are

$$0 = \frac{\partial \pi_A}{\partial p_A} = \frac{\mu + \Delta V - \mathrm{VAT}_A + \mathrm{VAT}_B - 2p_A + p_B + c_A}{2\mu} \tag{C.1}$$
$$0 = \frac{\partial \pi_B}{\partial p_B} = \frac{\mu - \Delta V + \mathrm{VAT}_A - \mathrm{VAT}_B + p_A - 2p_B + c_B}{2\mu}.$$

The second-order conditions are $\frac{\partial^2 \pi_A}{\partial (p_A)^2} = \frac{\partial^2 \pi_B}{\partial (p_B)^2} = -\frac{N}{\mu} < 0$. Solving the system of two equations (C.1) for p_A and p_B yields (11) and hence (12). Substituting p_A and p_B from (12) into (9) and (10) yields (13).

Result 3(a) follows from (12) because

$$\frac{\partial q_A^{\mathrm{II}}}{\partial \tau} = \frac{\mu(4\tau^2 + 12\tau + 9) + \Delta V + c_A(2\tau^2 + 6\tau + 5) + 2c_B(\tau^2 + 3\tau + 2)}{(2\tau+3)^2} > 0, \tag{C.2}$$
$$\frac{\partial q_B^{\mathrm{II}}}{\partial \tau} = \frac{\mu(4\tau^2 + 12\tau + 9) - \Delta V + 2c_A(\tau^2 + 3\tau + 2) + c_B(2\tau^2 + 6\tau + 5)}{(2\tau+3)^2} > 0.$$

The second inequality sign follows from Assumption 2 which states that $\mu > \Delta V$.

Result 3(b) follows from

$$\frac{\partial p_A^{\mathrm{II}}}{\partial \tau} = -\frac{\Delta c + 2\Delta V}{(2\tau+3)^2} < 0, \quad \frac{\partial p_B^{\mathrm{II}}}{\partial \tau} = \frac{\Delta c + 2\Delta V}{(2\tau+3)^2} > 0. \tag{C.3}$$

Appendix D Derivation of Result 5

First, it has to be verified that $U_{AA}^{(2)}(x) \geq U_{AB}^{(2)}(x)$. Substituting the equilibrium prices (18) into the second stage utilities (16) using $q_A^{\text{III}} = p_A^{\text{III}}(1+\tau)$ and $q_B^{\text{III}} = p_B^{\text{III}}(1+\tau)$, it has to be shown that

$$V_A - (1+\tau)\left(\mu + \frac{\Delta V + 2c_A + c_B}{3}\right) \geq V_B - (1+\tau)\left(\mu + \frac{-\Delta V + c_A + 2c_B}{3}\right) - \mu \cdot 1, \quad \text{(D.1)}$$

which holds if

$$\mu \geq \frac{(1-2\tau)\Delta V - \Delta c(1+\tau)}{3}. \quad \text{(D.2)}$$

The above inequality holds because $\mu > \Delta V$ by Assumption 2, and ΔV is greater than the right-hand-side of (D.2).

Next, it has to be verified that $U_{BB}^{(2)}(x) \geq U_{BA}^{(2)}(x)$ or

$$V_B - (1+\tau)\left(\mu + \frac{-\Delta V + c_A + 2c_B}{3}\right) \geq V_A - (1+\tau)\left(\mu + \frac{\Delta V + 2c_A + c_B}{3}\right) - \mu \cdot 1, \quad \text{(D.3)}$$

which holds if

$$\mu \geq \frac{(1-2\tau)\Delta V - \Delta c(1+\tau)}{3}. \quad \text{(D.4)}$$

The above inequality holds because $\mu > \Delta V$ by Assumption 2, and ΔV is greater than the right-hand-side of (D.4).