Is Sales Tax Included in the Price? How Consumer Inattention Affects Prices

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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 able to compute the exact sales tax each time they compare prices of different sellers and different brands. With slow-computing consumers, prices and profits are higher when sellers quote and compete in prices without sales tax.

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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.[2]

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 checkout payment 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 and consumer inattention could have different consequences for the intensity of price competition among retailers.

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. New Hampshire, Oregon, Montana, Alaska, and Delaware (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.[3]

Using a simple model of imperfectly-competitive sellers, I analyze price competition

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[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).

[2] Unit tax (also known as excise tax) is not analyzed because, unlike ad-valorem tax, it is embedded into the price even in the United States. Unit tax is often observed in sectors such as alcohol, tobacco, and fuel.

[3] 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/.

under the two pricing structures. With fast-computing consumers, who are able and willing to compute the exact sales tax each time they compare prices of different brands or different sellers, 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 fast-computing consumers' choice of which brand to purchase.

The model then shifts to analyzing slow-computing consumers who do not compute sales tax at the initial stage when they compare prices and select which brand to buy or which seller to buy from. Sellers then compete in prices to attract customers, taking into account that some consumers ignore sales tax during the brand search stage if they quote prices without tax. After these consumers select a brand (or from which seller to buy from), consumers pay the price plus sales tax and take delivery of the product or service.

The assumption that some consumers are slow-computing could be explained by consumers' desire to lower their "mental accounting" cost, Thaler (1985). That is, when prices are quoted without sales tax, these consumers do not bother to compute the sales tax when they decide which brand to buy or which seller to buy from. In that sense, consumers perceive the selection of a brand when 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).

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). Kroft et al. (2024) analyze the effect of sales tax salience on the distribution of the

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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 compete in prices against each other to attract customers to their store and brand.

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 conclude 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. Taubinsky and Rees-Jones (2018) conduct an experiment of online shopping for household products and find that consumers react to sales tax as if they were only 25-percent of their actual magnitude (with significant individual variations). Blake et al. (2021) find that the full purchase price salient to consumers reduces both the quality and quantity of goods purchased.

The empirical and experimental findings described above in which demand is lower when consumers face tax-inclusive prices (as opposed to prices before tax) is consistent with the main result of this paper which shows that equilibrium prices are lower when sellers compete in tax-inclusive prices and some consumers are slow-computing. However, the reasoning is slightly different. In Chetty, Looney, and Kroft (2009), Feldman and Ruffle (2015), Bradley and Feldman (2020), and Blake et al. (2021) consumers demand less when they face tax-inclusive prices. In the theoretical model analyzed in this paper, sellers compete more aggressively 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. More recently, using data on gasoline prices in separate Greek Islands, Dimitrakopoulou et al. (2024) find that VAT pass-through increases with competition, going from 50 percent in monopoly to around 80 percent in more competitive markets,

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 Section 3 in Bernheim and Taubinsky (2018). Research that integrates these behavioral aspects with price competition includes Ellison (2005), Azar (2008), Cunningham (2011), Piccione and Spiegler (2012), and Bordalo, Gennaioli, and Shleifer (2016).

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). Section 4 compares the two pricing structures and analyzes the effects of fast- and slow-computing consumers on equilibrium prices and profits. Section 5 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 rarely 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 "seller" prices received by merchants 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 of brand A and brand B are denoted by $V_A > 0$ and $V_B > 0$, 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, $\Delta V \geq 0$.*

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(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, $\Delta V \geq \Delta c(1 + \tau)$.

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) ensures that brand A (the high-quality brand) captures some market share under price competition. It means that the additional value of producing brand A relative to brand B exceeds the additional cost of producing A relative to 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 1 illustrates a possible allocation of consumers according to their choice of whether to purchase brand A or brand B.

$$N \;\text{-----}\; \overset{n_A \;=\; N\,\hat{x}}{\underset{\text{Buy brand } A}{}} \;\text{-----}\; \overset{n_B \;=\; N\,(1 - \hat{x})}{\underset{\text{Buy brand } B}{}} \;\text{---}\; N$$

$$0 \qquad\qquad\qquad\qquad \hat{x} \qquad\qquad\qquad 1 \qquad x$$
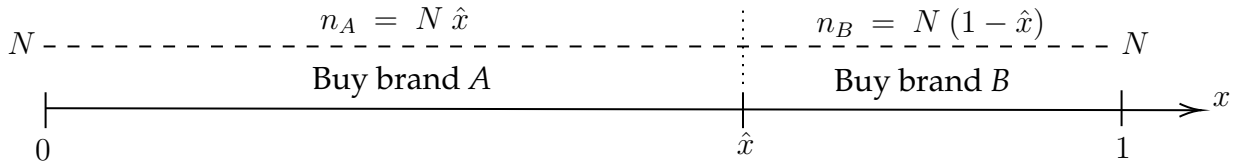
Figure 1: Consumers' choice whether to buy brand A or B.

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

Formally, the utility of a consumer indexed by x, $0 \leq x \leq 1$, is[4]

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

The parameter $\lambda > 0$ could be interpreted in several ways: (i) Travel (location) cost-per-mile to the seller of a brand. In this case, the interval $[0,1]$ is interpreted as the linear city according to Hotelling (1929) where store A is located on the left side and store B on the right hand side. (ii) The degree of product differentiation. Higher values λ correspond to more differentiated brands in consumer preferences. Consequently, (iii) higher values of λ also reflect stronger market power (weaker competition between the brand-producing sellers), which results in higher equilibrium prices and profits.

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

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

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. *The product differentiation parameter is sufficiently large. Formally, $\lambda > \Delta V$.*

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

In view of Figure 1, 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

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[4]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). Section 3 slightly modifies this utility function to capture slow-computing consumers who compare brand prices before sales tax is added.

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

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

$$\max_{q_B} \pi_B = (p_B - c_B)N(1 - \widehat{x}) = \left(\frac{q_B}{1+\tau} - c_B\right) N \left(\frac{1}{2} - \frac{\Delta V + q_B - q_A}{2\lambda}\right),$$

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 seller prices.

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

$$p_A^{\mathrm{I}} = \frac{q_A^{\mathrm{I}}}{(1+\tau)}, \quad \text{and} \quad p_B^{\mathrm{I}} = \frac{q_B^{\mathrm{I}}}{1+\tau},$$

where the superscript "I" (for "inclusive") 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

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

$$\pi_B^{\mathrm{I}} = N\frac{[3\lambda - \Delta V + \Delta c(1+\tau)])^2}{18\lambda(1+\tau)}. \tag{6}$$

Note that $0 < \widehat{x}^{\mathrm{I}} < 1$ by Assumption 1(c) and Assumption 2. The equilibrium prices (5) and profits (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, the equilibrium prices and profits increase when the brands become more differentiated (an increase in the parameter λ).

The following results, derived in Appendix A, summarize the consequences of com-

petition in tax-inclusive prices.

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.*

(b) *Seller 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 2. There are two sets of prices in Figure 2, one for brand A
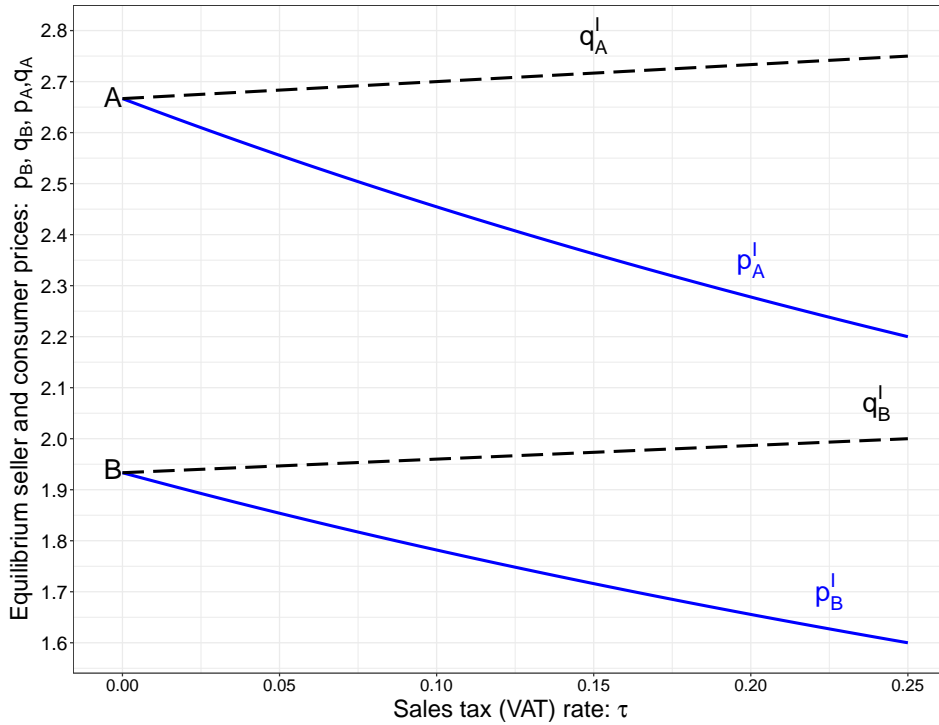

Figure 2: Equilibrium seller and consumer prices of brands A or B when sellers compete in tax-inclusive prices.

Notes: All prices are drawn from (5). Consumer prices q_A^I, q_B^I are drawn in dashed black lines. Seller prices p_A^I, p_B^I are drawn in solid blue lines. The figure is based on $\lambda = 2$, $\Delta V = 1$, $c_A = 0.4$, $c_B = 0.2$, and $\tau \in [0, 0.25]$ (zero to 25-percent sales tax).

and one for brand B. Equilibrium prices of brand A are higher than prices of brand B because brand A has higher quality ($\Delta V = V_A - V_B > 0$).

The dashed (black) lines $q_A^{\rm I}$ and $q_B^{\rm I}$ in Figure 2 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 2 by the solid (blue) lines $p_A^{\rm I}$ and $p_B^{\rm I}$. These prices decline steeply with higher tax rates τ which indicate that competition in tax-inclusive prices is very intense.

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.

ASSUMPTION 3. *There are two types of consumers: (i) A fraction σ, $\sigma \in [0,1]$, of the N consumers are **slow-computing** who disregard sales tax when they compare prices and choose between brands A and B. (ii) A fraction $(1-\sigma)$ of the N consumers are **fast-computing** and compare tax-inclusive prices of brands A and B even when prices are quoted without sales tax.*

The utility function (2) is now extended to include both consumer types.

$$U(x) = \begin{cases} V_A - p_A(1+\tau) - \lambda x & \text{if buys brand } A \text{ (fast-computing consumer)} \\ V_A - p_A - \lambda x & \text{if buys brand } A \text{ (slow-computing consumer)} \\ V_B - p_B(1+\tau) - \lambda(1-x) & \text{if buys brand } B \text{ (fast-computing consumer)} \\ V_B - p_B - \lambda(1-x) & \text{if buys brand } B \text{ (slow-computing consumer).} \end{cases} \tag{7}$$

That is, *ex-ante*, slow-computing consumers compare only the prices p_A and p_B that are quoted by the sellers (without the tax) when deciding which brand to purchase. However, *ex-post*, they will end up paying the tax-inclusive prices $q_A = p_A(1+\tau)$ and $q_B = p_B(1+\tau)$ which will be computed for them at the store's checkout counter during the last stage of the transaction (the payment stage).

Using the same method for computing the consumers who are indifferent between brand A and brand B given in (3), the utility functions (7) imply that fast- and slow-

computing consumers who are indifferent between buying brands A and B are

$$\widehat{x}^f = \frac{1}{2} + \frac{\Delta V + (p_B - p_A)(1+\tau)}{2\lambda} \quad \text{and} \quad \widehat{x}^s = \frac{1}{2} + \frac{\Delta V + p_B - p_A}{2\lambda}, \tag{8}$$

where superscripts "f" and "s" denote fast-computing and slow-computing consumers, respectively. Note that $\widehat{x}^f$ is the same as $\widehat{x}$ in (3) because fast-computing consumers consider only ex-post tax-inclusive prices even when sellers quote prices without tax. In terms of Figure 1, there are now two values of $\widehat{x}$, one for fast-computing $\widehat{x}^f$ and one for slow-computing consumers $\widehat{x}^s$.

Because prices are quoted without tax (p_A, p_B instead of q_A, q_B), the profit maximization problems (4) are now modified to

$$\max_{p_A} \pi_A = (p_A - c_A)N\left[(1-\sigma)\widehat{x}^f + \sigma\widehat{x}^s\right], \tag{9}$$

$$\max_{q_B} \pi_B = (p_B - c_B)N\left[(1-\sigma)(1-\widehat{x}^f) + \sigma(1-\widehat{x}^s)\right],$$

where $\widehat{x}^f$ and $\widehat{x}^s$ are specified in (8). Substituting $\widehat{x}^f$ and $\widehat{x}^s$ from (8) into (9), Appendix B derives the following equilibrium prices as functions of the fraction of slow-computing consumers σ.

$$p_A^E = \frac{3\lambda + \Delta V + (2c_A + c_B)(1 + \tau - \sigma\tau)}{3(1 + \tau - \sigma\tau)}, \tag{10}$$

$$p_B^E = \frac{3\lambda - \Delta V + (c_A + 2c_B)(1 + \tau - \sigma\tau)}{3(1 + \tau - \sigma\tau)},$$

where superscript "E" (for "exclusive" as opposed to "I" for "inclusive") denotes prices when sellers quote tax-exclusive prices (prices without sales tax). Substituting the equilibrium prices (10) into (8) and then into (9) yields the equilibrium profits

$$\pi_A^E = \frac{N\left\{3\lambda + \Delta V - \Delta c(1 + \tau - \sigma\tau)\right\}^2}{18\lambda(1 + \tau - \sigma\tau)}, \tag{11}$$

$$\pi_B^E = \frac{N\left\{3\lambda - \Delta V + \Delta c(1 + \tau - \sigma\tau)\right\}^2}{18\lambda(1 + \tau - \sigma\tau)}.$$

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4. A comparison of the two pricing structures

This section derives the main results. It compares prices and profits when firms quote and compete in tax-inclusive prices, (5) and (6), to equilibrium prices and profits when firms quote and compete in prices without sales tax, (10) and (11). The key parameter for these comparisons is the fraction σ of slow-computing consumers. In one extreme, $\sigma = 0$ implies that there are no slow-computing consumers and all consumers are fast-computing. In the opposite extreme, $\sigma = 1$ implies that all consumers are slow-computing.

Substituting $\sigma = 0$ into (10) and (11) yields (5) and (6). Therefore,

Result 2. *If all consumers are fast-computing, prices and profits when sellers compete in prices without sales tax (10) and (11) are the same as when sellers compete in tax-inclusive prices (5) and (6). Formally, $p_A^E = p_A^I$, $p_B^E = p_B^I$, $\pi_A^E = \pi_A^I$, and $\pi_B^E = \pi_B^I$ when $\sigma = 0$.*

Result 2 is rather intuitive. If all consumers are fast-computing, they can figure out the tax-inclusive prices even when sellers quote prices without sales tax. Then, they choose whether to purchase brand A or brand B based on tax-inclusive prices. Thus, when $\sigma = 0$, the intensity of price competition between seller A and seller B is unaffected by whether sellers compete in tax-inclusive prices or prices without sales tax.

Suppose now that some consumers are slow-computing ($\sigma > 0$). Based on the equilibrium prices and profits (10) and (11), Appendix B derives the following results.

Result 3. *Suppose sellers compete by quoting prices without sales tax. Then,*

(a) An increase in the fraction of slow-computing consumers will increase both prices and profits. Formally, $\frac{\partial p_A^E}{\partial \sigma} > 0$, $\frac{\partial p_B^E}{\partial \sigma} > 0$, $\frac{\partial \pi_A^E}{\partial \sigma} > 0$, and $\frac{\partial \pi_B^E}{\partial \sigma} > 0$. Hence,

(b) Consumers are worse off and sellers are better off with an increase in the fraction of slow-computing consumers (an increase in σ).

Result 3(a) is illustrated in Figure 3. In Figure 3, prices reach their lowest levels when there are no slow-computing consumers ($\sigma = 0$). At $\sigma = 0$, Result 2 shows that these prices are equal to the equilibrium prices when sellers compete in tax-inclusive prices. This is
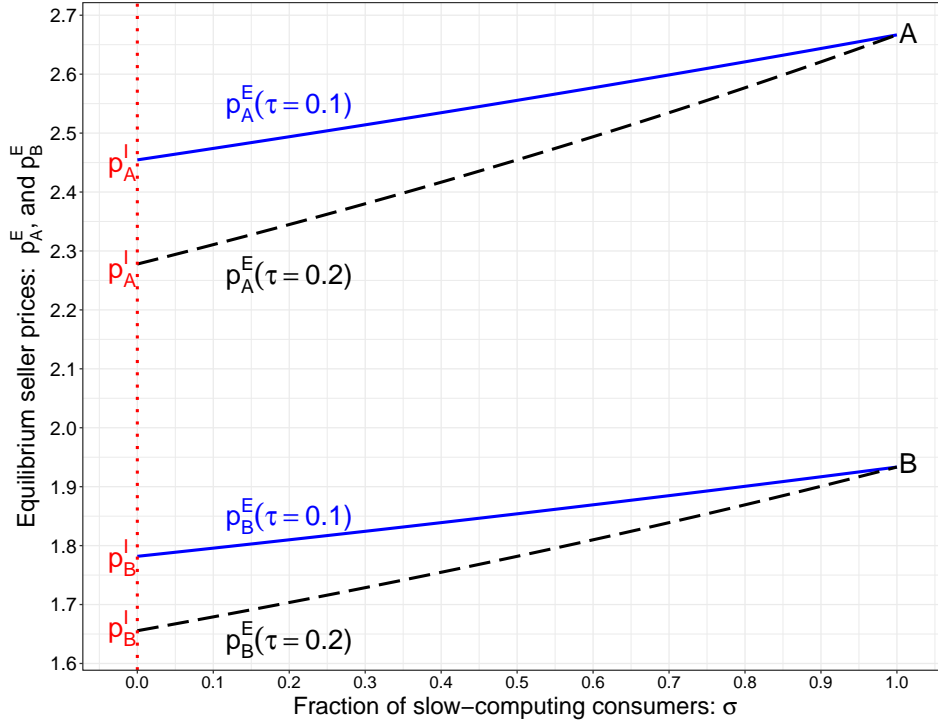
Figure 3: Seller prices of brand A or B when sellers compete in prices without sales tax.

Notes: Seller prices are drawn from (10). The figure is based on $\lambda = 2$, $\Delta V = 1$, $c_A = 0.4$, $c_B = 0.2$, $\tau \in \{0.1, 0.2\}$ (10 and 20 percent sales tax rates), and $\sigma \in [0, 1]$ (zero to 100-percent fraction of slow-computing consumers). The prices p_A^I and p_B^I near the dotted vertical line illustrate Result 2 where $p_A^E = p_A^I$ and $p_B^E = p_B^I$.

where seller competition is most intense. As σ increases, prices and profits rise and reach their highest levels when all consumers become slow-computing ($\sigma = 1$). This is where seller competition is the weakest. Therefore, slow-computing consumers inflict a negative externality on fast-computing consumers because they weaken price competition which results in higher prices.

Result 3(a) and Result 2 imply the following results.

Result 4. *Suppose that some consumers are slow-computing ($\sigma > 0$). Then,*

(a) Prices and profits are higher when sellers compete in prices without sales tax compared to competition in tax-inclusive prices. Formally, $p_A^E > p_A^I$, $p_B^E > p_B^I$, $\pi_A^E > \pi_A^I$, and $\pi_B^E > \pi_B^I$. Hence,

(b) Consumers are worse off and sellers are better off when sellers compete in prices that are quoted to consumers without sales tax.

Result 4 is also illustrated in Figure 3. It shows that prices are higher when evaluated at any $\sigma > 0$ compared with prices evaluated at $\sigma = 0$. By Result 2, prices evaluated at $\sigma = 0$ are equal to equilibrium prices when sellers compete in tax-inclusive prices.

Finally, substituting $\sigma = 1$ into (10) and (11) eliminates the tax rate τ from all four equations. Therefore, the last result reports on the opposite extreme of Result 2.

Result 5. *If all consumers are slow-computing ($\sigma = 1$), prices p_A^E, p_A^E and profits π_A^E, π_B^E reach their highest level and do not change with the sales tax rate τ.*

Result 5 is also illustrated in Figure 3. The figure shows that the price of each brand is the same when $\sigma = 1$ regardless of whether the sales tax rate is 10-percent or 20-percent. Intuitively, the utility functions (7) imply that slow-computing consumers initially ignore sales tax when they compare prices between the two sellers. Therefore, when all consumers are slow-computing ($\sigma = 1$), firms also ignore sales tax knowing that consumers compare only prices without sales tax. This weakens price competition between the two sellers which facilitates setting high prices.

5. Conclusion and Takeaway

Consumers may not be able to process information as fast as spreadsheets. Spreadsheets are designed so that changes made on the seller's price column result in an immediate automatic adjustment of the tax-inclusive price column. But consumers may not be willing or able to process information that fast. This article analyzes scenarios where a fraction of consumers is slow to compute tax-inclusive prices when sellers quote prices without sales tax. Sellers, in turn, take advantage of this consumer behavior when adjusting their price. That explains why price competition when prices are quoted separately from sales tax is weaker than competition in tax-inclusive prices.

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The key parameter in this model is the fraction σ of slow-computing consumers. These consumers ignore sales tax when they compare prices of different brands or different sellers. There are at least two ways in which σ could be interpreted: (i) For repeated purchases of the same item, consumers may eventually memorize the tax-inclusive prices, in which case σ will decrease over time. (ii) σ may differ across products and services. Specifically, σ may be lower for expensive items in which the tax portion of the payment is significantly large. In contrast, σ is larger for low-cost items in which the sales tax portion is very small.

The finding that tax-inclusive pricing enhances competition may support a policy that requires sellers to post prices inclusive of all fees and taxes. Indeed, some industries, such as airlines and hotels, already face legal requirements to include fees and taxes in their advertised prices. The findings in this article support this policy.

Finally, the analysis in this article focused mainly on horizontal brand differentiation as in Hotelling (1929) with a possible combination of some vertical (quality) differentiation when $\Delta V > 0$ (as opposed to $\Delta V = 0$). A similar analysis could be conducted using an alternative model by replacing completely horizontal differentiation and working out the equilibria under vertical differentiation only.[5]

Appendix A Derivations of (5) and Result 1

The first-order conditions of (4) are

$$0 = \frac{\partial \pi_A}{\partial q_A} = N \frac{c_A(1+\tau) + q_B - 2q_A + \Delta V + \lambda}{2\lambda(1+\tau)}, \tag{A.1}$$

$$0 = \frac{\partial \pi_B}{\partial q_B} = N \frac{c_B(1+\tau) + q_A - 2q_B - \Delta V + \lambda}{2\lambda(1+\tau)}.$$

The second-order conditions are $\frac{\partial^2 \pi_A}{\partial (q_A)^2} = \frac{\partial^2 \pi_B}{\partial (q_B)^2} = -\frac{N}{\lambda(1+\tau)} < 0$. 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

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[5]To focus only on vertically-differentiated brands with no horizontal differentiation, the utility function (2) can be replaced with $U_A(x) = \alpha x - q_A$ and $U_B(x) = \beta x - q_B$, where $\alpha > \beta \geq 0$. In this case, brands A and B become *vertically differentiated* because, under equal consumer prices $q_A = q_B$, all the N consumers indexed by any $x \in [0, 1]$ prefer brand A over brand B.

then obtained from (1).

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

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

The last inequality sign follows from Assumption 2.

Appendix B   Derivations of (10) and Result 3

Substituting $\widehat{x}^f$ and $\widehat{x}^s$ from (8) into (9), the first order conditions are

$$0 = \frac{\partial \pi_A}{\partial p_A} = \frac{N\left[\lambda + \Delta V + (c_A - 2p_A + p_B)(1 + \tau - \sigma\tau)\right]}{2\lambda}, \tag{B.1}$$
$$0 = \frac{\partial \pi_B}{\partial p_B} = \frac{N\left[\lambda - \Delta V + (c_B + p_A - 2p_B)(1 + \tau - \sigma\tau)\right]}{2\lambda}.$$

The second-order conditions are $\frac{\partial^2 \pi_A}{\partial(p_A)^2} = \frac{\partial^2 \pi_B}{\partial(p_B)^2} = -\frac{N(1+\tau-\sigma\tau)}{\lambda} < 0$. Solving (B.1) for p_A and p_B yields (10).

To prove Result 3(a), differentiating (10) yields

$$\frac{\partial p_A}{\partial \sigma} = \frac{(3\lambda + \Delta V)\tau}{3(1 + \tau - \sigma\tau)^2} > 0, \quad \frac{\partial p_B}{\partial \sigma} = \frac{(3\lambda - \Delta V)\tau}{3(1 + \tau - \sigma\tau)^2} > 0, \tag{B.2}$$

where the last inequality sign follows from Assumptions 2. Differentiating (11) yields

$$\frac{\partial \pi_A}{\partial \sigma} = \frac{N\tau\left\{(3\lambda + \Delta V)^2 - [\Delta c(1 + \tau - \sigma\tau)]^2\right\}}{18\lambda(1 + \tau - \sigma\tau)^2} > 0, \tag{B.3}$$
$$\frac{\partial \pi_B}{\partial \sigma} = \frac{N\tau\left\{(3\lambda - \Delta V)^2 - [\Delta c(1 + \tau - \sigma\tau)]^2\right\}}{18\lambda(1 + \tau - \sigma\tau)^2} > 0,$$

where the inequality signs follow from Assumptions 1(c) and 2.

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