Cross-border or Online – Tax Competition with Mobile Consumers under Destination and Origin Principle

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Abstract

This paper studies the effect of an online retailer on spatial tax competition with mobile consumers. Under non-cooperative Leviathan governments, tax treatment of online purchases according to the destination principle mitigates tax competition; tax treatment of online purchases of online purchases according to the origin principle enhances tax competition. Cooperation between government eliminates the potential pro-competitive effect of the online retailer: Under both tax treatments, the online retailer weakens tax competition. For a sufficiently low tax rate in the country hosting the online retailer, welfare in the online retailer's home country is higher under the origin principle, while welfare in the other country is higher under the destination principle. For a sufficiently low tax differential between both countries, global welfare is higher under the destination principle.

JEL Classification: F12, H20, L13

Keywords: tax competition, cross-border shopping, online retailer, destination principle, origin principle

1 Introduction

Tax differentials are one potential determinant of shopping decisions. In particular, cross-border shopping or buying online may allow consumers to benefit from lower tax rates in other jurisdictions. For tax revenue maximizing governments, attracting mobile consumers, cross-border or online shoppers, may also be a goal in tax policy and thus drive tax competition among governments.

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The interaction of mobile consumers and tax competition for mobile consumers is relevant in European Union: Cross border shopping is a frequent phenomenon in the European single market, with the free movement of goods, capital, services, and persons weakening the importance of national borders. In 2008, 25% of consumers in the European Union purchased goods or services in other member states (Eurostat, 2009). The extent of cross-border shopping is determined by country size, geographical location, and the close proximity of neighboring countries.[1] With the growth of internet use, online shopping has also become more important (European Commission, 2010). In 2014, 50% of citizens in the European Union made purchases online (European Commission, 2015).[2] At the same time, autonomous decisions of member states on tax policy may give rise to tax competition. Member states are free to set value-added tax rates with a minimum standard tax rate of 15% (Art. 97 Directive 2006/112/EC). Tax rates vary between high tax countries such as Hungary (27%), Croatia (25%), Denmark (25%), and Sweden (25%) and low tax countries such as Luxembourg (17%), Malta (18%), Cyprus (19%), Germany (19%), and Romania (19%). Similarly, in the United States, states may compete for mobile consumers, which may shop cross-border and/or online.

The tax treatment of cross-border transactions and online purchases may drive the incentives of consumers to turn their back on their local brick-and-mortar store and to buy at a brick-and-mortar store in another country or to buy online. Typically, cross-border shopping is tax treated according to the origin principle. Choosing whether to buy at the local brick-and-mortar store or at the brick-and-mortar store in neighboring jurisdiction allows consumers to benefit from tax differentials. If online purchases are tax treated according to the destination principle, buying online does not allow consumers to benefit from tax differentials. Choosing whether to buy at the local brick-and-mortar store or online involves paying the same tax rate then, the tax rate set by the country of residence. If online purchases are tax treated according to the origin principle, the situation for consumers living in the country hosting the online retailer is similar. However, in a country not hosting the online retailer, buying online allows consumers to

[1] 68 % of consumers in Luxembourg have purchased goods or service in other member states. In contrast, in countries at the European periphery the prevalence of cross-border shopping is much lower, e.g., 10 % of consumers in Greece and 9 % of consumers in Portugal and Bulgaria have purchased goods abroad (Eurostat, 2009).

[2] Consumers show a substantial degree of home bias for online shopping: In 2014, 44% of consumers purchased online nationally, only 15% bought from an online retailer from another EU country (European Commission, 2015). Cowgill, Dorobantu & Martens (2013) estimate from Google e-commerce data that over the period 2008-2011, online consumers in the EU were up to 55 times more likely to buy in their own country than in another EU country. Consumers from smaller countries are more likely to purchase from retailers from other member states, e.g., 42% of consumers in Malta have purchased from an online retailer from another country vs. 11% who purchased from a domestic online seller (Flash Eurobarometer 358, 2012).

benefit from tax differentials. The effect of the tax treatment of online purchases on consumers' shopping decisions, in turn, drives governments' incentives to engage in tax competition for mobile consumers. If tax treatment of online purchases according to the destination principle does not expose consumers buying online to tax differentials, the potential to compete for mobile consumers is lower; if tax treatment of online purchases according to the origin principle exposes consumers to tax differentials, the potential to compete for mobile consumers is higher.

For cross-border shopping within the EU, the origin principle applies (Art. 31 Directive 2006/112/EC). For online purchases, also the origin principle applies in principle (Art. 32 Directive 2006/112/EC) unless the recipient is a private household. In this case, the destination principle applies (Art. 33 Directive 2006/112/EC). If sales are below a threshold of 100,000 Euros, the origin principle may apply (Art. 34 Directive 2006/112/EC). This implies, for the majority of online purchases by private households, the destination principle applies. In general, for the supply of services to private households, the origin principle applies (Art. 45 Directive 2006/112/EC). For electronic services such as telecommunications services, supply of software, and supply of music, films and games, however, the taxation principle has changed, and the destination principle applies since January 2015 (Art. 5 Directive 2008/8/EC, Art. 58 and Annex II Directive 2006/112/EC).[3]

In the USA, most states levy sales taxes, but there is no uniform sales tax on the federal level. Cross-border shopping is tax treated according to the origin principle. Before 2018, states usually were only able to collect sales taxes from online stores in other US states, if they had a "nexus" to the respective state. Typically this required the online retailer to have a (permanent or temporary) physical presence in the state. If an online store did not have a nexus to the state, the tax authorities depended on tax declaration by users for tax collection (use tax) (Hu & Tang, 2014). In June 2018, the Supreme Court of the United States has decided that states may charge sales taxes based on remote purchases made by sellers from another state which have no physical presence in the state where the customer resides (South Dakota v. Wayfair, Inc.). After the Supreme Court's decision, most federal states that levy a sales tax have started to introduce laws requiring online sellers to collect sales taxes, even if they have no physical presence in the state. This requirement is – following the Supreme Court's decision – usually conditional on

[3] According to European Commission (2014), the 2008-amendment implies that "the advantage for companies to relocate [...] [to member states with a low VAT] for tax reasons is removed". Especially Luxembourg with a very low standard tax rate of 15% **(at this time)** might lose its attractiveness for companies such as Amazon, Skype, and PayPal. It **was** estimated that this new rule will result in a loss of tax revenues of € 200 million per year for Luxembourg (Castle, 2007).

the online seller making a minimum revenue of USD 100,000 in the respective sate or having at least 200 transactions per year in the respective state (Prete, 2018; Rosenberg, 2018). De facto, this corresponds to the destination principle being applied for online sales subject to a de minimis clause.

Previous literature on tax competition and cross-border shopping has emphasized the importance of differences between countries (see e.g., Kanbur & Keen, 1993; Nielsen, 2001), typically finding that the smaller country undercuts the tax rate of the larger country. In their seminal paper, Kanbur & Keen (1993) study revenue-maximizing governments in an open economy with two countries differing in population size. In the non-cooperative Nash equilibrium, the tax rate of the smaller country is lower than the tax rate in the larger country. Subsequent studies have also focused on differences between countries, in population size (Trandel 1994; Wang 1999) or geographical size (Ohsawa 1999; Nielsen 2001, 2002).[4]

Several empirical studies have stressed the effect of taxes on shopping decisions. Goolsbee (2000) finds that consumers in high sales tax locations are more likely to buy online. A 1%-increase in the sales tax increases the probability of buying online by 0.5%. Ballard and Lee (2007) show that consumers shop online to avoid sales taxes. They also find that consumers who live close to counties with lower sales tax rates are less likely to shop online. Leal, Lopez-Laborda & Rodrigo (2010) interpret these findings as cross-border shopping and Internet shopping being substitutes. Using eBay data, Einav et al. (2014) estimate the impact of sales taxes on online shopping. They find that a one percentage point increase in a state's sales tax increases online purchases by state residents by approximately 2 percent, but decreases their online purchases from home-state retailers by 3-4 percent. Using data from a retailer that sells through the Internet and catalogs, Hu & Tang (2014) study the effect of sales tax changes, finding that a tax cut by 4 percentage points has decreased remote sales by about 15%. Agrawal (2017) shows that an increase in Internet penetration decreases sales taxes, in low-tax jurisdictions by more than in high-tax jurisdictions.

Two recent papers have studied the effect of online shopping on tax competition in a spatial framework following Kanbur & Keen (1993) and Nielsen (2001). Agrawal (2017) compares the effect of online shopping on tax rates for tax-free online purchases and taxed online purchases in a spatial framework with perfect competition among physical stores. He assumes that the

[4] See Leal, Lopez-Laborda & Rodrigo (2010) for a survey on theoretical and empirical studies on cross-border shopping.

group of online shoppers is not the same as the group of cross-border shoppers. Agrawal (2017) finds that tax rates fall if online purchases are tax-free and tax rates increase if online purchases are subject to sales taxes. Bacache Beauvallet (2018) studies the effect of online shopping on tax competition under the destination and origin principle in a spatial framework with perfect competition. She shows that online shopping reduces tax competition under the origin principle. Bacache Beauvallet (2018) assumes that online shopping is subject to fiscal leakage and that two types of consumers exist, with one type preferring to shop offline, while the other type has weak preferences for shopping online.

In contrast, this paper uses a spatial framework with two brick-and-mortar stores at the endpoints of the Hotelling line (as e.g., in Aiura & Ogawa (2013)) to study the effect of an online retailer on tax competition under destination principle and origin principle. Differences in the consumers' location on the Hotelling line then translate to different traveling cost for purchases at the brick-and-mortar stores. Online shopping involves a fixed cost. With different traveling cost to brick-and-mortar stores, consumers have different incentives to shop online instead and pay the fixed cost instead of the traveling cost. This is, other than in Bacache Beauvallet (2018), the fraction of online shoppers is endogenous in the model. Other than in Agrawal (2017), consumers located close to the border may be both potential cross-border shoppers and online shoppers, with online shopping as a way to trade high traveling cost for fixed cost of online shopping. This is in line with the interpretation of cross-border shopping and online shopping as substitutes (as in Ballard & Lee (2007). Without additional or exogenous assumptions about the distribution or cost of online shoppers, this paper can explain how the tax treatment of online purchases may shape governments‘ incentives to compete for mobile consumers – mobile in the sense of cross border shopping and online shopping.

In this framework, the entry of the online retailer increases product market competition under both taxation principles, but weakens tax competition under the destination principle and enhances tax competition under the origin principle. Consumers in the center of the Hotelling line shop online to avoid high traveling cost for purchases at brick-and-mortar stores. Under the destination principle, buying online involves paying the same tax rate as for purchases at the local brick-and-mortar stores, shutting down strategic interaction between governments and thus tax competition. Under the origin principle, consumers located in the country not hosting the online shop choose between paying different tax rates when choosing between buying online or at the local brick-and-mortar store. This allows governments to compete for mobile consumers, with the country hosting the online shop setting a higher tax rate than the other country. Thus, under the destination principle, the online retailer eliminates competition for mobile consumers, which is similar to the closed-borders case of Kanbur & Keen (1993). Under the origin principle, the online retailer shifts competition for mobile consumers to the country not hosting the online retailer. The smaller country in terms of tax base (which is the country not hosting the online retailer) undercuts the tax rate of the larger country, which is equivalent to the result of Kanbur & Keen (1993) and Nielsen (2001) of the smaller country undercutting the tax rate of the larger country.

For a sufficiently low tax rate in the country hosting the online retailer, welfare in the online retailer's home country is higher under the origin principle, while welfare in the other country is higher under the destination principle. For a sufficiently low tax differential between both countries, global welfare is higher under the destination principle. A high tax differential under the destination principle shifts market shares from the brick-and-mortar store in the country with the higher tax rate to the brick-and-mortar store in the country with the lower tax rate. Also, the price-tax margin is lower for the brick-and-mortar store in the country with the higher tax rate. In addition, a high tax differential decreases the profit of the online shop, which sets a single price but is taxed differently in both countries.

The rest of the paper is organized as follows. The next section presents the model. Section 3 analyzes the effect of the entry of the online retailer on tax competition and welfare. Section 4 studies the role of governments. Section 5 discusses the role of market structure, location choices, and country size asymmetries. Section 6 concludes.

2 The Model

Consider a Hotelling economy with two countries, $j = H$, F (home, foreign) on the line segment $[0, 1]$, with country H extending to the interval $[0, \frac{1}{2}]$, country F to the interval $[\frac{1}{2}, 1]$. In each country, there is a brick-and-mortar shop $i = H, F$ located at the endpoint ($x_H = 0$, $x_F = 1$). An online shop $i = 0$ is located in country H. Firms sell a single homogeneous product at price p_i. Firms produce at constant marginal cost, which is normalized to zero.

Cross-border shopping is tax treated according to the origin principle; online shopping may be tax treated according to destination principle or origin principle.

2.1 Consumers

A unit mass of consumers is uniformly distributed on the line segment. Consumers differ in location $y \in [0,1]$. The utility of a consumer located at y and buying from the brick-and-mortar store i is given by

$$U_i = v - d\,|y - x_i| - p_i, \tag{1}$$

where v denotes the value of the product and d is transportation cost per unit of distance traveled. Assume that $v > \widehat{v} = \frac{9}{2}d$ so that the market is covered. The utility of a consumer buying online is given by

$$U_0 = v - \theta - p_0, \tag{2}$$

where θ denotes fixed cost of buying online. This can be interpreted as cost of going online, delivery cost, inconvenience of waiting for the parcel service or opportunity cost of non-immediate availability of the good purchased online. Assume that $\theta < d$ which ensures that the online retailer has positive sales if it enters the market.

If the online retailer is not active ("offline equilibrium"), the consumer indifferent between buying at the brick-and-mortar store in country H and the brick-and-mortar store in country F is located at $y^*_{HF} = \frac{1}{2} + \frac{p^*_F - p^*_H}{2d}$. An asterisk denotes variables associated with the offline equilibrium.

If the online retailer is active ("online equilibrium"), the consumer indifferent between buying from the brick-and-mortar store in country H and at the online retailer is located at $y_{H0} = \frac{\theta + p_0 - p_H}{d}$; and the consumer indifferent between buying from the brick-and-mortar store in country F and at the online retailer is located at $y_{0F} = \frac{d - \theta - p_0 + p_F}{d}$. The superscript DP denotes variables associated with the online equilibrium under destination principle; the superscript OP denotes variables associated with the online equilibrium under origin principle.

2.2 Firms

If the online retailer is not active, demand for both firms is

$$q^*_H = y^*_{HF},\ q^*_F = 1 - y^*_{HF} \tag{3}$$

and firms' profits are

$$\pi^*_H = \left(p^*_H - \tau^*_H\right) q^*_H,\ \pi^*_F = \left(p^*_F - \tau^*_F\right) q^*_F. \tag{4}$$

If the online retailer is active, demand for both firms is given as

$$q_H = y_{H0},\ q_F = 1 - y_{0F},\ q_0 = y_{0F} - y_{H0}. \tag{5}$$

If taxation follows the destination principle, firms' profits are given by

$$\begin{aligned} \pi_H^{DP} &= \left(p_H^{DP} - \tau_H^{DP}\right) q_H^{DP},\ \pi_F^{DP} = \left(p_F^{DP} - \tau_F^{DP}\right) q_F^{DP}, \\ \pi_0^{DP} &= \left(p_0^{DP} - \tau_H^{DP}\right)\left(\frac{1}{2} - y_{H0}\right) + \left(p_0^{DP} - \tau_F^{DP}\right)\left(y_{0F} - \frac{1}{2}\right). \end{aligned} \tag{6}$$

If taxation follows the origin principle, firms' profits are given by

$$\pi_H^{OP} = \left(p_H^{OP} - \tau_H^{OP}\right) q_H^{OP},\ \pi_F^{OP} = \left(p_F^{OP} - \tau_F^{OP}\right) q_F^{OP},\ \pi_0^{OP} = \left(p_0^{OP} - \tau_H^{OP}\right) q_0^{OP}. \tag{7}$$

2.3 Governments

In each country, there is a single revenue-maximizing government, imposing a unit tax at rate τ_j.

If the online retailer is not active, tax revenue is

$$R_H^* = \tau_H^* q_H^*,\ R_F^* = \tau_F^* q_F^*.$$

If the online retailer is active and taxation follows the destination principle, tax revenue is

$$R_H^{DP} = \tau_H^{DP}\left(q_H^{DP} + \left(\frac{1}{2} - y_{H0}\right)\right),\ R_F^{DP} = \tau_F^{DP}\left(q_F^{DP} + \left(y_{0F} - \frac{1}{2}\right)\right).$$

If taxation follows the origin principle, tax revenue is

$$R_H^{OP} = \tau_H^{OP}\left(q_H^{OP} + q_0^{OP}\right),\ R_F^{OP} = \tau_F^{OP} q_F^{OP}.$$

The structure of the model can be summarized by the following two-stage game: In the first stage, governments set tax rates; in the second stage firms compete in prices. Stage two results as well as first stage equilibrium prices and quantities can be found in the Appendix A.1.

3 The Effect of the Online Retailer On Tax Competition

3.1 Offline Equilibrium

Consider first the case without the online retailer. Consumers buy only from brick-and-mortar stores. Cross-border shopping takes place if a consumer located in country j decides to buy from the brick-and-mortar store in the other country.

Figure 1a illustrates the offline equilibrium. The consumer located at y_{HF} is indifferent between buying at the brick-and-mortar store in country H and the brick-and-mortar store in country F. The tax base in country H is equal to the sales of the brick-and-mortar store in H, the tax base in country F is equal to the sales of the brick-and-mortar store in F.

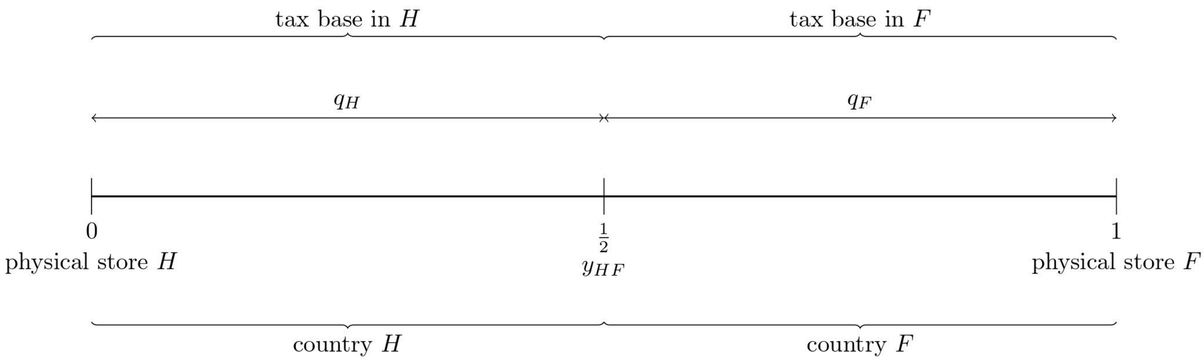

Figure 1a: Market Structure, Offline Equilibrium.

When setting tax rates, countries trade off the revenue-increasing effect of a higher tax rate against the revenue-decreasing effect of a smaller tax base. By unilaterally lowering the tax rate, a country can increase its own tax base at the expense of the tax base of the other country. Figure 1b visualizes the best response functions for countries H and F. Best response functions are upward sloping, tax rates are strategic complements. Both best response functions are monotonically increasing. Therefore a unique Nash equilibrium exists.

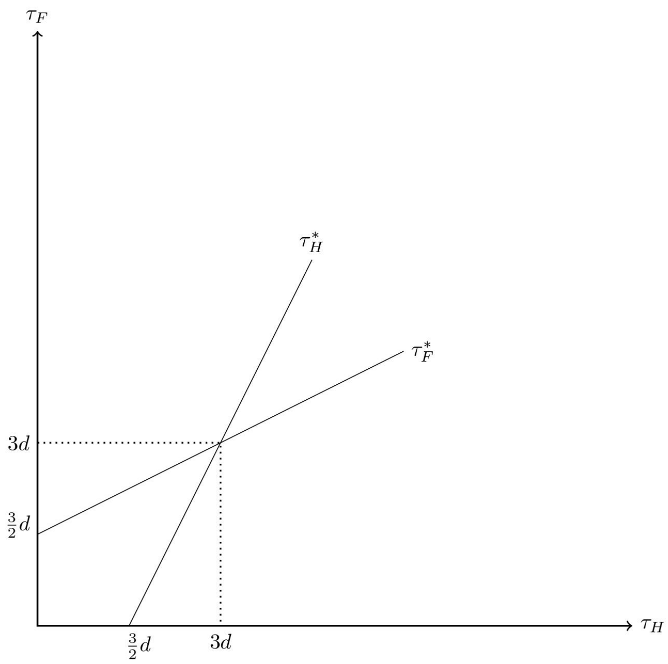

Figure 1b: Best Response Functions, Offline Equilibrium.

In equilibrium, tax rates are

$$\tau_H^* = \tau_F^* = 3d \tag{8}$$

The tax differential is zero ($\Delta\tau^* = \tau_F^* - \tau_H^* = 0$). Tax revenues are

$$R_H^* = R_F^* = \frac{3}{2}d. \tag{9}$$

Tax rates and revenues increase in transportation cost d, as higher transportation cost makes consumers less mobile and less willing to travel to the brick-and-mortar shop in the other country, i.e., cross-border shop, weakening tax competition.

3.2 Online Equilibrium under Destination Principle

Consider now the case with the online retailer. Consider first that online purchases are taxed according to the destination principle. Purchases at the brick-and-mortar stores are tax treated according to the origin principle.

Figure 2a illustrates the online equilibrium under the destination principle. The consumer located at y_{H0} is indifferent between buying at the brick-and-mortar store in country H and buying online, the consumer located at y_{0F} is indifferent between buying at brick-and-mortar store in country F and buying online.

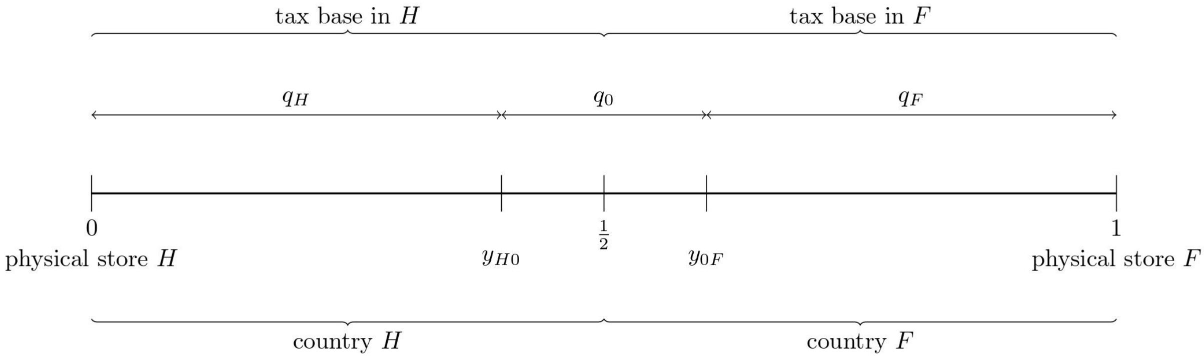

Figure 2a: Market Structure, Online Equilibrium Under Destination Principle.

Buying online is in particular attractive for consumers with high traveling cost, i.e., consumers with a relatively high distance to the brick-and-mortar stores at the endpoints. Consider a consumer located at some small distance left to the border in country H. This consumer does not compare the surplus from buying at the brick-and-mortar store in country H and the brick-and-mortar store in country F (options with high traveling cost), as in the offline equilibrium. This consumer rather trades off buying at the brick-and-mortar store in country H and buying at the online shop.[5] As consumers do no longer choose between the two brick-and-mortar stores but between the local brick-and-mortar store and buying online, cross-border shopping does not take place.

With online purchases being tax treated according to the destination principle, a consumer located in country H, who chooses between buying from the local brick-and-mortar store and buying online, is taxed in country H in both cases. Deciding between the local brick-and-mortar store and buying online implies that consumers choose from which retailer to buy but not by which government to be taxed.[6]

The tax base in both countries is equal to the sales of the local brick-and-mortar store plus the sales of the online store to local residents. This implies that only country size[7] defines the tax base. From the perspective of governments, there are no mobile consumers to compete for, and the tax base does not respond to tax changes.[8]

[5] **As long as the price difference between the online shop and the brick-and-mortar store in H plus the fixed cost of buying online θ sets off the traveling cost incurred when buying at the brick-and-mortar store in H, this consumer will buy online.**

[6] **By deciding to buy online instead of cross-border shopping, consumers willingly accept being taxed only by their respective home government and voluntarily forgo the benefits of tax competition.**

[7] **In this model, country size is equivalent to population size and geographical size.**

[8] **Note that the elimination of tax competition depends on the non-existence of cross-border shopping.**

Governments set tax rates to extract the surplus of the consumers with the smallest surplus. These are the indifferent consumers located at y_{H0} and y_{0F} (and all consumers in between). This yields the best response functions $\tau_H^{DP} = 2v - \frac{2}{3}d - \frac{4}{3}\theta - \tau_F^{DP}$ and $\tau_F^{DP} = 2v - \frac{2}{3}d - \frac{4}{3}\theta - \tau_H^{DP}$. Best response functions are identical and define a set of equilibria.

For this set of equilibria, three conditions have to hold: i) Cross-border shopping does not take place. ii) All three firms sell non-negative quantities. iii) The online retailer's profit is non-negative. This implies that consumers cannot choose where to be taxed, i.e., tax bases are fixed by country size, and that all three firms are active. These conditions define a maximum tax differential $\left|\overline{\Delta\tau^{DP}}\right| = min\{\frac{2}{3}\sqrt{2}\left(d-\theta\right), \frac{2}{3}\left(d+2\theta\right)\}$ (see Appendix A.1).

For the following, it is useful to define the maximum and minimum tax rates that are compatible with the maximum tax differential $\left|\overline{\Delta\tau^{DP}}\right|$. For i) $\theta > \widehat{\theta} = d\frac{\sqrt{2}-1}{\sqrt{2}+2}$, the maximum tax differential is given as $\frac{2}{3}\sqrt{2}\left(d-\theta\right)$. The maximum tax rate is then $\overline{\tau_j^{DP,\theta>\widehat{\theta}}} = v + \frac{1}{3}\left(d\left(\sqrt{2}-1\right) - \theta\left(\sqrt{2}+2\right)\right)$, the minimum tax rate is $\underline{\tau_{-j}^{DP,\theta>\widehat{\theta}}} = v - \frac{1}{3}\left(d\left(\sqrt{2}+1\right) + \theta\left(2-\sqrt{2}\right)\right)$. Corresponding maximum and minimum tax revenues are $\overline{R_j^{DP,\theta>\widehat{\theta}}} = \frac{1}{2}\left(v + \frac{1}{3}\left(d\left(\sqrt{2}-1\right) - \theta\left(\sqrt{2}+2\right)\right)\right)$ and $\underline{R_{-j}^{DP,\theta>\widehat{\theta}}} = \frac{1}{2}\left(v - \frac{1}{3}\left(d\left(\sqrt{2}+1\right) + \theta\left(2-\sqrt{2}\right)\right)\right)$.

For ii) $\theta < \widehat{\theta} = d\frac{\sqrt{2}-1}{\sqrt{2}+2}$, the maximum tax differential is given as $\frac{2}{3}\left(d+2\theta\right)$. The maximum tax rate is $\overline{\tau_j^{DP,\theta<\widehat{\theta}}} = v$, the minimum tax rate is $\underline{\tau_{-j}^{DP,\theta<\widehat{\theta}}} = v - \frac{2}{3}d - \frac{4}{3}\theta$. Corresponding maximum and minimum tax revenues are $\overline{R_j^{DP,\theta<\widehat{\theta}}} = \frac{1}{2}v$ and $\underline{R_{-j}^{DP,\theta<\widehat{\theta}}} = \frac{1}{2}\left(v - \frac{2}{3}d - \frac{4}{3}\theta\right)$.

(Minimum) Tax rates and revenues are higher than tax rates and revenues in the offline equilibrium ($\underline{\tau_{-j}^{DP,\theta>\widehat{\theta}}} > \tau_j^*$, $\underline{\tau_{-j}^{DP,\theta<\widehat{\theta}}} > \tau_j^*$, $\underline{R_{-j}^{DP,\theta>\widehat{\theta}}} > R_j^*$, $\underline{R_{-j}^{DP,\theta<\widehat{\theta}}} > R_j^*$).

Figure 2b visualizes best response functions for countries H and F under the destination principle for the cases $\theta > \widehat{\theta}$ and $\theta < \widehat{\theta}$. Best response functions are downward sloping, i.e., tax rates are strategic substitutes. Vertical and horizontal dashed lines indicate maximum and minimum tax rates.

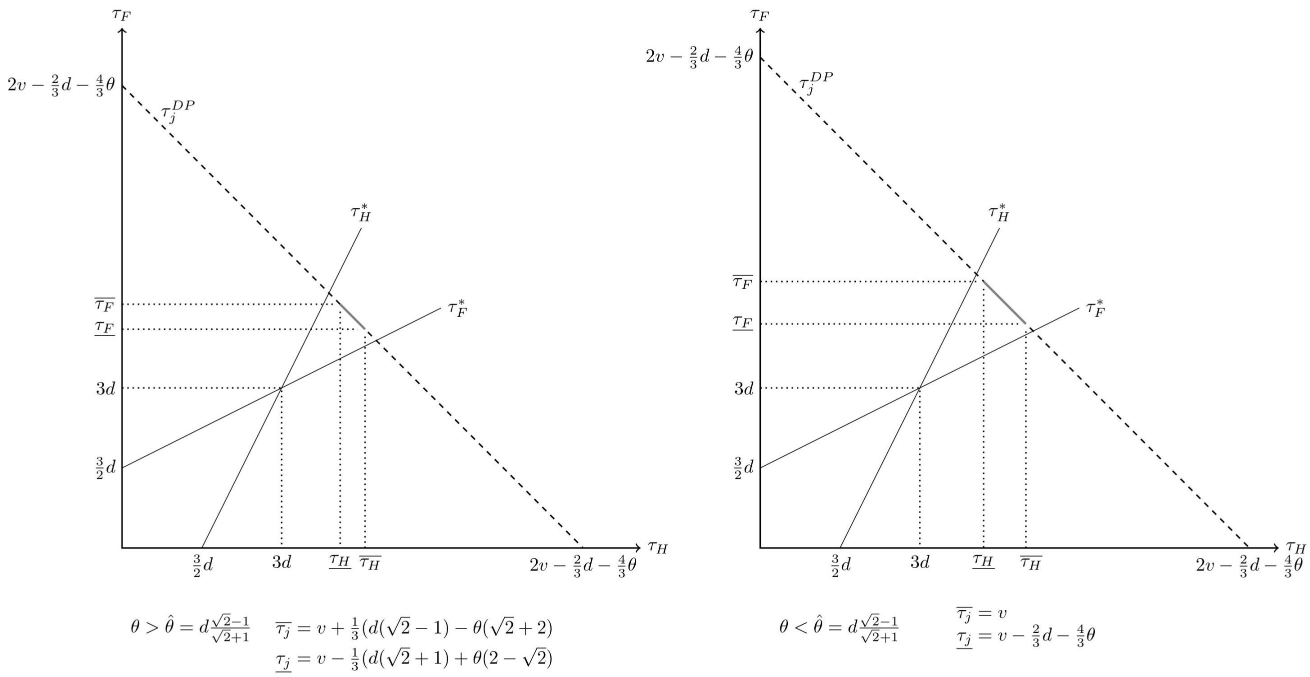

Figure 2b: Best Response Functions, Online Equilibrium Under Destination Principle.

The set of tax rates and revenues, respectively, is given as

$$\tau_H^{DP}, \tau_F^{DP} \in \{\tau_H^{DP} + \tau_F^{DP} = 2v - \frac{2}{3}d - \frac{4}{3}\theta\} \cap \{\left|\Delta\tau^{DP}\right| \leq min\{\frac{2}{3}\sqrt{2}\,(d-\theta)\,,\frac{2}{3}\,(d+2\theta)\}\} \quad (10)$$

and

$$R_H^{DP} = R_F^{DP} = \frac{1}{2}\tau_H^{DP} = \frac{1}{2}\tau_F^{DP}. \quad (11)$$

The tax differential may be zero, positive or negative. ($\Delta\tau^{DP} = \tau_F^{DP} - \tau_H^{DP} = (max\{-\frac{2}{3}\sqrt{2}\,(d-\theta)\,, -\frac{2}{3}\,(d+$ $min\{\frac{2}{3}\sqrt{2}\,(d-\theta)\,, \frac{2}{3}\,(d+2\theta)\}\})$).

The elimination of tax competition under the destination principle with tax bases corresponding to country size is similar to the closed borders-case of Kanbur & Keen (1993). As the tax base does not respond to tax changes, governments can extract consumer surplus via (excessive) taxes. Other than in the Kanbur & Keen (1993)-framework, governments are not independent in their taxing decisions. The online shop's price depends on both tax rates and thus links governments' decisions on tax rates.

Proposition 1 summarizes the effect of the entry of the online retailer on tax rates under the destination principle.

Proposition 1 *Suppose that taxation for online purchases follows the destination principle.*

Then i) tax rates and tax revenues are higher than in the offline equilibrium, and ii) the tax differential may be zero, positive or negative.

3.3 Online Equilibrium under Origin Principle

Assume now that taxation for online purchases follows the origin principle.

Figure 3a illustrates the online equilibrium under the origin principle. The consumer located at y_{H0} is indifferent between buying at the brick-and-mortar store in country H and buying online, the consumer located at y_{0F} is indifferent between buying at brick-and-mortar store in country F and buying online. As under the destination principle, in both countries, consumers choose between buying from the local brick-and-mortar store and buying from the online shop.

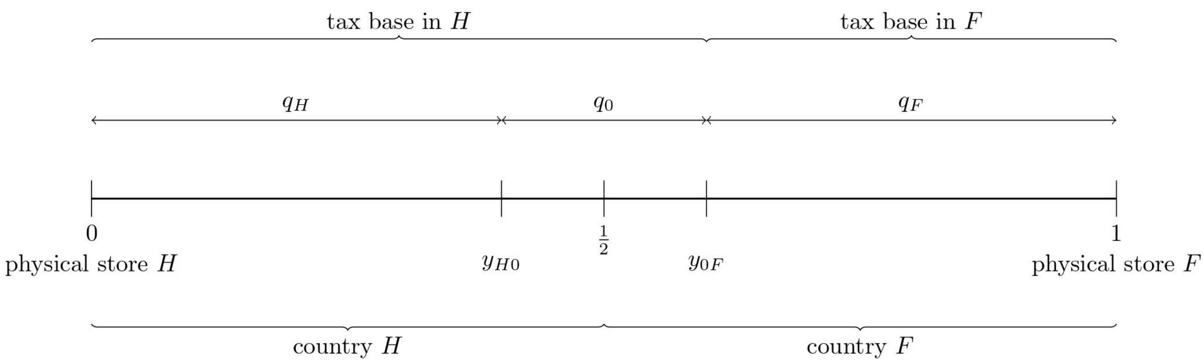

Figure 3a: Market Structure, Online Equilibrium Under Origin Principle.

With online purchases being tax treated according to the origin principle, a consumer located in country H, who chooses between buying from the local brick-and-mortar store and buying online, is taxed in country H in both cases. However, a consumer located in country F, who chooses between buying from the local brick-and-mortar store and buying online, decides between retailers with different tax rates.

Governments compete for mobile consumers in country F who decide between buying from the brick-and-mortar store in country F and buying online.

Compared to the offline equilibrium, where governments compete for mobile consumers as cross-border-shoppers, this competition for mobile consumers is different in two dimensions: First, the presence of the online retailer facilitates the choice of which tax to pay in country F. Consumers located at some distance from the border in country F do not have to travel all the way to the brick-and-mortar store in country H but can buy online instead to benefit from the tax differential. Second, as the tax base in country H is equal to the sales of the local brick-and-mortar store plus the sales of the online store, while the tax base in country F is equal to the sales of the local brick-and-mortar store only, there is an asymmetry between countries, with the government in H taxing online purchases of consumers located in F. Countries are asymmetric not in geographical size or population size but in tax base size.

Figure 3b illustrates best response functions. Best response functions are upward-sloping, tax rates are strategic complements. Both best response functions are monotonically increasing. Therefore a unique Nash equilibrium exists.

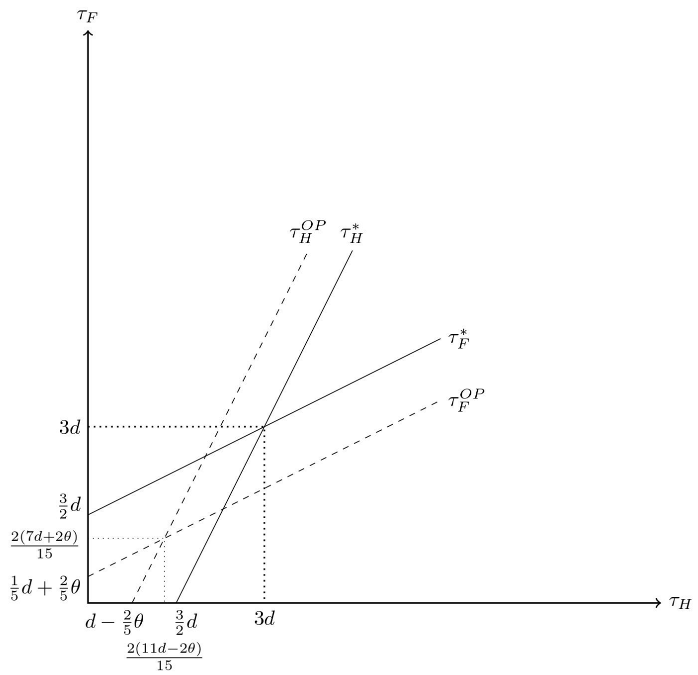

Figure 3b: Best Response Functions, Online Equilibrium Under Origin Principle.

Tax rates are given as

$$\tau_H^{OP} = \frac{2\,(11d - 2\theta)}{15}, \;\; \tau_F^{OP} = \frac{2\,(7d + 2\theta)}{15}. \tag{12}$$

The tax differential is negative ($\Delta\tau^{OP} = \tau_F^{OP} - \tau_H^{OP} < 0$).

$$R_H^{OP} = \frac{(11d - 2\theta)^2}{135d}, \;\; R_F^{OP} = \frac{(7d + 2\theta)^2}{135d}. \tag{13}$$

Compared to the offline equilibrium, in the online equilibrium under the destination principle, taxes and revenues are lower ($\tau_H^{OP} < \tau_H^*$, $\tau_F^{OP} < \tau_F^*$, $R_H^{OP} < R_H^*$, $R_F^{OP} < R_F^*$).

This implies, the entry of the online retailer enhances tax competition, with the country which does not host the online retailer undercutting the tax rate of the online retailer's home country. This corresponds to the result of Kanbur & Keen (1993) and Nielsen (2001), with the difference that country H is not larger in geographical or population size but has a larger tax base as online purchases are taxed in country H.

Proposition 2 summarizes the effect of the entry of the online retailer on tax rates under the origin principle.

Proposition 2 *Suppose that taxation for online purchases follows the origin principle. Then i) tax rates and tax revenues are lower than in the offline equilibrium, and ii) the tax differential is negative.*

Under the origin principle, tax competition is stronger than under the destination principle, which is reflected in lower tax rates and revenues under the origin principle ($\tau_H^{OP} < \underline{\tau_{-j}^{DP,\theta>\widehat{\theta}}}$, $\tau_H^{OP} < \underline{\tau_{-j}^{DP,\theta<\widehat{\theta}}}$, $\tau_F^{OP} < \underline{\tau_{-j}^{DP,\theta>\widehat{\theta}}}$, $\tau_F^{OP} < \underline{\tau_{-j}^{DP,\theta<\widehat{\theta}}}$, $R_H^{OP} < \underline{R_{-j}^{DP,\theta>\widehat{\theta}}}$, $R_H^{OP} < \underline{R_{-j}^{DP,\theta<\widehat{\theta}}}$, $R_F^{OP} < \underline{R_{-j}^{DP,\theta>\widehat{\theta}}}$, $R_F^{OP} < \underline{R_{-j}^{DP,\theta<\widehat{\theta}}}$). As prices increase in tax rates, also prices are lower under the origin principle ($p_H^{OP} < p_H^{DP}$, $p_F^{OP} < p_F^{DP}$, $p_0^{OP} < p_0^{DP}$).

Under the origin principle, country F undercuts the tax rate of country H. This translates to a lower price for the brick-and-mortar store in F vis-a-vis the online store and the brick-and-mortar store in H, resulting in a competitive advantage for the brick-and-mortar store in F. Compared to the destination principle with a sufficiently high tax differential $\Delta\tau^{DP} = \tau_F^{DP} - \tau_H^{DP}$, the quantity of the brick-and-mortar store in F is higher ($q_F^{OP} > q_F^{DP}$ if $\Delta\tau^{DP} > \Delta\tau_{q_H}^{DP}$) and the quantities of the brick-and-mortar store in H and the online shop are lower under the origin principle ($q_H^{OP} < q_H^{DP}$ if $\Delta\tau^{DP} > \Delta\tau_{q_H}^{DP}$, $q_0^{OP} < q_0^{DP}$). If, however, $\tau_H^{DP} >> \tau_F^{DP}$, i.e., the tax differential $\Delta\tau^{DP} = \tau_F^{DP} - \tau_H^{DP}$ is sufficiently low, then under the destination principle, the quantity sold by the brick-and-mortar store in H is much lower than the quantity sold by the brick-and-mortar store in F. A change to the origin principle (with a lower asymmetry in taxes and quantities) then increases the quantity of the brick-and-mortar store in H and decreases the quantity of the brick-and-mortar store in F.

3.4 Welfare Analysis

This subsection compares firms' profits, tax revenues, consumer surplus, and welfare between the tax treatment according to the destination principle (for given tax rates) and the tax treatment of the online shop according to the origin principle. Welfare in country H is given as $W_H = CS_H + \pi_H + \pi_0 + R_H$; welfare in country F is given as $W_F = CS_F + \pi_F + R_F$.

For all three stores, the extent of tax differential $\Delta\tau^{DP} = \tau_F^{DP} - \tau_H^{DP}$ under the destination principle determines which taxation principle yields higher profits: For the brick-and-mortar store in country H, profits are higher under the destination principle if the tax differential $\Delta\tau^{DP}$ is sufficiently high ($\pi_H^{OP} < \pi_H^{DP}$, if $\Delta\tau^{DP} > \widehat{\Delta\tau_{\pi_H}^{DP}}$). For the brick-and-mortar store in country F profits are higher under the origin principle if the tax differential $\Delta\tau^{DP}$ is sufficiently high ($\pi_F^{OP} > \pi_F^{DP}$, if $\Delta\tau^{DP} > \widehat{\Delta\tau_{\pi_F}^{DP}}$). For the brick-and-mortar store in country H, the price-tax margin and the quantity sold increase in the tax differential; for the brick-and-mortar store in country F, the price-tax margin and the quantity sold decrease in the tax differential. A high tax differential under the destination principle shifts market shares from the brick-and-mortar store in the country with the higher tax rate to the brick-and-mortar store in the country with the lower tax rate. Also, the price-tax margin is lower for the brick-and-mortar store in the country with the higher tax rate.

For the online retailer, profits are higher under the destination principle if the tax differential $\Delta\tau^{DP} = \tau_F^{DP} - \tau_H^{DP}$ is sufficiently low ($\pi_0^{OP} < \pi_0^{DP}$, if $\Delta\tau^{DP} < \left|\widehat{\Delta\tau_{\pi_0}^{DP}}\right|$). Under the destination principle, the online shop sets a single price p_0 while its sales are taxed with different rates in both countries. In both countries, the online shop competes (with the same price p_0) against the local brick-and-mortar stores whose sales are only taxed in the respective countries.

Consider the change from an equilibrium with symmetric tax rates $\tau_H^{DP} = \tau_F^{DP}$ to an asymmetric equilibrium with $\tau_F^{DP} >> \tau_H^{DP}$. This is equivalent to an increase in the tax differential $\Delta\tau^{DP} = \tau_F^{DP} - \tau_H^{DP}$. A decrease in the tax rate τ_H^{DP} and increase in the tax rate τ_F^{DP} increases the price-tax-margin of the brick-and-mortar store in country H and decreases the price-tax-margin of the brick-and-mortar store in country F. For the online shop, the price-tax-margin for sales in country H increases, the price-tax-margin for sales in country F decreases. In country H, the change in tax rates shifts market shares from the online retailer to the brick-and-mortar store; in country F, the change in tax rates shifts market shares from the brick-and-mortar store to the online retailer. This implies that for the online shop, sales in the country with the high margin (country H) decrease and sales in the country with the low margin (country F) increase. The profit of the brick-and-mortar store in country H increases, the profit brick-and-mortar store in country F and the profit of the online shop decrease.

For both governments, tax revenues are higher under the destination principle ($R_H^{OP} <$

R_H^{DP}, $R_F^{OP} < R_F^{DP}$). Under the destination principle, governments do not compete for mobile consumers, as cross-border shopping does not take place and thus consumers are not exposed to different tax rates. This allows governments to extract the surplus of the consumers with the lowest surplus, i.e., the indifferent consumers located at y_{H0} and y_{0F} (and all consumers in between).

In both countries, consumer surplus is higher under the origin principle ($CS_H^{OP} > CS_H^{DP}$, $CS_F^{OP} > CS_F^{DP}$), as tax competition for mobile consumers prevents excessively high tax rates (and prices) under the origin principle.

For a sufficiently low τ_H^{DP} (or equivalently, a sufficiently high τ_F^{DP}), welfare in country H is higher under the origin principle, and welfare in country F is higher under the destination principle ($W_H^{OP} > W_H^{DP}$ if $\tau_H^{DP} < \widehat{\tau_{H,W_H}^{DP}}$, $W_F^{OP} < W_F^{DP}$, if $\tau_H^{DP} < \widehat{\tau_{H,W_F}^{DP}}$). Global welfare is higher under the destination principle if the tax differential $\Delta\tau^{DP}$ is sufficiently low ($W^{OP} < W^{DP}$ if $\left|\Delta\tau^{DP}\right| < \widehat{\Delta\tau_W^{DP}}$). With tax revenue being higher under the destination principle and consumer surplus being higher under the origin principle, the impact of tax differentials on firms' profits under the destination principle determines the welfare effect of tax treatments substantially.

Proposition 3 summarizes the welfare effect of the two taxation principles.

Proposition 3 *For a sufficiently low tax rate in country H, welfare in country H is higher under the origin principle, while welfare in country F is higher under the destination principle. For a sufficiently low tax differential between both countries, global welfare is higher under the destination principle.*

4 The Role of Governments

This section discusses alternative roles of governments. So far, this paper has assumed non-cooperative revenue-maximizing governments. Governments could also be thought of cooperating and/or maximizing welfare. The superscript C denotes variables associated with equilibria with cooperation among governments; the superscript W denotes variables associated with equilibria with welfare-maximizing governments.

4.1 Cooperative Leviathan Governments

Consider the case of governments cooperating in setting tax rates and maximizing joint revenue.

4.1.1 Offline Equilibrium

In the offline equilibrium, joint tax revenue is given as $R^{*,C} = R_H^{*,C} + R_F^{*,C} = \frac{3d\left(\tau_F^{*,C}+\tau_H^{*,C}\right)-\left(\tau_F^{*,C}-\tau_H^{*,C}\right)^2}{6d}$. Joint tax revenue increases in tax rate τ_j as long as $\tau_j = \tau_{-j}$. In order to increase joint tax revenue, governments do not compete for mobile consumers and set tax rates to extract the full surplus of the indifferent consumer located y_{H0} and y_{0F}. Cooperatively set tax rates are given as

$$\tau_H^{*,C} = \tau_F^{*C} = v - \frac{3}{2}d. \tag{14}$$

$$R_H^{*C} = R_F^{*C} = \frac{1}{2}\left(v - \frac{3}{2}d\right), \tag{15}$$

Tax rates and revenues are higher than under no cooperation ($\tau_j^{*,C} > \tau_j^*$, $R_j^{*,C} > R_j^*$).

4.1.2 Online Equilibrium under Destination Principle

In the online equilibrium under the destination principle, joint tax revenue is given as $R^{DP,C} = R_H^{DP,C} + R_F^{DP,C} = \tau_H^{DP,C}\frac{1}{2} + \tau_F^{DP,C}\frac{1}{2} = \frac{1}{2}\left(\tau_H^{DP,C} + \tau_F^{DP,C}\right)$. Joint tax revenue increases in both tax rates.

This case is equivalent to the one discussed in 3.2. The set of equilibrium tax rates and revenues is given as

$$\tau_H^{DP,C}, \tau_F^{DP,C} \in \{\tau_H^{DP} + \tau_F^{DP} = 2v - \frac{2}{3}d - \frac{4}{3}\theta\} \cap \{\left|\Delta\tau^{DP}\right| \leq min\{\frac{2}{3}\sqrt{2}\,(d-\theta)\,, \frac{2}{3}\,(d+2\theta)\}\} \tag{16}$$

and

$$R_H^{DP,C} = R_F^{DP,C} = \frac{1}{2}\tau_H^{DP,C} = \frac{1}{2}\tau_F^{DP,C}. \tag{17}$$

Compared to the offline equilibrium with cooperation, (minimum) tax rates and revenues are higher ($\underline{\tau_{-j}^{DP,\theta>\widehat{\theta},C}} > \tau_j^{*,C}$, $\underline{\tau_{-j}^{DP,\theta<\widehat{\theta},C}} > \tau_j^{*,C}$, $\underline{R_{-j}^{DP,\theta>\widehat{\theta},C}} > R_j^{*,C}$, $\underline{R_{-j}^{DP,\theta<\widehat{\theta},C}} > R_j^{*,C}$).

4.1.3 Online Equilibrium under Origin Principle

In the online equilibrium under the origin principle, joint tax revenue is given as $R^{OP,C} = R_H^{OP,C} + R_F^{OP,C} = \frac{2\tau_F(d+2\theta)+2\tau_H(5d-2\theta)-5(\tau_F-\tau_H)^2}{12d}$. Joint tax revenue increases in tax rate τ_j as long as $\tau_j = \tau_{-j}$. Similar to the offline equilibrium, governments do not compete for mobile consumers and set tax rates to extract the full surplus of the indifferent consumer located y_{H0}

and y_{0F}.

Equilibrium tax rates are

$$\tau_H^{OP,C} = \tau_F^{OP,C} = v - \frac{1}{3}d - \frac{2}{3}\theta. \tag{18}$$

Tax revenues are

$$R_H^{OP,C} = \frac{(5d-2\theta)\left(v - \frac{1}{3}d - \frac{2}{3}\theta\right)}{6d}, R_F^{OP,C} = \frac{(2d+4\theta)\left(v - \frac{1}{3}d - \frac{2}{3}\theta\right)}{12d}. \tag{19}$$

Compared to the online equilibrium under the origin principle with no cooperation, tax rates are higher ($\tau_H^{OP,C} > \tau_H^{OP}$, $\tau_F^{OP,C} > \tau_F^{OP}$).

Compared to the offline equilibrium with cooperation, tax rates are higher ($\tau_j^{OP,C} > \tau_j^{*,C}$). Tax revenue for country H is higher, tax revenue for country F is lower ($R_H^{OP,C} > R_H^{*,C}$, $R_F^{OP,C} < R_F^{*,C}$). Cooperation among governments eliminates competition for mobile consumers, thus increasing tax rates compared to the case in 3.3. The asymmetry in tax bases under the origin principle creates an asymmetry in tax revenues.

Cooperation among governments changes the effect of the online retailer on tax competition: Both under the destination principle and the origin principle, the online retailer weakens tax competition. The presence of the online retailer increases the surplus of the indifferent consumers: It increases competition among retailers and decreases prices and it shifts the indifferent consumers closer to the endpoints (as compared to the offline equilibrium) and decreases traveling cost. This allows governments to extract more surplus from these consumers, translating to higher tax rates in the online equilibria.

Proposition 4 summarizes the effect of cooperation between governments.

Proposition 4 *Suppose that governments cooperate and maximize joint tax revenue. Under both the destination and origin principle, the online retailer weakens tax competition.*

4.2 Benevolent Governments

Consider now the case of non-cooperative governments setting tax rates to maximize welfare, given as the sum of consumer surplus, firms' profits, and tax revenue.

4.2.1 Offline Equilibrium

Welfare in countries H and F, respectively, is given as
$W_H^{*,W} = CS_H^{*,W} + \pi_H^{*,W} + R_H^{*,W} = \frac{1}{2}v + \frac{-9d^2+4\left(\tau_F^{*,W}-\tau_H^{*,W}\right)\left(3d+\tau_F^{*,W}+2\tau_H^{*,W}\right)}{72d}$ and
$W_F^{*,W} = CS_F^{*,W} + \pi_F^{*,W} + R_F^{*,W} = \frac{1}{2}v + \frac{-9d^2-4\left(\tau_F^{*,W}-\tau_H^{*,W}\right)\left(3d+\tau_H^{*,W}+2\tau_F^{*,W}\right)}{72d}$. In both countries, welfare decreases in the tax rate of the respective country and increases in the tax rate of the other country ($\frac{\partial W_H^{*,W}}{\partial \tau_H^{*,W}} < 0$, $\frac{\partial W_F^{*,W}}{\partial \tau_F^{*,W}} < 0$, $\frac{\partial W_H^{*,W}}{\partial \tau_F^{*,W}} > 0$, $\frac{\partial W_F^{*,W}}{\partial \tau_H^{*,W}} > 0$).

A unilateral increase in $\tau_H^{*,W}$ would increase the price of the brick-and-mortar store in H and, by strategic response, to a lesser extent also the price of the brick-and-mortar store in F. This induces some consumers located in H to buy at the brick-and-mortar store in country F. The increase in prices decreases consumer surplus; the decrease in the price-tax-margin and decrease in quantity decreases the local brick-and-mortar store's profit. However, the increase in $\tau_H^{*,W}$ increases tax revenue. By symmetry, a unilateral increase in $\tau_F^{*,W}$ results in similar effects in country F. The profit of the local brick-and-mortar store in H decreases in the tax differential, while the profit of the local brick-and-mortar store in F increases in the tax differential. Thus, there is an incentive for one country to undercut the tax rate of the other country.

Equilibrium tax rates are

$$\tau_H^{*,W} = \tau_F^{*,W} = 0. \tag{20}$$

Tax revenues are

$$R_H^{*,W} = R_F^{*,W} = 0. \tag{21}$$

Compared to the offline equilibrium under Leviathan governments, tax rates and revenues are lower ($\tau_j^{*,W} < \tau_j^*$, $R_j^{*,W} < R_j^*$).

4.2.2 Online Equilibrium under Destination Principle

Welfare in countries H and F, respectively, is
$W_H^{DP,W} = CS_H^{DP,W} + \pi_H^{DP,W} + \pi_0^{DP,W} + R_H^{DP,W} = \frac{1}{2}v + \frac{28d^2-176d\theta+112\theta^2-9\left(\tau_F^{DP,W}-\tau_H^{DP,W}\right)\left(4d-8\theta+5\tau_F^{DP,W}-5\tau_H^{DP,W}\right)}{288d}$
and
$W_F^{DP,W} = CS_F^{DP,W} + \pi_F^{DP,W} + R_F^{DP,W} = \frac{1}{2}v - \frac{12d^2+16d\theta-16\theta^2-3\left(\tau_F^{DP,W}-\tau_H^{DP,W}\right)\left(4d-8\theta+3\tau_F^{DP,W}-3\tau_H^{DP,W}\right)}{96d}$.

Best response functions are $\tau_H^{DP,W} = \frac{2}{5}\left(d-2\theta\right) + \tau_F^{DP,W}$ and
$\tau_F^{DP,W} = \tau_H^{DP,W} - \frac{2}{3}\left(d-2\theta\right)$. Best response functions are upward-sloping, tax rates are strategic complements.

The presence of the online retailer creates an asymmetry between countries: The online retailer's profit is part of the welfare of country H, but its sales are taxed – according to the country of residence of customers – in both countries.

A unilateral increase in $\tau_H^{DP,W}$ increases prices of all three stores and shifts market shares from the brick-and-mortar store in country H to the brick-and-mortar store in country F. Sales of the online retailer are independent of tax rates, an increase in $\tau_H^{DP,W}$ shifts the indifferent consumers located at y_{H0} and y_{0F} by the same amount. The increase in $\tau_H^{DP,W}$ raises tax revenue (the tax base does not respond to tax changes), decreases consumer surplus (prices increase), and decreases the local brick-and-mortar store's profit (the price-tax-margin and quantity decrease). Vice versa, a unilateral increase in $\tau_F^{DP,W}$ has the same effect on tax revenue in country F, consumer surplus, and the local brick-and-mortar store's profit. The welfare-maximizing tax rate is the tax rate that balances these three effects, the increase in tax revenue and the decrease in consumer surplus and the brick-and-mortar store's profit.

In country H, the negative effect on consumer surplus and local brick-and-mortar store's profit increases in the tax differential $\Delta\tau^{DP,W} = \tau_F^{DP,W} - \tau_H^{DP,W}$, providing an incentive to match a potential increase or decrease in the tax rate $\tau_F^{DP,W}$. Similarly, in country F, the negative effect on consumer surplus and local brick-and-mortar store's profit decreases in the tax differential $\Delta\tau^{DP,W}$. Thus, tax rates are strategic complements. Moreover, country F has an incentive to undercut $\tau_H^{DP,W}$, as undercutting $\tau_H^{DP,W}$ increases the brick-and-mortar store's profit by raising the price-tax-margin and quantity. Similarly, country H, however, has an incentive to undercut $\tau_F^{DP,W}$ to increase the profit of its brick-and-mortar store. However, as the online shop's profit decreases in the tax differential (see 3.4) the incentive is lower for country H if θ is sufficiently low. Thus, in equilibrium, country H sets a higher tax rate than country F if θ is sufficiently low.

Equilibrium tax rates are

$$\tau_H^{DP,W} = \begin{cases} \frac{2}{5}(d-2\theta) & \text{if } \theta < \frac{1}{2}d \\ 0 & \text{if } \theta \geq \frac{1}{2}d \end{cases}, \ \tau_F^{DP,W} = 0. \tag{22}$$

Tax revenues are

$$R_H^{DP,W} = \begin{cases} \frac{2}{10}(d-2\theta) & \text{if } \theta < \frac{1}{2}d \\ 0 & \text{if } \theta \geq \frac{1}{2}d \end{cases}, \ R_F^{DP,W} = 0. \tag{23}$$

Compared to the online equilibrium under the destination principle and Leviathan governments, tax rates and revenues are lower (for $\theta < \frac{1}{2}d$: $\tau_H^{DP,W} < \underline{\tau_{-j}^{DP,\theta>\widehat{\theta}}}$, $\tau_H^{DP,W} < \underline{\tau_{-j}^{DP,\theta<\widehat{\theta}}}$;

$R_H^{DP,W} < \underline{R_{-j}^{DP,\theta>\widehat{\theta}}}$, $R_H^{DP,W} < \underline{R_{-j}^{DP,\theta<\widehat{\theta}}}$, for $\theta \geq \frac{1}{2}d$: $\tau_H^{DP,W} < \underline{\tau_{-j}^{DP,\theta>\widehat{\theta}}}$, $\tau_H^{DP,W} < \underline{\tau_{-j}^{DP,\theta<\widehat{\theta}}}$; $\tau_F^{DP,W} < \underline{\tau_{-j}^{DP,\theta>\widehat{\theta}}}$, $\tau_F^{DP,W} < \underline{\tau_{-j}^{DP,\theta<\widehat{\theta}}}$; $R_H^{DP,W} < \underline{R_{-j}^{DP,\theta>\widehat{\theta}}}$, $R_H^{DP,W} < \underline{R_{-j}^{DP,\theta<\widehat{\theta}}}$, $R_F^{DP,W} < \underline{R_{-j}^{DP,\theta>\widehat{\theta}}}$, $R_F^{DP,W} < \underline{R_{-j}^{DP,\theta<\widehat{\theta}}}$).

Compared to the offline equilibrium under benevolent governments, the tax rate and revenue in H is higher for sufficiently low θ and the same for sufficiently high θ (if $\theta < \frac{1}{2}d$: $\tau_H^{DP,W} > \tau_H^{*,W}$, $R_H^{DP,W} > R_H^{*,W}$; if $\theta \geq \frac{1}{2}d$: $\tau_H^{DP,W} = \tau_H^{*,W}$, $R_H^{DP,W} = R_H^{*,W}$), the tax rate and revenue in F is the same ($\tau_F^{DP,W} = \tau_H^{*,W}$, $R_F^{DP,W} = R_F^{*,W}$).

4.2.3 Online Equilibrium under Origin Principle

Welfare in countries H and F, respectively, is
$W_H^{OP,W} = CS_H^{OP,W} + \pi_H^{OP,W} + \pi_0^{OP,W} + R_H^{OP,W}$
$= \frac{1}{2}v + \frac{28d^2-176d\theta+112\theta^2+52d\tau_F^{OP,W}+44d\tau_H^{OP,W}-40\theta\tau_F^{OP,W}-56\theta\tau_H^{OP,W}+\left(\tau_F^{OP,W}-\tau_H^{OP,W}\right)\left(19\tau_F^{OP,W}+101\tau_H^{OP,W}\right)}{288d}$
and $W_F^{OP,W} = CS_F^{OP,W} + \pi_F^{OP,W} + R_F^{OP,W}$
$= \frac{1}{2}v - \frac{4(3d-2\theta)(d+2\theta)+12d\tau_F^{OP,W}+20d\tau_H^{OP,W}+8\theta\tau_F^{OP,W}-40\theta\tau_H^{OP,W}+5\left(\tau_F^{OP,W}-\tau_H^{OP,W}\right)\left(3\tau_F^{OP,W}+5\tau_H^{OP,W}\right)}{96d}$.

Best response functions are $\tau_H^{OP,W} = \frac{22}{101}d - \frac{28}{101}\theta + \frac{41}{101}\tau_F^{OP,W}$ and $\tau_F^{OP,W} = -\frac{2}{5}d - \frac{4}{15}\theta - \frac{1}{3}\tau_H^{OP,W}$. The best response function $\tau_H^{OP,W}$ is upward sloping, the tax rate $\tau_F^{OP,W}$ is downward sloping. Tax rates are strategic complements for country H and strategic substitutes for country F.

A unilateral increase in $\tau_H^{OP,W}$ increases all three prices and shifts market shares from the brick-and-mortar store in H and the online shop to the brick-and-mortar store in F. Profits of the brick-and-mortar store in H and the online shop, consumer surplus, and tax revenue decrease, with the negative effect on profits and consumer surplus increasing and the negative effect on tax revenue decreasing in the tax differential $\Delta\tau^{OP,W} = \tau_F^{OP,W} - \tau_H^{OP,W}$. In country F, a unilateral increase in $\tau_F^{OP,W}$ decreases the profit of the brick-and-mortar store and consumer surplus but increases tax revenue; all three effects decrease in the tax differential. As profits of the brick-and-mortar store in H and the online shop increase in $\Delta\tau^{OP,W}$, profits of the brick-and-mortar store in F decrease in $\Delta\tau^{OP,W}$, there is the incentive to undercut the tax rate of the other country. For country F, this incentive is stronger than for country H.

Equilibrium tax rates are

$$\tau_H^{OP,W} = \begin{cases} \frac{2(11d-14\theta)}{101} & \text{if } \theta < \frac{11}{14}d \\ 0 & \text{if } \theta \geq \frac{11}{14}d \end{cases}, \tau_F^{OP,W} = 0. \tag{24}$$

Tax revenues are

$$R_H^{OP,W} = \begin{cases} \frac{2(11d-14\theta)(75d-22\theta)}{10\,201d} & \text{if } \theta < \frac{11}{14}d \\ 0 & \text{if } \theta \geq \frac{11}{14}d \end{cases}, R_F^{OP,W} = 0. \tag{25}$$

Compared to the online equilibrium under the origin principle and Leviathan governments, tax rates and revenues are lower
(for $\theta < \frac{11}{14}d$: $\tau_H^{OP,W} < \tau_H^{OP}$; $R_H^{OP,W} < R_H^{OP}$; for $\theta \geq \frac{11}{14}d$: $\tau_H^{OP,W} < \tau_H^{OP}$; $\tau_F^{OP,W} < \tau_F^{OP}$; $R_H^{OP,W} < R_H^{OP}$; $R_F^{OP,W} < R_F^{OP}$).

Compared to the offline equilibrium under benevolent governments, the tax rate and revenue in H is higher for sufficiently low θ and the same for sufficiently high θ (if $\theta < \frac{11}{14}d$: $\tau_H^{OP,W} > \tau_H^{*,W}$, $R_H^{OP,W} > R_H^{*,W}$; if $\theta \geq \frac{11}{14}d$: $\tau_H^{OP,W} = \tau_H^{*,W}$, $R_H^{OP,W} = R_H^{*,W}$), the tax rate and revenue in F is the same ($\tau_F^{OP,W} = \tau_H^{*,W}$, $R_F^{OP,W} = R_F^{*,W}$).

Under benevolent and non-cooperative governments, the effect of the online retailer on taxes is country-specific: Under both the destination principle and the origin principle, the online retailer may increase the tax rate in country H for sufficiently low θ and has no effect on the tax rate in country F. Under both the destination and origin principle, the presence of the online retailer limits the incentive for country H to undercut the tax rate of country F.

Proposition 5 summarizes the effect of benevolent non-cooperative governments.

Proposition 5 *Suppose that governments maximize welfare non-cooperatively. Then under both the destination principle and the origin principle, the presence of the online retailer may increase the tax rate in country H for sufficiently low θ and has no effect on the tax rate in country F, creating a negative tax differential $\Delta\tau$ for sufficiently low θ.*

4.3 Cooperative Benevolent Governments

Consider now the case of cooperative benevolent governments setting tax rates to maximize global welfare.

4.3.1 Offline Equilibrium

Global welfare is $W^{*,W,C} = W_H^{*,W,C} + W_F^{*,W,C} = v - \frac{9d^2+2\left(\tau_F^{*,W,C}-\tau_H^{*,W,C}\right)^2}{36d}$. Global welfare decreases in the tax differential, so governments set the same tax. The set of equilibrium tax rates is defined by

$$\tau_H^{*,W,C}, \tau_F^{*,W,C} \in \{\tau_H^{*,W,C} = \tau_F^{*,W,C}\}. \tag{26}$$

Taxes are welfare-neutral, as long as tax rates in the two countries are the same. Taxes shift rents from consumers and producers to governments. A tax differential induces cross-border shopping and therefore inefficiently high traveling cost which reduce global welfare. Therefore, cooperative benevolent governments set identical tax rates.

4.3.2 Online Equilibrium under Destination Principle

Global welfare is $W^{DP,W,C} = W_H^{DP,W,C} + W_F^{DP,W,C} = v - \frac{4d^2+112d\theta-80\theta^2+9\left(\tau_F^{DP,W,C}-\tau_H^{DP,W,C}\right)^2}{144d}$. Global welfare decreases in the tax differential so that governments set the same tax.

The set of equilibrium tax rates is defined by

$$\tau_H^{DP,W,C}, \tau_F^{DP,W,C} \in \{\tau_H^{DP,W,C} = \tau_F^{DP,W,C}\}. \tag{27}$$

Similar to the offline equilibrium, tax rate differences induce online shopping and therefore inefficiently high cost which decreases global welfare. Therefore both governments cooperatively set identical tax rates.

4.3.3 Online Equilibrium under Origin Principle

Global welfare is $W^{OP,W,C} = W_H^{OP,W,C} + W_F^{OP,W,C} = v - \frac{112d\theta-80\theta^2+4d^2-8(d-4\theta)(\tau_F-\tau_H)+13(\tau_F-\tau_H)^2}{144d}$. If $\theta > \frac{1}{4}d$, global welfare decreases in the tax differential and governments set the same tax rate. The set of equilibrium tax rates is defined by

$$\tau_H^{OP,W,C}, \tau_F^{OP,W,C} \in \{\tau_H^{OP,W,C} = \tau_F^{OP,W,C}\}. \tag{28}$$

If $\theta < \frac{1}{4}d$, global welfare decreases in the tax differential $\Delta\tau^{OP,W,C} = \tau_F^{OP,W,C} - \tau_H^{OP,W,C}$ if $\Delta\tau^{OP,W,C}$ is sufficiently high ($\frac{\partial W^{OP,W,C}}{\partial \Delta\tau^{OP,W,C}} < 0$ if $\Delta\tau^{OP,W,C} > \frac{4}{13}(d-4\theta)$). Best response functions are $\tau_H^{OP,W,C} = \tau_F^{OP,W,C} - \frac{4}{13}(d-4\theta)$ and $\tau_F^{OP,W,C} = \frac{4}{13}(d-4\theta) + \tau_H^{OP,W,C}$. Best response functions are upward-sloping, tax rates are strategic complements. The set of equilibrium tax rates is defined by

$$\tau_H^{OP,W,C}, \tau_F^{OP,W,C} \in \{\tau_F^{OP,W,C} - \tau_H^{OP,W,C} \leq \frac{4}{13}(d-4\theta)\}. \tag{29}$$

The set of equilibria under the origin principle depends on the competitiveness of the online retailer as reflected in the fixed cost of online shopping θ. If θ is sufficiently low ($\theta < \frac{1}{4}d$), welfare increases if $\tau_F^{OP,W,C} > \tau_H^{OP,W,C}$. If θ is sufficiently high ($\theta > \frac{1}{4}d$), competition for the indifferent consumer is inefficient as it results in inefficiently high cost of online shopping. Therefore welfare decreases if $\tau_F^{OP,W,C} > \tau_H^{OP,W,C}$.

Under cooperative benevolent governments, the presence of the online retailer may limit the incentive of country H to undercut the tax rate of country F under the origin principle.

Under cooperative benevolent governments, equilibrium tax rates are only restricted by the condition of equal tax rates (or sufficiently similar taxes) in H and in F under both tax treatments. Therefore, the effect of tax treatment on tax competition cannot be identified.

5 Discussion

This section addresses assumptions of the model and their implications for the analysis.

5.1 Market Structure

So far, the model has assumed that the brick-and-mortar stores are local monopolies and that all three retailers have pricing power. Assuming perfect competition among firms would result in marginal cost pricing and effective consumer prices equal to the (respective) tax rate.

For the model, however, a crucial assumption is that the cost of buying at the brick-and-mortar stores is location-dependent, i.e., other than in the Kanbur & Keen (1993)-framework, consumers do not "live above a store". Then the choice between buying at a brick-and-mortar store and buying online involves trading off location-dependent traveling cost and fixed cost of buying online. If there was perfect competition among a continuum of brick-and-mortar stores along the Hotelling line, consumers would not buy online for positive fixed cost of shopping online. If there were no fixed cost of buying online, consumers would buy at the retailer with the lowest price, giving rise to equilibria where all consumers buy online or consumers split between both as they are indifferent.[9]

Consider a scenario with perfect competition among brick-and-mortar stores located at the endpoints of the Hotelling line and perfect competition among several online shops, where

[9] **Agrawal (2017) notes that in the perfect competition framework a uniform distribution of both (potential) cross-border shoppers and online shoppers would not affect equilibrium tax rates. Similarly, introducing perfect competition with a uniform distribution of stores into my model would be equivalent to this case described by Agrawal (2017) and yield the same result.**

retailers set prices equal to marginal cost. Under destination-based taxation, this would imply that the online retailer charges an average price of the two tax rates or sets country-specific (and tax rate-specific) prices.

In the offline equilibrium, assuming perfect competition among brick-and-mortar stores yields tax rates

$$\tau_H^{*,PC} = \tau_F^{*,PC} = d, \tag{30}$$

which are lower than under market power.

In the online equilibrium under the destination principle, equilibrium tax rates are

$$\tau_H^{DP,PC} = \tau_F^{DP,PC} = v - \theta, \tag{31}$$

which are lower than maximum tax rates under market power and higher than minimum tax rates under market power.

In the online equilibrium under the origin principle, equilibrium tax rates are

$$\tau_H^{OP,PC} = \frac{2d-\theta}{3}, \tau_F^{OP,PC} = \frac{d+\theta}{3}, \tag{32}$$

which are lower than tax rates under market power.

The scenario of perfect competition among brick-and-mortar stores and online shops while keeping the location of brick-and-mortar stores at the endpoints of the Hotelling line yields qualitatively similar results: Under the destination principle, the entry of the online retailer mitigates tax competition and results in higher tax rates in the online equilibrium ($\tau_H^{DP,PC} > \tau_H^{*,PC}$; $\tau_F^{DP,PC} > \tau_F^{*,PC}$). Under the origin principle, the entry of the online retailer enhances tax competition and results in lower tax rates in the online equilibrium ($\tau_H^{OP,PC} < \tau_H^{*,PC}$; $\tau_F^{OP,PC} < \tau_F^{*,PC}$).

5.2 Location

As discussed above, a crucial assumption of the model is that buying at brick-and-mortar stores involves location-dependent cost.

Brick-and-mortar stores, however, do not have to be located at the endpoints of the Hotelling line but could be located closer to the center. In the Hotelling economy, both stores have an incentive to move to the center to lower competitive pressure. For the brick-and-mortar store in country H, a location at $x_H > 0$ would create a segment of captive consumers between 0 and x_H, weakening competition among firms.

If physical stores are located sufficiently far away from the center of the Hotelling line, i.e., the border, cross-border shopping would not take place, and the effect of the online retailer on tax competition would be similar. If physical stores are located sufficiently close to the border, online shopping would be attractive for consumers with high traveling cost, which are now the consumer located near the endpoints. Cross-border shopping would take place. Then governments would compete for mobile consumers under both taxation principles. Under the destination principle, governments would compete for cross-border shoppers; under the origin principle, governments would compete for cross-border shoppers plus the consumers deciding between buying at the brick-and-mortar store in country F and buying online.

The effect of the online retailer on tax competition is independent of its location: Under the destination principle, the taxation of online sales is independent of the online shop's location. Under the origin principle, the online retailer could choose where to be taxed by locating in one country or the other. Therefore, tax competition arises. However, for symmetric countries, the equilibrium is also symmetric with one country hosting the online retailer. If countries would strategically compete for the location of the online retailer, this could affect the results, but normally countries do not compete for the location of firms by sales taxes.

5.3 Country Size Asymmetries

So far, the model has assumed symmetric countries. For the offline equilibrium, country size is irrelevant as the tax bases of both countries only depend on the location of the indifferent consumer y_{HF}. Similarly, in the online equilibrium under the origin principle, tax bases of both countries only depend on the location of the indifferent consumer y_{0F}. For the online equilibrium under the destination principle, however, an asymmetry in country size could give rise to cross-border shopping, e.g., if country F is relatively small and consumers from country H which are located close to the border prefer to buy at the brick-and-mortar store in country F rather than buy online. In this case, the online equilibrium under the destination principle would be similar to the online equilibrium under the origin principle, with all online purchases being taxed by country H and countries competing for mobile consumers.

6 Conclusion

This paper has studied the effect of an online retailer on spatial tax competition with mobile consumers.

For non-cooperative Leviathan governments, tax treatment of online purchases according to the destination principle mitigates tax competition; tax treatment of online purchases of online purchases according to the origin principle enhances tax competition. Cooperation between government eliminates the potential pro-competitive effect of the online retailer: Under both tax treatment according to the destination principle and the origin principle, the online retailer weakens tax competition.

Under non-cooperative Leviathan governments, the choice of the taxation principle shapes the effect of the online retailer on tax competition. In the European Union, the destination principle applies to online retailers with sales to private households and with sales above the threshold of 100,000 Euros, suggesting that the entry of online retailers has mitigated tax competition. Similarly, in the United States, the Supreme Court's decision allowing for the tax treatment of online sales according to the destination principle for a threshold of USD 100,000 or 200 transactions per year can be expected to have a similar effect. Higher Internet penetration and lower cost of online shopping may enhance the effect of the online retailer on tax competition, suggesting that further growth of online shopping increase the competition-mitigating impact of online retailers over time.

For a sufficiently low tax rate in the country hosting the online retailer, welfare in the online retailer's home country is higher under the origin principle, while welfare in the other country is higher under the destination principle. For a sufficiently low tax differential between both countries, global welfare is higher under the destination principle. This does not imply that there is a conflict between both countries with respect to the choice of the taxation regime if side payments are feasible, as global welfare is higher under the destination principle. The member states of the European Union have agreed on the destination principle, which this model may explain with welfare maximizing governments or tax revenue maximizing, but tax competition avoiding governments.

This model has considered commodity tax competition so far. An issue of increasing relevance in the European Union is the taxation of profits of online retailers, especially with respect to the question which member states may tax online retailers. This question is left for further research.

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Appendix

A. 1 The Effect of the Online Retailer

Offline Equilibrium

In the second stage, firms maximize $\pi_H^* = (p_H^* - \tau_H^*)\left(\frac{1}{2} + \frac{p_F^* - p_H^*}{2d}\right)$ and
$\pi_F^* = (p_F^* - \tau_F^*)\left(1 - \left(\frac{1}{2} + \frac{p_F^* - p_H^*}{2d}\right)\right)$.
Equilibrium prices are $p_H^* = \frac{3d+\tau_F^*+2\tau_H^*}{3}$ and $p_F^* = \frac{3d+2\tau_F^*+\tau_H^*}{3}$. Quantities are
$q_H^* = \frac{3d+\tau_F^*-\tau_H^*}{6d}$ and $q_F^* = \frac{3d-\tau_F^*+\tau_H^*}{6d}$. The tax base in country H is $b_H^* = q_H^* = \frac{3d+\tau_F^*-\tau_H^*}{6d}$, the tax base in country F is $b_F^* = q_F^* = \frac{3d-\tau_F^*+\tau_H^*}{6d}$.
In the first stage, governments H and F maximize tax revenues $R_H^* = \tau_H^* \frac{3d+\tau_F^*-\tau_H^*}{6d}$ and $R_F^* = \tau_F^* \frac{3d-\tau_F^*+\tau_H^*}{6d}$. Best response functions are $\tau_H^* = \frac{3}{2}d + \frac{1}{2}\tau_F^*$ and $\tau_F^* = \frac{3}{2}d + \frac{1}{2}\tau_H^*$. Equilibrium tax rates are $\tau_H^* = \tau_F^* = 3d$. The tax differential is zero
$(\Delta\tau^* = \tau_F^* - \tau_H^* = 0)$. Tax revenues are $R_H^* = R_F^* = \frac{3}{2}d$. Equilibrium prices are $p_H^* = p_F^* = 4d$, quantities are $q_H^* = q_F^* = \frac{1}{2}$. Equilibrium profits are $\pi_H^* = \pi_F^* = \frac{1-6d}{4}$.
Consumer surplus in countries H and F, respectively, is
$CS_H^* = \int_0^{\frac{1}{2}} (v - p_H^* - dx)\,dx = CS_F^* = \int_{\frac{1}{2}}^{1} (v - p_F^* - d\,(1-x))\,dx = \frac{1}{2}v - \frac{17}{8}d$. Welfare in countries H and F, respectively, is $W_H^* = W_F^* = CS_j^* + \pi_j^* + R_j^* = \frac{1}{2}v - \frac{17}{8}d + \frac{1}{4}$. Global welfare is $W^* = W_H^* + W_F^* = v - \frac{17}{4}d + \frac{1}{2}$.

Online Equilibrium under Destination Principle

In the second stage, firms maximize $\pi_H^{DP} = \left(p_H^{DP} - \tau_H^{DP}\right)\left(\frac{\theta+p_0^{DP}-p_H^{DP}}{d}\right)$,
$\pi_F^{DP} = \left(p_F^{DP} - \tau_F^{DP}\right)\left(1 - \frac{d-\theta-p_0^{DP}+p_F^{DP}}{d}\right)$, and
$\pi_0^{DP} = \left(p_0^{DP} - \tau_H^{DP}\right)\left(\frac{1}{2} - \frac{\theta+p_0^{DP}-p_H^{DP}}{d}\right) + \left(p_0^{DP} - \tau_F^{DP}\right)\left(\frac{d-\theta-p_0^{DP}+p_F^{DP}}{d} - \frac{1}{2}\right)$.
Equilibrium prices are $p_H^{DP} = \frac{2d+4\theta+3\left(3\tau_H^{DP}+\tau_F^{DP}\right)}{12}$, $p_F^{DP} = \frac{2d+4\theta+3\left(3\tau_F^{DP}+\tau_H^{DP}\right)}{12}$, and
$p_0^{DP} = \frac{2d-2\theta+3\left(\tau_F^{DP}+\tau_H^{DP}\right)}{6}$. Quantities are $q_H^{DP} = \frac{2d+4\theta+3\left(\tau_F^{DP}-\tau_H^{DP}\right)}{12d}$, $q_F^{DP} = \frac{2d+4\theta-3\left(\tau_F^{DP}-\tau_H^{DP}\right)}{12d}$, and $q_0^{DP} = \frac{2(d-\theta)}{3d}$. The tax base in country H is $b_H^{DP} = q_H^{DP} + \left(\frac{1}{2} - \frac{\theta+p_0^{DP}-p_H^{DP}}{d}\right) = \frac{1}{2}$, the tax base in country F is $b_F^{DP} = q_F^{DP} + \left(\frac{d-\theta-p_0^{DP}+p_F^{DP}}{d} - \frac{1}{2}\right) = \frac{1}{2}$. Tax revenues are given as $R_H^{DP} = \frac{1}{2}\tau_H^{DP}$ and $R_F^{DP} = \frac{1}{2}\tau_F^{DP}$. Tax bases are fixed by geographical size and do not respond to tax changes. This implies that governments do not compete for mobile consumers.
Governments set tax rates to extract the full surplus of the indifferent consumers. The surplus of the consumer located at y_{H0} is

$U^{DP}(y_{H0}) = v - p_H^{DP} - dy_{H0} = v - \frac{1}{3}d - \frac{2}{3}\theta - \frac{1}{2}\tau_F^{DP} - \frac{1}{2}\tau_H^{DP}$; the surplus of the consumer located at y_{0F} is

$U^{DP}(y_{0F}) = v - p_F^{DP} - d(1 - y_{0F}) = v - \frac{1}{3}d - \frac{2}{3}\theta - \frac{1}{2}\tau_F^{DP} - \frac{1}{2}\tau_H^{DP}$. This yields best response functions $\tau_H^{DP} = 2v - \frac{2}{3}d - \frac{4}{3}\theta - \tau_F^{DP}$ and $\tau_F^{DP} = 2v - \frac{2}{3}d - \frac{4}{3}\theta - \tau_H^{DP}$, which are identical and define a set of equilibria.

For this set of equilibria, three conditions have to hold: i) Cross-border shopping does not take place. ii) All three firms sell non-negative quantities. iii) The online retailer's profit is non-negative. This implies that consumers cannot choose where to be taxed, i.e. tax bases are fixed by country size, and that all three firms are active.

Condition i) and ii) imply that $y_{H0} \in [0, \frac{1}{2}]$ and $y_{0F} \in [\frac{1}{2}, 1]$, indifferent consumer y_{H0} is located in country H and indifferent consumer y_{0F} is located in country F. All three stores sell a non-negative quantity and in both countries, all consumers buy either at the local brick-and-mortar store or at the online retailer. This defines a maximum tax differential: For $y_{H0} \in [0, \frac{1}{2}]$, $\tau_H^{DP} \leq \tau_F^{DP} + \frac{2}{3}(d + 2\theta)$ and

$\tau_H^{DP} \geq \tau_F^{DP} - \frac{4}{3}(d - \theta)$. For $y_{0F} \in [\frac{1}{2}, 1]$, $\tau_H^{DP} \leq \tau_F^{DP} + \frac{4}{3}(d - \theta)$ and $\tau_H^{DP} \geq \tau_F^{DP} - \frac{2}{3}(d + 2\theta)$.

Condition iii) requires that $\pi_0^{DP} = \frac{-16d\theta + 8\theta^2 + 8d^2 - 9\left(\tau_F^{DP} - \tau_H^{DP}\right)^2}{36d} \geq 0$. The online shop sets a single price p_0 while part of his sales are taxed in country H and part of his sales are taxed in country F. At the same time, he competes with the same price p_0 against the brick-and-mortar store in H whose sales are taxed only in country H and against the brick-and-mortar store in F whose sales are taxed only in country F. A high tax difference would result in a positive margin in one country and a negative margin in the other, with more sales occurring in the country with the higher tax, which is the country with the negative margin. The online shop would therefore run losses.

Conditions i) - iii) define a maximum tax differential

$\left|\overline{\Delta\tau^{DP}}\right| = min\{\frac{2}{3}\sqrt{2}(d - \theta), \frac{2}{3}(d + 2\theta)\}$, with $\theta < (>) \widehat{\theta} = d\frac{\sqrt{2}-1}{\sqrt{2}+2}$, $\frac{2}{3}\sqrt{2}(d - \theta) > (<) \frac{2}{3}(d + 2\theta)$.

For low cost of online shopping $\theta < \widehat{\theta}$, the maximum tax differential is

$\left|\overline{\Delta\tau^{DP,\theta<\widehat{\theta}}}\right| = \frac{2}{3}(d + 2\theta)$; for high cost of online shopping $\theta > \widehat{\theta}$, the maximum tax differential is $\left|\overline{\Delta\tau^{DP,\theta>\widehat{\theta}}}\right| = \frac{2}{3}\sqrt{2}(d - \theta)$.

The set of equilibria in the online equilibrium under the destination principle are defined by $\tau_H^{DP}, \tau_F^{DP} \in \{\tau_H^{DP} + \tau_F^{DP} = 2v - \frac{2}{3}d - \frac{4}{3}\theta\} \cap \{\left|\Delta\tau^{DP}\right| \leq min\{\frac{2}{3}\sqrt{2}(d - \theta), \frac{2}{3}(d + 2\theta)\}\}$.

Assuming the maximum tax differential yields the maximum and minimum tax rates $\overline{\tau^{DP}}, \underline{\tau^{DP}}$.

For i) $\theta > \widehat{\theta} = d\frac{\sqrt{2}-1}{\sqrt{2}+2}$, the maximum tax differential is given as

$\left|\overline{\Delta\tau^{DP,\theta>\widehat{\theta}}}\right| = \frac{2}{3}\sqrt{2}\,(d-\theta)$. For $\overline{\tau_j^{DP,\theta>\widehat{\theta}}} = \underline{\tau_{-j}^{DP,\theta>\widehat{\theta}}} + \frac{2}{3}\sqrt{2}\,(d-\theta)$, the maximum tax rate is $\overline{\tau_j^{DP,\theta>\widehat{\theta}}} = v + \frac{1}{3}\left(d\left(\sqrt{2}-1\right) - \theta\left(\sqrt{2}+2\right)\right)$ and the minimum tax rate is $\underline{\tau_{-j}^{DP,\theta>\widehat{\theta}}} = v - \frac{1}{3}\left(d\left(\sqrt{2}+1\right) + \theta\left(2-\sqrt{2}\right)\right)$. Corresponding maximum and minimum tax revenues are $\overline{R_j^{DP,\theta>\widehat{\theta}}} = \frac{1}{2}\left(v + \frac{1}{3}\left(d\left(\sqrt{2}-1\right) - \theta\left(\sqrt{2}+2\right)\right)\right)$ and $\underline{R_{-j}^{DP,\theta>\widehat{\theta}}} = \frac{1}{2}\left(v - \frac{1}{3}\left(d\left(\sqrt{2}+1\right) + \theta\left(2-\sqrt{2}\right)\right)\right)$.

Minimum tax rates and revenues are higher than tax rates and revenues in the offline equilibrium ($\underline{\tau_{-j}^{DP,\theta>\widehat{\theta}}} - \tau_j^* = v - \frac{1}{3}\left(d\left(\sqrt{2}+10\right) + \theta\left(2-\sqrt{2}\right)\right) > 0$, $\underline{R_{-j}^{DP,\theta>\widehat{\theta}}} - R_j^* = \frac{1}{2}\left(v - \frac{1}{3}\left(d\left(\sqrt{2}+10\right) + \theta\left(2-\sqrt{2}\right)\right)\right) > 0$).

For ii) $\theta < \widehat{\theta} = d\frac{\sqrt{2}-1}{\sqrt{2}+2}$, the maximum tax differential is given as $\left|\overline{\Delta\tau^{DP,\theta<\widehat{\theta}}}\right| = \frac{2}{3}(d+2\theta)$. For $\overline{\tau_j^{DP,\theta<\widehat{\theta}}} = \underline{\tau_{-j}^{DP,\theta<\widehat{\theta}}} + \frac{2}{3}(d+2\theta)$, the maximum tax rate is $\overline{\tau_j^{DP,\theta<\widehat{\theta}}} = v$, the minimum tax rate is $\underline{\tau_{-j}^{DP,\theta<\widehat{\theta}}} = v - \frac{2}{3}d - \frac{4}{3}\theta$. Corresponding maximum and minimum tax revenues are $\overline{R_j^{DP,\theta<\widehat{\theta}}} = \frac{1}{2}v$ and $\underline{R_{-j}^{DP,\theta<\widehat{\theta}}} = \frac{1}{2}\left(v - \frac{2}{3}d - \frac{4}{3}\theta\right)$.

Minimum tax rates and revenues are higher than tax rates and revenues in the offline equilibrium ($\underline{\tau_{-j}^{DP,\theta<\widehat{\theta}}} - \tau_j^* = v - \frac{1}{3}(11d+4\theta) > 0$, $\underline{R_{-j}^{DP,\theta<\widehat{\theta}}} - R_j^* = \frac{1}{2}v - \frac{1}{6}(11d+4\theta) > 0$).

Firm's profits are given as $\pi_H^{DP} = \frac{\left(2d+4\theta+3\left(\tau_F^{DP}-\tau_H^{DP}\right)\right)^2}{144d}$, $\pi_F^{DP} = \frac{\left(2d+4\theta-3\left(\tau_F^{DP}-\tau_H^{DP}\right)\right)^2}{144d}$, and $\pi_0^{DP} = \frac{8(d-\theta)^2-9\left(\tau_F^{DP}-\tau_H^{DP}\right)^2}{36d}$. Consumer surplus in countries H and F is given as $CS_H^{DP} = \int_0^{y_{H0}}\left(v - p_H^{DP} - dx\right)dx + \int_{y_{H0}}^{\frac{1}{2}}\left(v - p_0^{DP} - \theta\right)dx$
$= \frac{1}{2}v - \frac{4(11d-2\theta)(d+2\theta)+60d\tau_F^{DP}+84d\tau_H^{DP}-3\left(\tau_F^{DP}-\tau_H^{DP}\right)\left(8\theta+3\left(\tau_F^{DP}-\tau_H^{DP}\right)\right)}{288d}$ and
$CS_F^{DP} = \int_{\frac{1}{2}}^{y_{0F}}\left(v - p_0^{DP} - \theta\right)dx + \int_{y_{0F}}^{1}\left(v - p_F^{DP} - d(1-x)\right)dx$
$= \frac{1}{2}v - \frac{4(11d-2\theta)(d+2\theta)+84d\tau_F^{DP}+60d\tau_H^{DP}+3\left(\tau_F^{DP}-\tau_H^{DP}\right)\left(8\theta-3\left(\tau_F^{DP}-\tau_H^{DP}\right)\right)}{288d}$. Welfare in countries H and F, respectively, is
$W_H^{DP} = CS_H^{DP} + \pi_H^{DP} + \pi_0^{DP} + R_H^{DP} = \frac{1}{2}v + \frac{28d^2-176d\theta+112\theta^2-9\left(\tau_F^{DP}-\tau_H^{DP}\right)\left(4d-8\theta+5\left(\tau_F^{DP}-\tau_H^{DP}\right)\right)}{288d}$ and $W_F^{DP} = CS_F^{DP} + \pi_F^{DP} + R_F^{DP} = \frac{1}{2}v - \frac{12d^2+16d\theta-16\theta^2-3\left(\tau_F^{DP}-\tau_H^{DP}\right)\left(4d-8\theta+3\left(\tau_F^{DP}-\tau_H^{DP}\right)\right)}{96d}$. Global welfare is $W^{DP} = W_H^{DP} + W_F^{DP} = v - \frac{4d^2+112d\theta-80\theta^2+9\left(\tau_F^{DP}-\tau_H^{DP}\right)^2}{144d}$.

Example: Symmetric Equilibrium

In the symmetric equilibrium, tax rates are $\tau_H^{DP,s} = \tau_F^{DP,s} = v - \frac{1}{3}d - \frac{2}{3}\theta$. The tax differential is zero ($\Delta\tau^{DP,s} = \tau_F^{DP,s} - \tau_H^{DP,s} = 0$). Tax revenues are $R_H^{DP,s} = R_F^{DP,s} = \frac{1}{2}\left(v - \frac{1}{3}d - \frac{2}{3}\theta\right)$. Equilibrium prices are $p_H^{DP,s} = p_F^{DP,s} = v - \frac{1}{6}d - \frac{1}{3}\theta$ and $p_0^{DP,s} = v - \theta$, quantities are $q_H^{DP,s} = q_F^{DP,s} = \frac{d+2\theta}{6d}$ and $q_0^{DP,s} = \frac{2(d-\theta)}{3d}$. Equilibrium profits are $\pi_H^{DP,s} = \pi_F^{DP,s} = \frac{(d+2\theta)^2}{36d}$ and $\pi_0^{DP} = \frac{2(d-\theta)^2}{9d}$.

Consumer surplus in countries H and F, respectively, is

$CS_H^{DP,s} = \int\limits_0^{y_{H0}} \left(v - p_H^{DP,s} - dx\right) dx + \int\limits_{y_{H0}}^{\frac{1}{2}} \left(v - p_0^{DP,s} - \theta\right) dx$

$= CS_F^{DP,s} = \int\limits_{\frac{1}{2}}^{y_{0F}} \left(v - p_0^{DP,s} - \theta\right) dx + \int\limits_{y_{0F}}^{1} \left(v - p_F^{DP,s} - d\left(1-x\right)\right) dx = \frac{(d+2\theta)^2}{72d}$. Welfare in country H is $W_H^{DP,s} = CS_H^{DP,s} + \pi_H^{DP,s} + \pi_0^{DP,s} + R_H^{DP,s} = \frac{36vd-44d\theta+28\theta^2+7d^2}{72d}$. Welfare in country F is $W_F^{DP,s} = CS_F^{DP,s} + \pi_F^{DP,s} + R_F^{DP,s} = \frac{12vd-3d^2-4d\theta+4\theta^2}{24d}$. Global welfare is $W^{DP,s} = W_H^{DP,s} + W_F^{DP,s} = \frac{36vd-d^2-28d\theta+20\theta^2}{36d}$.

Compared to the offline equilibrium, prices are higher $(p_H^{DP,s} - p_H^* = p_F^{DP,s} - p_F^* = v - \frac{25}{6}d - \frac{1}{3}\theta > 0)$, quantities of the physical stores are lower $(q_H^{DP,s} - q_H^* = q_F^{DP,s} - q_F^* = -\frac{(d-\theta)}{3d} < 0)$, taxes and revenues are higher $(\tau_H^{DP,s} - \tau_H^* = \tau_F^{DP,s} - \tau_F^* = v - \frac{10}{3}d - \frac{2}{3}\theta > 0$, $R_H^{DP,s} - R_H^* = R_F^{DP,s} - R_F^* = \frac{1}{2}v - \frac{5}{3}d - \frac{1}{3}\theta > 0)$.

Online Equilibrium under Origin Principle

In the second stage, firms maximize $\pi_H^{OP} = \left(p_H^{OP} - \tau_H^{OP}\right)\left(\frac{\theta+p_0^{OP}-p_H^{OP}}{d}\right)$,
$\pi_F^{OP} = \left(p_F^{OP} - \tau_F^{OP}\right)\left(1 - \frac{d-\theta-p_0^{OP}+p_F^{OP}}{d}\right)$, and $\pi_0^{OP} = \left(p_0^{OP} - \tau_H^{OP}\right)\left(\frac{d-\theta-p_0^{OP}+p_F^{OP}}{d} - \frac{\theta+p_0^{OP}-p_H^{OP}}{d}\right)$.
Equilibrium prices are $p_H^{OP} = \frac{2d+4\theta+\tau_F^{OP}+11\tau_H^{OP}}{12}$, $p_F^{OP} = \frac{2d+4\theta+7\tau_F^{OP}+5\tau_H^{OP}}{12}$, and $p_0^{OP} = \frac{2d-2\theta+\tau_F^{OP}+5\tau_H^{OP}}{6}$. Quantities are $q_H^{OP} = \frac{2d+4\theta+\tau_F^{OP}-\tau_H^{OP}}{12d}$, $q_F^{OP} = \frac{2d+4\theta-5\tau_F^{OP}+5\tau_H^{OP}}{12d}$, and $q_0^{OP} = \frac{2d-2\theta+\tau_F^{OP}-\tau_H^{OP}}{3d}$.

In the first stage, governments H and F maximize tax revenues $R_H^{OP} = \tau_H^{OP}\left(\frac{2d+4\theta+\tau_F^{OP}-\tau_H^{OP}}{12d} + \frac{2d-2\theta+\tau_F^{OP}-\tau_H^{OP}}{3d}\right)$ and $R_F^{OP} = \tau_F^{OP}\left(\frac{2d+4\theta-5\tau_F^{OP}+5\tau_H^{OP}}{12d}\right)$. Best response functions are $\tau_H^{OP} = d - \frac{2}{5}\theta + \frac{1}{2}\tau_F^{OP}$ and $\tau_F^{OP} = \frac{1}{5}d + \frac{2}{5}\theta + \frac{1}{2}\tau_H^{OP}$. Equilibrium tax rates are $\tau_H^{OP} = \frac{2(11d-2\theta)}{15}$ and $\tau_F^{OP} = \frac{2(7d+2\theta)}{15}$. The tax differential is negative ($\Delta\tau^{OP} = \tau_F^{OP} - \tau_H^{OP} = -\frac{8(d-\theta)}{15} < 0$). Tax revenues are $R_H^{OP} = \frac{(11d-2\theta)^2}{135d}$ and $R_F^{OP} = \frac{(7d+2\theta)^2}{135d}$. Equilibrium prices are $p_H^{OP} = \frac{143d+10\theta}{90}$, $p_F^{OP} = \frac{17(7d+2\theta)}{90}$, and $p_0^{OP} = \frac{77d-23\theta}{45}$; quantities are $q_H^{OP} = \frac{11d+34\theta}{90d}$, $q_F^{OP} = \frac{7d+2\theta}{18d}$, and $q_0^{OP} = \frac{22(d-\theta)}{45d}$. Equilibrium profits are $\pi_H^{OP} = \frac{(11d+34\theta)^2}{8100d}$, $\pi_F^{OP} = \frac{(7d+2\theta)^2}{324d}$, and $\pi_0^{OP} = \frac{242(d-\theta)^2}{2025d}$.

Consumer surplus in countries H and F, respectively, is
$CS_H^{OP} = \int\limits_0^{y_{H0}} \left(v - p_H^{OP} - dx\right) dx + \int\limits_{y_{H0}}^{\frac{1}{2}} \left(v - p_0^{OP} - \theta\right) dx = \frac{1}{2}v + \frac{1156\theta^2-13\,739d^2-3212d\theta}{16\,200d}$ and
$CS_F^{OP} = \int\limits_{\frac{1}{2}}^{y_{0F}} \left(v - p_0^{OP} - \theta\right) dx + \int\limits_{y_{0F}}^{1} \left(v - p_F^{OP} - d\left(1-x\right)\right) dx = \frac{1}{2}v + \frac{20\theta^2-2527d^2-652d\theta}{3240d}$. Welfare in country H is $W_H^{OP} = CS_H^{OP} + \pi_H^{OP} + \pi_0^{OP} + R_H^{OP} = \frac{\left(2959d^2-10\,868d\theta+8100vd+5884\theta^2\right)}{16\,200d}$. Welfare in country F is $W_F^{OP} = CS_F^{OP} + \pi_F^{OP} + R_F^{OP} = \frac{\left(540vd+52\theta^2-287d^2+100d\theta\right)}{1080d}$. Global welfare is

$W^{OP} = W_H^{OP} + W_F^{OP} = \frac{8100vd+3332\theta^2-673d^2-4684d\theta}{8100d}$.

Compared to the offline equilibrium, in the online equilibrium under the origin principle, prices and quantities are lower ($p_H^{OP} - p_H^* = -\frac{217d-10\theta}{90} < 0$, $p_F^{OP} - p_F^* = -\frac{241d-34\theta}{90} < 0$, $q_H^{OP} - q_H^* = -\frac{17(d-\theta)}{45d} < 0$, $q_F^{OP} - q_F^* = -\frac{d-\theta}{9d} < 0$), taxes and revenues are lower ($\tau_H^{OP} - \tau_H^* = -\frac{23d+4\theta}{15} < 0$, $\tau_F^{OP} - \tau_F^* = -\frac{31d-4\theta}{15} < 0$, $R_H^{OP} - R_H^* = -\frac{163d^2+88d\theta-8\theta^2}{270d} < 0$, $R_F^{OP} - R_F^* = -\frac{307d^2-56d\theta-8\theta^2}{270d} < 0$).

Compared to the online equilibrium under the destination principle, in the online equilibrium under the origin principle, prices are lower ($p_H^{OP} - p_H^{DP} = -\frac{45\left(\tau_F^{DP}+3\tau_H^{DP}\right)-8(32d-5\theta)}{180} < 0$, $p_F^{OP} - p_F^{DP} = -\frac{45\left(3\tau_F^{DP}+\tau_H^{DP}\right)-8(26d+\theta)}{180} < 0$, $p_0^{OP} - p_0^{DP} = -\frac{45\left(\tau_F^{DP}+\tau_H^{DP}\right)-4(31d-4\theta)}{90} < 0$). For a sufficiently high tax differential $\Delta\tau^{DP} = \tau_F^{DP} - \tau_H^{DP}$, the quantity of the brick-and-mortar store in H is lower and the quantity of the brick-and-mortar store in F is higher ($q_H^{OP} - q_H^{DP} = -\frac{8d-8\theta+45(\tau_F-\tau_H)}{180d} < 0$ if $\Delta\tau^{DP} > \Delta\tau_{q_H}^{DP} = -\frac{8(d-\theta)}{45}$, $q_F^{OP} - q_F^{DP} = \frac{8d-8\theta+9(\tau_F-\tau_H)}{36d} > 0$ if if $\Delta\tau^{DP} > \Delta\tau_{q_H}^{DP} = -\frac{8(d-\theta)}{9}$), the quantity of the online shop is lower ($q_0^{OP} - q_0^{DP} = -\frac{8(d-\theta)}{45d} < 0$). Tax rates and revenues are lower ($\tau_H^{OP} - \underline{\tau_{-j}^{DP,\theta>\widehat{\theta}}} = -\left(v - \frac{1}{15}\left(d\left(5\sqrt{2}+27\right) - \theta\left(5\sqrt{2}-6\right)\right)\right) < 0$,

$\tau_H^{OP} - \underline{\tau_{-j}^{DP,\theta<\widehat{\theta}}} = -\left(v - \frac{16}{15}\left(2d+\theta\right)\right) < 0$,

$\tau_F^{OP} - \underline{\tau_{-j}^{DP,\theta>\widehat{\theta}}} = -\left(v - \frac{1}{15}\left(d\left(5\sqrt{2}+19\right) + \theta\left(14-5\sqrt{2}\right)\right)\right) < 0$,

$\tau_F^{OP} - \underline{\tau_{-j}^{DP,\theta<\widehat{\theta}}} = -\left(v - \frac{8}{5}\left(d+\theta\right)\right) < 0$,

$R_H^{OP} - \underline{R_{-j}^{DP,\theta>\widehat{\theta}}} = -\left(\frac{1}{2}v - \frac{d^2\left(45\sqrt{2}+287\right)-d\theta\left(45\sqrt{2}-2\right)+8\theta^2}{270d}\right) < 0$,

$R_H^{OP} - \underline{R_{-j}^{DP,\theta<\widehat{\theta}}} = -\left(\frac{1}{2}v - \frac{332d^2+92d\theta+8\theta^2}{270d}\right) < 0$,

$R_F^{OP} - \underline{R_{-j}^{DP,\theta>\widehat{\theta}}} = -\left(\frac{1}{2}v - \frac{d^2\left(45\sqrt{2}+143\right)-d\theta\left(45\sqrt{2}-146\right)+8\theta^2}{270d}\right) < 0$,

$R_F^{OP} - \underline{R_{-j}^{DP,\theta<\widehat{\theta}}} = -\left(\frac{1}{2}v - \frac{188d^2+236d\theta+8\theta^2}{270d}\right) < 0$).

Welfare Analysis

For the brick-and-mortar store in country H, profits are higher under the destination principle if the tax differential $\Delta\tau^{DP} = \tau_F^{DP} - \tau_H^{DP}$ is sufficiently high ($\pi_H^{OP} - \pi_H^{DP} = -\frac{32(d-\theta)(13d+32\theta)+2700\left(\tau_F^{DP}-\tau_H^{DP}\right)(d+2\theta)+2025\left(\tau_F^{DP}-\tau_H^{DP}\right)^2}{32\,400d} < 0$, if $\Delta\tau^{DP} > \widehat{\Delta\tau_{\pi_H}^{DP}} = -\frac{8(d-\theta)}{45}$, with $\left|\widehat{\Delta\tau_{\pi_H}^{DP}}\right| < \left|\overline{\Delta\tau^{DP,\theta<\widehat{\theta}}}\right|$, $\left|\widehat{\Delta\tau_{\pi_H}^{DP}}\right| < \left|\overline{\Delta\tau^{DP,\theta>\widehat{\theta}}}\right|$).

For the brick-and-mortar store in country F profits are higher under the origin principle if the tax differential $\Delta\tau^{DP}$ is sufficiently high

$(\pi_F^{OP} - \pi_F^{DP} = \frac{32(d-\theta)(5d+4\theta)+108\left(\tau_F^{DP}-\tau_H^{DP}\right)(d+2\theta)-81\left(\tau_F^{DP}-\tau_H^{DP}\right)^2}{1296d} > 0$, if $\Delta\tau^{DP} > \widehat{\Delta\tau_{\pi_F}^{DP}} - \frac{8(d-\theta)}{9}$, with $\left|\widehat{\Delta\tau_{\pi_F}^{DP}}\right| < \left|\overline{\Delta\tau^{DP,\theta<\widehat{\theta}}}\right|$, if $\theta < \frac{1}{10}d$ and $\left|\widehat{\Delta\tau_{\pi_F}^{DP}}\right| < \left|\overline{\Delta\tau^{DP,\theta>\widehat{\theta}}}\right|$).

For the online retailer, profits are higher under the destination principle if the tax differential $\Delta\tau^{DP}$ is sufficiently low ($\pi_0^{OP} - \pi_0^{DP} = -\frac{832(d-\theta)^2-2025\left(\tau_F^{DP}-\tau_H^{DP}\right)^2}{8100d} < 0$, if $\left|\widehat{\Delta\tau_{\pi_0}^{DP}}\right| < \frac{8}{45}\sqrt{13}\,(d-\theta)$, with $\left|\widehat{\Delta\tau_{\pi_0}^{DP}}\right| < \left|\overline{\Delta\tau^{DP,\theta<\widehat{\theta}}}\right|$, $\left|\widehat{\Delta\tau_{\pi_0}^{DP}}\right| < \left|\overline{\Delta\tau^{DP,\theta>\widehat{\theta}}}\right|$.

For both governments, tax revenues are higher under the destination principle ($R_H^{OP} - R_H^{DP} = -\left(\frac{1}{2}\tau_H^{DP} - \frac{(11d-2\theta)^2}{135d}\right) < 0$; $R_F^{OP} - R_F^{DP} = -\left(\frac{1}{2}\tau_F^{DP} - \frac{(7d+2\theta)^2}{135d}\right) < 0$).

In both countries, consumer surplus is higher under the origin principle
($CS_H^{OP} - CS_H^{DP} = \frac{-32\left(1408d^2-161d\theta-32\theta^2\right)+2700d\left(5\tau_F^{DP}+7\tau_H^{DP}\right)-675\left(\tau_F^{DP}-\tau_H^{DP}\right)\left(8\theta+3\left(\tau_F^{DP}-\tau_H^{DP}\right)\right)}{64\,800d} > 0$;
$\frac{\partial\left(CS_H^{OP}-CS_H^{DP}\right)}{\partial\tau_H} > 0$ if $\tau_H^{DP} < \frac{2(7d+2\theta)}{3} + \tau_F^{DP}$; for $\tau_H^{DP} = \underline{\tau^{DP,\theta>\widehat{\theta}}}$ and $\tau_F^{DP} = \overline{\tau^{DP,\theta>\widehat{\theta}}}$, $CS_H^{OP} - CS_H^{DP} = \frac{1}{2}v - \frac{d^2\left(225\sqrt{2}+7207\right)-\theta^2\left(450\sqrt{2}-97\right)+d\theta\left(225\sqrt{2}+1606\right)}{8100d} > 0$; for $\tau_H^{DP} = \underline{\tau_{-j}^{DP,\theta<\widehat{\theta}}}$ and $\tau_F^{DP} = \overline{\tau_j^{DP,\theta<\widehat{\theta}}} = v$, $CS_H^{OP} - CS_H^{DP} = \frac{1}{2}v - \frac{6812d\theta+2444\theta^2+14\,639d^2}{16\,200d} > 0$;
$CS_F^{OP} - CS_F^{DP} = \frac{-8128d^2+992d\theta-640\theta^2+540d\left(7\tau_F^{DP}+5\tau_H^{DP}\right)+135\left(\tau_F^{DP}-\tau_H^{DP}\right)\left(8\theta-3\left(\tau_F^{DP}-\tau_H^{DP}\right)\right)}{12\,960d} > 0$;
$\frac{\partial\left(CS_F^{OP}-CS_F^{DP}\right)}{\partial\tau_F} > 0$, if $\tau_F^{DP} < \frac{2}{3}(7d+2\theta) + \tau_H^{DP}$, for $\tau_H^{DP} = \overline{\tau^{DP,\theta>\widehat{\theta}}}$ and $\tau_F^{DP} = \underline{\tau^{DP,\theta>\widehat{\theta}}}$, $CS_F^{OP} - CS_F^{DP} = \frac{1}{2}v - \frac{d^2\left(45\sqrt{2}+1331\right)-\theta^2\left(90\sqrt{2}-125\right)+d\theta\left(45\sqrt{2}+326\right)}{1620d} > 0$; for $\tau_H^{DP} = \overline{\tau^{DP,\theta<\widehat{\theta}}}$ and $\tau_F^{DP} = \underline{\tau^{DP,\theta<\widehat{\theta}}}$, $CS_F^{OP} - CS_F^{DP} = \frac{1}{2}v - \frac{1372d\theta+700\theta^2+2707d^2}{3240d} > 0$).

Welfare in country H is higher under the origin principle if τ_H^{DP} is sufficiently low ($W_H^{OP} - W_H^{DP} = \frac{5536d^2-3872d\theta-1664\theta^2+8100\left(\tau_F^{DP}-\tau_H^{DP}\right)(d-2\theta)+10\,125\left(\tau_F^{DP}-\tau_H^{DP}\right)^2}{64\,800d} > 0$,
if $\tau_H^{DP} < \widehat{\tau_{H,W_H}^{DP}} = \tau_F^{DP} + \frac{\frac{2}{45}\sqrt{5}\sqrt{-652d\theta+2036\theta^2-979d^2}+2d-4\theta}{5}$). Welfare in country F is higher under the destination principle if τ_H^{DP} is sufficiently high
($W_F^{OP} - W_F^{DP} = -\frac{608d^2-1120d\theta+512\theta^2+540\left(\tau_F^{DP}-\tau_H^{DP}\right)(d-2\theta)+405\left(\tau_F^{DP}-\tau_H^{DP}\right)^2}{4320d} < 0$,
if $\tau_H^{DP} < \widehat{\tau_{H,W_F}^{DP}} = \tau_F^{DP} + \frac{2\left(d-2\theta+\frac{1}{15}\sqrt{5}\sqrt{100d\theta+52\theta^2-107d^2}\right)}{3}$).

Global welfare is higher under the destination principle if the tax differential $\Delta\tau^{DP}$ is sufficiently low
($W^{OP} - W^{DP} = -\frac{1792d^2-6464d\theta+4672\theta^2-2025\left(\tau_F^{DP}-\tau_H^{DP}\right)^2}{32\,400d} < 0$,
if $\left|\Delta\tau^{DP}\right| < \widehat{\Delta\tau_W^{DP}} = \frac{8}{45}\sqrt{(28d-73\theta)(d-\theta)}$, with $\left|\widehat{\Delta\tau_W^{DP}}\right| < \left|\overline{\Delta\tau^{DP,\theta<\widehat{\theta}}}\right|$,
if $\theta < \left(-\frac{45}{67}\sqrt{47} + \frac{629}{134}\right)d$).

A. 2 Role of Governments

Cooperative Leviathan Governments

Offline Equilibrium In the offline equilibrium, joint revenue of both governments is $R^{*,C} = R_H^{*,C} + R_F^{*,C} = \frac{3d\left(\tau_F^{*,C}+\tau_H^{*,C}\right)-\left(\tau_F^{*,C}-\tau_H^{*,C}\right)^2}{6d}$. Joint revenue increases in both tax rates but decreases in the tax differential. Joint revenue increases in tax rate τ_j as long as $\tau_j = \tau_{-j}$.

Governments set tax rates to extract the full surplus of the indifferent consumer. The surplus of the consumer located at $y_{HF}^{*,C}$ is

$U^{*,C}(y_{HF}) = v - p_H^{*,C} - dy_{HF}^{*,C} = v - p_F^{*,C} - d\left(1 - y_{HF}^{*,C}\right) = v - \frac{3}{2}d - \frac{1}{2}\tau_F^{*,C} - \frac{1}{2}\tau_H^{*,C}$, yielding response functions $\tau_H^{*,C} = 2v - 3d - \tau_F^{*,C}$ and $\tau_F^{*,C} = 2v - 3d - \tau_H^{*,C}$.

By symmetry, equilibrium tax rates are $\tau_H^{*,C} = \tau_F^{*,C} = v - \frac{3}{2}d$. The tax differential is zero ($\Delta\tau^{*,C} = \tau_F^{*,C} - \tau_H^{*,C} = 0 = \Delta\tau^*$). Tax revenues are $R_H^{*,C} = R_F^{*,C} = \frac{1}{2}\left(v - \frac{3}{2}d\right)$. Equilibrium prices are $p_H^{*,C} = p_F^{*,C} = v - \frac{1}{2}d$. Quantities are $q_H^{*,C} = q_F^{*,C} = \frac{1}{2}$.

Compared to the offline equilibrium with no cooperation, tax rates and revenues are higher ($\tau_H^{*,C} - \tau_H^* = \tau_F^{*,C} - \tau_F^* = v - \frac{9}{2}d > 0$, $R_H^{*,C} - R_H^* = R_F^{*,C} - R_F^* = \frac{1}{2}v - \frac{9}{4}d > 0$).

Online Equilibrium under Destination Principle

The online equilibrium under the destination principle with cooperation of governments is equivalent to the online equilibrium under the destination principle with no cooperation. Joint tax revenue is $R^{DP,C} = R_H^{DP,C} + R_F^{DP,C} = \tau_H\frac{1}{2} + \tau_F\frac{1}{2} = \frac{1}{2}(\tau_F + \tau_H)$. The joint revenue increases in both tax rates.

Equilibrium tax rates in the online equilibrium under the destination principle are defined by $\tau_H^{DP,C}, \tau_F^{DP,C} \in \{\tau_H^{DP} + \tau_F^{DP} = 2v - \frac{2}{3}d - \frac{4}{3}\theta\} \cap \{\left|\Delta\tau^{DP}\right| \leq min\{\frac{2}{3}\sqrt{2}(d-\theta), \frac{2}{3}(d+2\theta)\}\}$.

Compared to the symmetric online equilibrium under destination principle with no cooperation, tax rates and revenues are the same.

Compared to the offline equilibrium with cooperation, tax rates and revenues are higher ($\tau_H^{DP,C,s} - \tau_H^{*,C} = \tau_F^{DP,C,s} - \tau_F^{*,C} = \frac{7d-4\theta}{6} > 0$;
$\underline{\tau_{-j}^{DP,\theta>\widehat{\theta}}} - \tau_j^{*,C} = \frac{1}{6}\left(d\left(7-2\sqrt{2}\right) - \theta\left(4-2\sqrt{2}\right)\right) > 0$, $\underline{\tau_{-j}^{DP,\theta<\widehat{\theta}}} - \tau_j^{*,C} = \frac{1}{6}(5d - 8\theta) > 0$;
$R_H^{DP,C,s} - R_H^{*,C} = R_F^{DP,C,s} - R_F^{*,C} = \frac{7d-4\theta}{12} > 0$,
$\underline{R_{-j}^{DP,\theta>\widehat{\theta}}} - R_j^{*,C} = \frac{1}{12}\left(d\left(7-2\sqrt{2}\right) - \theta\left(4-2\sqrt{2}\right)\right) > 0$, $\underline{R_{-j}^{DP,\theta<\widehat{\theta}}} - R_j^{*,C} = \frac{1}{12}(5d - 8\theta) > 0$).

Online Equilibrium under Origin Principle

In the online equilibrium under the origin principle, joint revenue of both governments is

$R^{OP,C} = R_H^{OP,C} + R_F^{OP,C} = \frac{2\tau_F(d+2\theta)+2\tau_H(5d-2\theta)-5(\tau_F-\tau_H)^2}{12d}$. The joint revenue increases in both tax rates but decreases in the tax differential. The joint revenue increases in tax rate τ_j as long as $\tau_j = \tau_{-j}$.

Governments set tax rates to extract the full surplus of the indifferent consumer. The surplus of the consumer located at $y_{H0}^{OP,C}$ is

$U^{OP,C}\left(y_{H0}^{OP,C}\right) = v - p_H - dy_{H0}^{OP,C} = v - \frac{1}{3}d - \frac{2}{3}\theta - \frac{1}{6}\tau_F^{OP,C} - \frac{5}{6}\tau_H^{OP,C}$, the surplus of the consumer located at $y_{0F}^{OP,C}$ is

$U^{OP,C}\left(y_{0F}^{OP,C}\right) = v - p_F - d\left(1 - y_{0F}^{OP,C}\right) = v - \frac{1}{3}d - \frac{2}{3}\theta - \frac{1}{6}\tau_F^{OP,C} - \frac{5}{6}\tau_H^{OP,C}$. Best response functions are $\tau_H^{OP,C} = \frac{6}{5}v - \frac{2}{5}d - \frac{4}{5}\theta - \frac{1}{5}\tau_F^{OP,C}$, $\tau_F^{OP,C} = 6v - 2d - 4\theta - 5\tau_H^{OP,C}$. Equilibrium tax rates are $\tau_H^{OP,C} = \tau_F^{OP,C} = v - \frac{1}{3}d - \frac{2}{3}\theta$. The tax differential is zero ($\Delta\tau^{OP,C} = \tau_F^{OP,C} - \tau_H^{OP,C} = 0$). Tax revenues are $R_H^{OP,C} = \frac{(5d-2\theta)\left(v-\frac{1}{3}d-\frac{2}{3}\theta\right)}{6d}$,

$R_F^{OP,C} = \frac{(2d+4\theta)\left(v-\frac{1}{3}d-\frac{2}{3}\theta\right)}{12d}$. Equilibrium prices are $p_H^{OP,C} = p_F^{OP,C} = v - \frac{1}{6}d - \frac{1}{3}\theta$ and $p_0^{OP,C} = v - \theta$. Quantities are $q_H^{OP,C} = q_F^{OP,C} = \frac{d+2\theta}{6d}$ and $q_0^{OP,C} = \frac{2(d-\theta)}{3d}$.

Compared to the online equilibrium under origin principle with no cooperation, tax rates and revenues are higher ($\tau_H^{OP,C} - \tau_H^{OP} = v - \frac{9}{5}d - \frac{2}{5}\theta > 0$,

$\tau_F^{OP,C} - \tau_F^{OP} = v - \frac{19}{15}d - \frac{14}{15}\theta > 0$, $R_H^{OP,C} - R_H^{OP} = \frac{45v(5d-2\theta)-317d^2-32d\theta+52\theta^2}{270d} > 0$,

$R_F^{OP,C} - R_F^{OP} = \frac{45v(d+2\theta)-113d^2-116d\theta-68\theta^2}{270d} > 0$).

Compared to the offline equilibrium with cooperation, tax rates are higher

($\tau_H^{OP,C} - \tau_H^{*,C} = \tau_F^{OP,C} - \tau_F^{*,C} = \frac{7d-4\theta}{6} > 0$). Tax revenue for country H is higher, tax revenue for country F is lower ($R_H^{OP,C} - R_H^{*,C} = \frac{12v(d-\theta)+17d^2-16d\theta+8\theta^2}{36d} > 0$,

$R_F^{OP,C} - R_F^{*,C} = -\frac{12v(d-\theta)-25d^2+8d\theta+8\theta^2}{36d} < 0$).

Benevolent Governments

Offline Equilibrium

In the second stage, profits are given as $\pi_H^{*,W} = \frac{\left(3d+\tau_F^{*,W}-\tau_H^{*,W}\right)^2}{18d}$ and $\pi_F^{*,W} = \frac{\left(3d-\tau_F^{*,W}+\tau_H^{*,W}\right)^2}{18d}$.

Consumer surplus in countries H and F is given as

$CS_H^{*,W} = \int_0^{\frac{1}{2}} \left(v - p_H^{*,W} - dx\right) dx = \frac{1}{2}v - \frac{15d+4\tau_F^{*,W}+8\tau_H^{*,W}}{24}$ and

$CS_F^{*,W} = \int_{\frac{1}{2}}^{1} \left(v - p_F^{*,W} - d(1-x)\right) dx = \frac{1}{2}v - \frac{15d+8\tau_F^{*,W}+4\tau_H^{*,W}}{24}$. Tax revenues in countries H and F are $R_H^{*,W} = \tau_H^{*,W}\frac{3d+\tau_F^{*,W}-\tau_H^{*,W}}{6d}$ and $R_F^{*,W} = \tau_F^{*,W}\frac{3d-\tau_F^{*,W}+\tau_H^{*,W}}{6d}$. Welfare in countries H and F, respectively, is given as

$W_H^{*,W} = CS_H^{*,W} + \pi_H^{*,W} + R_H^{*,W} = \frac{1}{2}v + \frac{-9d^2+4\left(\tau_F^{*,W}-\tau_H^{*,W}\right)\left(3d+\tau_F^{*,W}+2\tau_H^{*,W}\right)}{72d}$ and

$W_F^{*,W} = CS_F^{*,W} + \pi_F^{*,W} + R_F^{*,W} = \frac{1}{2}v + \frac{-9d^2+4\left(\tau_H^{*,W}-\tau_F^{*,W}\right)\left(3d+\tau_H^{*,W}+2\tau_F^{*,W}\right)}{72d}$. In both countries, welfare is decreasing in the tax rate of the respective country and increasing in the tax rate of the other country ($\frac{\partial W_H^{*,W}}{\partial \tau_H^{*,W}} = -\frac{1}{72d}\left(12d - 4\tau_F^{*,W} + 16\tau_H^{*,W}\right) < 0$, $\frac{\partial W_F^{*,W}}{\partial \tau_F^{*,W}} = -\frac{1}{72d}\left(12d + 16\tau_F^{*,W} - 4\tau_H^{*,W}\right) < 0$, $\frac{\partial W_H^{*,W}}{\partial \tau_F^{*,W}} = \frac{1}{18d}\left(3d + 2\tau_F^{*,W} + \tau_H^{*,W}\right) > 0$,
$\frac{\partial W_F^{*,W}}{\partial \tau_H^{*,W}} = \frac{1}{18d}\left(3d + \tau_F^{*,W} + 2\tau_H^{*,W}\right) > 0$). Equilibrium tax rates are $\tau_H^{*,W} = \tau_F^{*,W} = 0$. The tax differential is zero ($\Delta\tau^{*,W} = \tau_F^{*,W} - \tau_H^{*,W} = 0$). Tax revenues are $R_H^{*,W} = R_F^{*,W} = 0$. Equilibrium prices are $p_H^{*,W} = p_F^{*,W} = d$. Quantities are $q_H^{*,W} = q_F^{*,W} = \frac{1}{2}$.

Compared to the offline equilibrium under Leviathan governments, tax rates and revenues are lower ($\tau_H^{*,W} - \tau_H^* = \tau_F^{*,W} - \tau_F^* = -3d < 0$, $R_H^{*,W} - R_H^* = R_F^{*,W} - R_F^* = -\frac{3}{2}d < 0$).

Online Equilibrium under Destination Principle

In the second stage, profits are given as $\pi_H^{DP,W} = \frac{\left(2d+4\theta+3\left(\tau_F^{DP,W}-\tau_H^{DP,W}\right)\right)^2}{144d}$, $\pi_F^{DP,W} = \frac{\left(2d+4\theta-3\left(\tau_F^{DP,W}-\tau_H^{DP,W}\right)\right)^2}{144d}$, and $\pi_0^{DP,W} = \frac{8(d-\theta)^2-9\left(\tau_F^{DP,W}-\tau_H^{DP,W}\right)^2}{36d}$. Consumer surplus in countries H and F is given as

$$CS_H^{DP,W} = \int_0^{y_{H0}} \left(v - p_H^{DP,W} - dx\right) dx + \int_{y_{H0}}^{\frac{1}{2}} \left(v - p_0^{DP,W} - \theta\right) dx$$
$$= \frac{1}{2}v - \frac{4(11d-2\theta)(d+2\theta)+60d\tau_F^{DP,W}+84d\tau_H^{DP,W}-3\left(\tau_F^{DP,W}-\tau_H^{DP,W}\right)\left(8\theta+3\tau_F^{DP,W}-3\tau_H^{DP,W}\right)}{288d}$$
and
$$CS_F^{DP,W} = \int_{\frac{1}{2}}^{y_{0F}} \left(v - p_0^{DP,W} - \theta\right) dx + \int_{y_{0F}}^{1} \left(v - p_F^{DP,W} - d\left(1-x\right)\right) dx$$
$$= \frac{1}{2}v - \frac{4(11d-2\theta)(d+2\theta)+84d\tau_F^{DP,W}+60d\tau_H^{DP,W}+3\left(\tau_F^{DP,W}-\tau_H^{DP,W}\right)\left(8\theta-3\tau_F^{DP,W}+3\tau_H^{DP,W}\right)}{288d}.$$
Tax revenues in countries H and F are $R_H^{DP,W} = \tau_H^{DP,W}\frac{1}{2}$ and $R_F^{DP,W} = \tau_F^{DP,W}\frac{1}{2}$. Welfare in countries H and F, respectively, is given as

$$W_H^{DP,W} = CS_H^{DP,W} + \pi_H^{DP,W} + \pi_0^{DP,W} + R_H^{DP,W} = \frac{1}{2}v + \frac{28d^2-176d\theta+112\theta^2-9\left(\tau_F^{DP,W}-\tau_H^{DP,W}\right)\left(4d-8\theta+5\tau_F^{DP,W}-5\tau_H^{DP,W}\right)}{288d}$$
and
$$W_F^{DP,W} = CS_F^{DP,W} + \pi_F^{DP,W} + R_F^{DP,W} = \frac{1}{2}v - \frac{12d^2+16d\theta-16\theta^2-3\left(\tau_F^{DP,W}-\tau_H^{DP,W}\right)\left(4d-8\theta+3\tau_F^{DP,W}-3\tau_H^{DP,W}\right)}{96d}.$$

Governments maximize welfare. Best response functions are $\tau_H^{DP,W} = \frac{2}{5}\left(d-2\theta\right) + \tau_F^{DP,W}$ and $\tau_F^{DP,W} = \tau_H^{DP,W} - \frac{2}{3}\left(d-2\theta\right)$. Equilibrium tax rates are
$$\tau_H^{DP,W} = \begin{cases} \frac{2}{5}\left(d-2\theta\right) & \text{if } \theta < \frac{1}{2}d \\ 0 & \text{if } \theta \geq \frac{1}{2}d \end{cases}$$
and $\tau_F^{DP,W} = 0$. Tax revenues are
$$R_H^{DP,W} = \begin{cases} \frac{2}{10}\left(d-2\theta\right) & \text{if } \theta < \frac{1}{2}d \\ 0 & \text{if } \theta \geq \frac{1}{2}d \end{cases}$$
and $R_F^{DP,W} = 0$.

Compared to the online equilibrium under the destination principle and Leviathan governments, tax rates and revenues are lower

(for $\theta < \frac{1}{2}d$: $\tau_H^{DP,W} - \tau_H^{DP,s} = -\left(v - \frac{1}{15}\left(11d - 2\theta\right)\right) < 0$,
$\tau_H^{DP,W} - \underline{\tau_{-j}^{DP,\theta>\widehat{\theta}}} = -\left(v - \frac{1}{15}\left(d\left(5\sqrt{2}+11\right) - \theta\left(5\sqrt{2}+2\right)\right)\right) < 0$,
$\tau_H^{DP,W} - \underline{\tau_{-j}^{DP,\theta<\widehat{\theta}}} = -\left(v - \frac{8}{15}\left(2d+\theta\right)\right) < 0$;
for $\theta > \frac{1}{2}d$: $\tau_H^{DP,W} - \tau_H^{DP,s} = -\left(v - \frac{1}{3}d - \frac{2}{3}\theta\right) < 0$,
$\tau_H^{DP,W} - \underline{\tau_{-j}^{DP,\theta>\widehat{\theta}}} = -\left(v - \frac{1}{3}\left(d\left(\sqrt{2}+1\right) + \theta\left(2-\sqrt{2}\right)\right)\right) < 0$,
$\tau_H^{DP,W} - \underline{\tau_{-j}^{DP,\theta<\widehat{\theta}}} = -\left(v - \frac{2}{3}d - \frac{4}{3}\theta\right) < 0$;
$\tau_F^{DP,W} - \tau_F^{DP,s} = -\left(v - \frac{1}{3}d - \frac{2}{3}\theta\right) < 0$,
$\tau_F^{DP,W} - \underline{\tau_{-j}^{DP,\theta>\widehat{\theta}}} = -\left(v - \frac{1}{3}\left(d\left(\sqrt{2}+1\right) + \theta\left(2-\sqrt{2}\right)\right)\right) < 0$,
$\tau_F^{DP,W} - \underline{\tau_{-j}^{DP,\theta<\widehat{\theta}}} = -\left(v - \frac{2}{3}d - \frac{4}{3}\theta\right) < 0$;
for $\theta < \frac{1}{2}d$: $R_H^{DP,W} - R_H^{DP,s} = -\left(\frac{1}{2}v - \frac{1}{30}\left(11d - 2\theta\right)\right) < 0$,
$R_H^{DP,W} - \underline{R_{-j}^{DP,\theta>\widehat{\theta}}} = -\frac{1}{2}\left(v - \frac{1}{15}\left(d\left(5\sqrt{2}+11\right) - \theta\left(5\sqrt{2}+2\right)\right)\right) < 0$,
$R_H^{DP,W} - \underline{R_{-j}^{DP,\theta<\widehat{\theta}}} = -\left(\frac{1}{2}v - \frac{4}{15}\left(2d+\theta\right)\right) < 0$;
for $\theta > \frac{1}{2}d$: $R_H^{DP,W} - R_H^{DP,s} = -\frac{1}{2}\left(v - \frac{1}{3}d - \frac{2}{3}\theta\right) < 0$,
$R_H^{DP,W} - \underline{R_{-j}^{DP,\theta>\widehat{\theta}}} = -\frac{1}{2}\left(v - \frac{1}{3}\left(d\left(\sqrt{2}+1\right) + \theta\left(2-\sqrt{2}\right)\right)\right) < 0$;
$R_H^{DP,W} - \underline{R_{-j}^{DP,\theta<\widehat{\theta}}} = -\frac{1}{2}\left(v - \frac{2}{3}d - \frac{4}{3}\theta\right) < 0$; $R_F^{DP,W} - R_F^{DP,s} = -\frac{1}{2}\left(v - \frac{1}{3}d - \frac{2}{3}\theta\right) < 0$,
$R_F^{DP,W} - \underline{R_{-j}^{DP,\theta>\widehat{\theta}}} = -\left(\frac{1}{2}\left(v - \frac{1}{3}\left(d\left(\sqrt{2}+1\right) + \theta\left(2-\sqrt{2}\right)\right)\right)\right) < 0$,
$R_F^{DP,W} - \underline{R_{-j}^{DP,\theta<\widehat{\theta}}} = -\frac{1}{2}\left(v - \frac{2}{3}d - \frac{4}{3}\theta\right) < 0$).

Compared to the offline equilibrium under benevolent governments, the tax rate and revenue in H is higher for sufficiently low θ or the same for sufficiently high θ (if $\theta < \frac{1}{2}d$: $\tau_H^{DP,W} - \tau_H^{*,W} = \frac{2}{5}\left(d - 2\theta\right) > 0$, $R_H^{DP,W} - R_H^{*,W} = \frac{2}{10}\left(d - 2\theta\right) > 0$;
if $\theta \geq \frac{1}{2}d$: $\tau_H^{DP,W} - \tau_H^{*,W} = 0$, $R_H^{DP,W} - R_H^{*,W} = 0$), the tax rate and revenue in F is the same ($\tau_F^{DP,W} - \tau_H^{*,W} = 0$, $R_F^{DP,W} - R_F^{*,W} = 0$).

Online Equilibrium under Origin Principle In the second stage, profits are given as $\pi_H^{OP,W} = \frac{\left(2d+4\theta+\tau_F^{OP,W}-\tau_H^{OP,W}\right)^2}{144d}$, $\pi_F^{OP,W} = \frac{\left(2d+4\theta-5\tau_F^{OP,W}+5\tau_H^{OP,W}\right)^2}{144d}$, and
$\pi_0^{OP,W} = \frac{\left(2d-2\theta+\tau_F^{OP,W}-\tau_H^{OP,W}\right)^2}{18d}$. Consumer surplus in countries H and F is given as

$$CS_H^{OP,W} = \int_0^{y_{H0}} \left(v - p_H^{OP,W} - dx\right) dx + \int_{y_{H0}}^{\frac{1}{2}} \left(v - p_0^{OP,W} - \theta\right) dx$$
$$= \frac{1}{2}v - \frac{4(11d-2\theta)(d+2\theta)+20d\tau_F^{OP,W}+124d\tau_H^{OP,W}-\left(\tau_F^{OP,W}-\tau_H^{OP,W}\right)\left(8\theta+\tau_F^{OP,W}-\tau_H^{OP,W}\right)}{288d}$$

and

$$CS_F^{OP,W} = \int_{\frac{1}{2}}^{y_{0F}} \left(v - p_0^{OP,W} - \theta\right) dx + \int_{y_{0F}}^{1} \left(v - p_F^{OP,W} - d\left(1-x\right)\right) dx$$
$$= \frac{1}{2}v - \frac{4(11d-2\theta)(d+2\theta)+44d\tau_F^{OP,W}+100d\tau_H^{OP,W}+5\left(\tau_F^{OP,W}-\tau_H^{OP,W}\right)\left(8\theta-5\tau_F^{OP,W}+5\tau_H^{OP,W}\right)}{288d}.$$

Tax revenues in countries H and F are $R_H^{OP,W} = \tau_H^{OP,W}\left(\frac{2d+4\theta+\tau_F^{OP,W}-\tau_H^{OP,W}}{12d} + \frac{2d-2\theta+\tau_F^{OP,W}-\tau_H^{OP,W}}{3d}\right)$ and

$R_F^{OP,W} = \tau_F^{OP,W}\left(\frac{2d+4\theta-5\tau_F^{OP,W}+5\tau_H^{OP,W}}{12d}\right)$.

Welfare in countries H and F, respectively, is given as

$W_H^{OP,W} = CS_H^{OP,W} + \pi_H^{OP,W} + \pi_0^{OP,W} + R_H^{OP,W}$

$= \frac{1}{2}v + \frac{28d^2-176d\theta+112\theta^2+52d\tau_F^{OP,W}+44d\tau_H^{OP,W}-40\theta\tau_F^{OP,W}-56\theta\tau_H^{OP,W}+\left(\tau_F^{OP,W}-\tau_H^{OP,W}\right)\left(19\tau_F^{OP,W}+101\tau_H^{OP,W}\right)}{288d}$

and $W_F^{OP,W} = CS_F^{OP,W} + \pi_F^{OP,W} + R_F^{OP,W}$

$= \frac{1}{2}v - \frac{4(3d-2\theta)(d+2\theta)+12d\tau_F^{OP,W}+20d\tau_H^{OP,W}+8\theta\tau_F^{OP,W}-40\theta\tau_H^{OP,W}+5\left(\tau_F^{OP,W}-\tau_H^{OP,W}\right)\left(3\tau_F^{OP,W}+5\tau_H^{OP,W}\right)}{96d}$.

Governments maximize welfare. Best response functions are

$\tau_H^{OP,W} = \frac{22}{101}d - \frac{28}{101}\theta + \frac{41}{101}\tau_F^{OP,W}$ and $\tau_F^{OP,W} = -\frac{2}{5}d - \frac{4}{15}\theta - \frac{1}{3}\tau_H^{OP,W}$. Equilibrium tax rates are

$\tau_H^{OP,W} = \begin{cases} \frac{2(11d-14\theta)}{101} & \text{if } \theta < \frac{11}{14}d \\ 0 & \text{if } \theta \geq \frac{11}{14}d \end{cases}$ and $\tau_F^{OP,W} = 0$. Tax revenues are

$R_H^{OP,W} = \begin{cases} \frac{2(11d-14\theta)(75d-22\theta)}{10\,201d} & \text{if } \theta < \frac{11}{14}d \\ 0 & \text{if } \theta \geq \frac{11}{14}d \end{cases}$ and $R_F^{OP,W} = 0$.

Compared to the online equilibrium under the origin principle and Leviathan governments, tax rates and revenues are lower

(for $\theta < \frac{11}{14}d$: $\tau_H^{OP,W} - \tau_H^{OP} = -\frac{4(473d+4\theta)}{1515} < 0$; for $\theta > \frac{11}{14}d$: $\tau_H^{OP,W} - \tau_H^{OP} = -\frac{2(11d-2\theta)}{15} < 0$; $\tau_F^{OP,W} - \tau_F^{OP} = -\frac{2(7d+2\theta)}{15} < 0$; for $\theta < \frac{11}{14}d$: $R_H^{OP,W} - R_H^{OP} = -\frac{\left(1011\,571d^2-100\,004d\theta-42\,356\theta^2\right)}{1377\,135d} < 0$; for $\theta > \frac{11}{14}d$: $R_H^{OP,W} - R_H^{OP} = -\frac{(11d-2\theta)^2}{135d} < 0$; $R_F^{OP,W} - R_F^{OP} = -\frac{(7d+2\theta)^2}{135d} < 0$).

Compared to the offline equilibrium under benevolent governments, the tax rate and revenue in H is higher for sufficiently low θ and the same for sufficiently high θ ($\tau_H^{OP,W} - \tau_H^{*,W} = \frac{2(11d-14\theta)}{101} > 0$, $R_H^{OP,W} - R_H^{*,W} = \frac{2(11d-14\theta)(75d-22\theta)}{10\,201d} > 0$), the tax rate and revenue in F is the same ($\tau_F^{OP,W} - \tau_H^{*,W} = 0$, $R_F^{OP,W} - R_F^{*,W} = 0$).

Cooperative Benevolent Governments

Offline Equilibrium

Global welfare is $W^{*,W,C} = W_H^{*,W,C} + W_F^{*,W,C} = v - \frac{9d^2+2\left(\tau_F^{*,W,C}-\tau_H^{*,W,C}\right)^2}{36d}$. Global welfare decreases in the tax differential. Governments set the same tax. There is a continuum of equilibria $\tau_H^{*,W,C}$, $\tau_F^{*,W,C} \in \{\tau_H^{*,W,C} = \tau_F^{*,W,C}\}$.

Online Equilibrium under Destination Principle

Global welfare is $W^{DP,W,C} = W_H^{DP,W,C} + W_F^{DP,W,C} = v - \frac{4d^2+112d\theta-80\theta^2+9\left(\tau_F^{DP,W,C}-\tau_H^{DP,W,C}\right)^2}{144d}$. Global welfare decreases in the tax differential. Governments set the same tax. There is a continuum of equilibria $\tau_H^{DP,W,C}$, $\tau_F^{DP,W,C} \in \{\tau_H^{DP,W,C} = \tau_F^{DP,W,C}\}$.

Online Equilibrium under Origin Principle

Global welfare is

$W^{OP,W,C} = W_H^{OP,W,C} + W_F^{OP,W,C} = v - \frac{112d\theta - 80\theta^2 + 4d^2 - 8(d-4\theta)(\tau_F - \tau_H) + 13(\tau_F - \tau_H)^2}{144d}$. If $\theta > \frac{1}{4}d$, global welfare decreases in the tax differential. Governments set the same tax. There is a continuum of equilibria $\tau_H^{OP,W,C}$, $\tau_F^{OP,W,C} \in \{\tau_H^{OP,W,C} = \tau_F^{OP,W,C}\}$.

If $\theta < \frac{1}{4}d$, global welfare decreases in the tax differential $\Delta\tau^{OP,W,C} = \tau_F^{OP,W,C} - \tau_H^{OP,W,C}$ if $\Delta\tau^{OP,W,C}$ is sufficiently high ($\frac{\partial W^{OP,W,C}}{\partial \Delta\tau^{OP,W,C}} = -\frac{(26(\tau_F - \tau_H) - 8(d-4\theta))}{144d} < 0$ if $\Delta\tau^{OP,W,C} > \frac{4}{13}(d - 4\theta)$). Best response functions are $\tau_H^{OP,W,C} = \tau_F^{OP,W,C} - \frac{4}{13}(d-4\theta)$ and $\tau_F^{OP,W,C} = \frac{4}{13}(d-4\theta) + \tau_H$. There is a continuum of equilibria $\tau_H^{OP,W,C}$, $\tau_F^{OP,W,C} \in \{\tau_F^{OP,W,C} - \tau_H^{OP,W,C} \leq \frac{4}{13}(d-4\theta)\}$.

A.3 Discussion

Market Structure

Offline Equilibrium

Equilibrium prices are $p_H^{*,PC,PC} = \tau_H^{*,PC,PC}$ and $p_F^{*,PC,PC} = \tau_F^{*,PC,PC}$. Quantities of all brick-and-mortar stores in both countries are $Q_H^{*,PC,PC} = \frac{d + \tau_F^{*,PC} - \tau_H^{*,PC}}{2d}$ and $Q_F^{*,PC} = \frac{d - \tau_F^{*,PC} + \tau_H^{*,PC}}{2d}$. The tax base in country H is $b_H^{*,PC} = Q_H^{*,PC} = \frac{d + \tau_F^{*,PC} - \tau_H^{*,PC}}{2d}$, the tax base in country F is $b_F^{*,PC} = Q_F^{*,PC} = \frac{d - \tau_F^{*,PC} + \tau_H^{*,PC}}{2d}$.

In the first stage, governments H and F maximize tax revenues $R_H^{*,PC} = \tau_H^{*,PC} \frac{d + \tau_F^{*,PC} - \tau_H^{*,PC}}{2d}$ and $R_F^{*,PC} = \tau_F^{*,PC} \frac{d - \tau_F^{*,PC} + \tau_H^{*,PC}}{2d}$.

Best response functions are $\tau_H^{*,PC} = \frac{1}{2}d + \frac{1}{2}\tau_F^{*,PC}$ and $\tau_F^{*,PC} = \frac{1}{2}d + \frac{1}{2}\tau_H^{*,PC}$. Equilibrium tax rates are $\tau_H^{*,PC} = \tau_F^{*,PC} = d$. Tax revenues are $R_H^{*,PC} = R_F^{*,PC} = \frac{1}{2}d$. Tax rates and revenues are lower than under market power ($\tau_H^{*,PC} - \tau_H^* = \tau_F^{*,PC} - \tau_F^* = -2d < 0$, $R_H^{*,PC} - R_H^* = R_F^{*,PC} - R_F^* = -d < 0$).

Online Equilibrium under Destination Principle

Equilibrium prices are $p_H^{DP,PC} = \tau_H^{DP,PC}$, $p_F^{DP,PC} = \tau_F^{DP,PC}$, and $p_0^{DP,PC} = \frac{1}{2}\tau_H^{DP,PC} + \frac{1}{2}\tau_F^{DP,PC}$. Quantities of all brick-and-mortar stores in both countries and all online stores are $Q_H^{DP,PC} = \frac{2\theta + \tau_F^{DP,PC} - \tau_H^{DP,PC}}{2d}$, $Q_F^{DP,PC} = \frac{2\theta - \tau_F^{DP,PC} + \tau_H^{DP,PC}}{2d}$, $Q_0^{DP,PC} = \frac{d - 2\theta}{d}$. The tax base in country H is $b_H^{DP,PC} = \frac{1}{2}$, the tax base in country F is $b_F^{DP,PC} = \frac{1}{2}$. Tax revenues are given as $R_H^{DP,PC} = \tau_H^{DP,PC}\frac{1}{2}$ and $R_F^{DP,PC} = \tau_F^{DP,PC}\frac{1}{2}$.

Governments set tax rates to extract the full surplus of the indifferent consumers. The surplus of the consumer located at y_{H0} is

$U^{DP,PC}(y_{H0}) = v - \tau_H^{DP,PC} - dy_{H0} = v - \theta - \frac{1}{2}\tau_F^{DP,PC} - \frac{1}{2}\tau_H^{DP,PC}$; the surplus of the consumer located at y_{0F} is

$U^{DP,PC}(y_{0F}) = v - \tau_F^{DP,PC} - d(1 - y_{0F}) = v - \theta - \frac{1}{2}\tau_F^{DP,PC} - \frac{1}{2}\tau_H^{DP,PC}$. This yields response functions $\tau_H^{DP,PC} = 2v - 2\theta - \tau_F^{DP,PC}$ and $\tau_F^{DP,PC} = 2v - 2\theta - \tau_H^{DP,PC}$. For the online retailer to have non-negative profits, $\tau_H^{DP,PC} = \tau_F^{DP,PC}$. By symmetry, equilibrium tax rates are $\tau_H^{DP,PC} = \tau_F^{DP,PC} = v - \theta$. Tax revenues are given as $R_H^{DP,PC} = R_F^{DP,PC} = \frac{1}{2}(v - \theta)$. Tax rates are lower than maximum tax rates under market power and higher than minimum tax rates under market power ($\tau_j^{DP,PC} - \overline{\tau_j^{DP,\theta>\widehat{\theta}}} = -\frac{1}{3}\left(\sqrt{2} - 1\right)(d - \theta) < 0$, $\tau_j^{DP,PC} \underline{-\tau_{-j}^{DP,\theta>\widehat{\theta}}} = \frac{1}{3}\left(\sqrt{2} + 1\right)(d - \theta) > 0$, $\tau_j^{DP,PC} - \overline{\tau_j^{DP,\theta<\widehat{\theta}}} = -\theta < 0$,

$\tau_j^{DP,PC} - \underline{\tau_{-j}^{DP,\theta<\widehat{\theta}}} = \frac{1}{3}(2d + \theta) > 0$). Similarly, tax revenues are lower than maximum tax revenues under market power and higher than minimum tax revenues under market power

($R_j^{DP,PC} - \overline{R_j^{DP,\theta>\widehat{\theta}}} = -\frac{1}{6}\left(\sqrt{2} - 1\right)(d - \theta) < 0$,

$R_j^{DP,PC} - \underline{R_{-j}^{DP,\theta>\widehat{\theta}}} = \frac{1}{6}\left(\sqrt{2} + 1\right)(d - \theta) > 0$, $R_j^{DP,PC} - \overline{R_j^{DP,\theta<\widehat{\theta}}} = -\frac{1}{2}\theta < 0$,

$R_j^{DP,PC} - \underline{R_{-j}^{DP,\theta<\widehat{\theta}}} = \frac{1}{6}(2d + \theta) > 0$).

Tax rates and revenues are higher than in the offline equilibrium without market power ($\tau_j^{DP,PC} - \tau_j^{*,PC} = v - \theta - d > 0$, $R_j^{DP,PC} - R_j^{*,PC} = \frac{1}{2}(v - \theta - d) > 0$).

Online Equilibrium under Origin Principle

Equilibrium prices are $p_H^{OP,PC} = \tau_H^{OP,PC}$, $p_F^{OP,PC} = \tau_F^{OP,PC}$, and $p_0^{OP,PC} = \tau_H^{OP,PC}$. Quantities of all brick-and-mortar stores in both countries and all online stores are $Q_H^{OP,PC} = \frac{\theta}{d}$, $Q_F^{OP,PC} = \frac{\theta - \tau_F^{OP,PC} + \tau_H^{OP,PC}}{d}$, $Q_0^{OP,PC} = \frac{d - 2\theta + \tau_F^{OP,PC} - \tau_H^{OP,PC}}{d}$. The tax base in country H is $b_H^{OP,PC} = \frac{d - \theta + \tau_F^{OP,PC} - \tau_H^{OP,PC}}{d}$, the tax base in country F is $b_F^{DP} = \frac{\theta - \tau_F^{OP,PC} + \tau_H^{OP,PC}}{d}$.

In the first stage, governments H and F maximize tax revenues

$R_H^{OP,PC} = \tau_H^{OP,PC} \frac{d - \theta + \tau_F^{OP,PC} - \tau_H^{OP,PC}}{d}$ and $R_F^{OP,PC} = \tau_F^{OP,PC} \frac{\theta - \tau_F^{OP,PC} + \tau_H^{OP,PC}}{d}$. Best response functions are $\tau_H^{OP,PC} = \frac{1}{2}d - \frac{1}{2}\theta + \frac{1}{2}\tau_F^{OP,PC}$ and $\tau_F^{OP,PC} = \frac{1}{2}\theta + \frac{1}{2}\tau_H^{OP,PC}$. Equilibrium tax rates are $\tau_H^{OP,PC} = \frac{2d - \theta}{3}$ and $\tau_F^{OP,PC} = \frac{d + \theta}{3}$. Tax revenues are $R_H^{OP,PC} = \frac{(2d - \theta)^2}{9d}$ and $R_F^{OP,PC} = \frac{(d + \theta)^2}{9d}$.

Tax rates and revenues are lower than under market power

($\tau_H^{OP,PC} - \tau_H^{OP} = -\frac{(12d + \theta)}{15} < 0$, $\tau_F^{OP,PC} - \tau_F^{OP} = -\frac{(9d - \theta)}{15} < 0$,

$R_H^{OP,PC} - R_H^{OP} = -\frac{61d^2 + 16d\theta - 11\theta^2}{135d} < 0$, $R_F^{OP,PC} - R_F^{OP} = -\frac{34d^2 - 2d\theta - 11\theta^2}{135d} < 0$).

Tax rates and revenues are lower than in the offline equilibrium without market power ($\tau_H^{OP,PC} - \tau_H^{*,PC} - \frac{(d + \theta)}{3} < 0$, $\tau_F^{OP,PC} - \tau_F^{*,PC} = -\frac{(2d - \theta)}{3} < 0$,

$R_H^{OP,PC} - R_H^{*,PC} - \frac{d^2+8d\theta-2\theta^2}{18d} < 0,\ R_F^{OP,PC} - R_F^{*,PC} = -\frac{7d^2-4d\theta-2\theta^2}{18d} < 0).$