Efficient Tax Competition under the Origin Principle

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Abstract

This paper studies fiscal competition under the origin principle. It identifies a pattern of consumers' taste heterogeneity under which the first-best world social optimum arises as a non cooperative Nash equilibrium. Consumers' tastes are characterized by the strength of their preference for home and foreign goods. Nash implementation of the first-best obtains when in every tax jurisdiction the number of consumers who display a home bias (those consumers who prefer purchasing the home good to shopping abroad at equal prices) equals, for every magnitude of the home bias, the number of consumers who display an 'import bias' (those who instead prefer shopping abroad) equal in magnitude.

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Keywords: fiscal competition, origin principle, third-price discrimination, Internet taxes, electronic commerce.

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1 Introduction

Principles of international commodity taxation refer to the physical attributes of the commodities as well as buyers' and sellers' locations. The two main principles provide for tax levy where commodities are produced (origin principle) or consumed (destination principle). Although the origin principle is applied widely (it currently applies within the US through the 'use tax' and it was also ruling EU transactions until January 2015), it is often found dominated by the destination principle in the academic literature. Pioneering studies by Mintz and Tulkens (1986), Kanbur and Keen (1993) or Lockwood (2001) indeed identified under the origin principle a race to the bottom that leads to setting inefficiently low taxes in the attempt to attract foreign tax bases. Our paper shows that the inefficiency of tax competition arising under this principle crucially relates to the form taken by the heterogeneity of consumers.

In general the academic literature assumes that consumers differ according to a home bias due to mobility or transaction costs when shopping abroad. There is indeed empirical evidence to support such a kind of bias (recent studies include Ellison and Ellison (2009) and Cosar, Grieco and Tintelnot (2015)). However one may think of cases where this bias is less likely to arise, and instead a 'country-of-origin' effect should operate (Riefler and Diamantopoulos (2009)). Country-of-origin effects are especially relevant when the country of origin acts as branding, e.g., Swiss watches, German engineering, French wine, Kentucky bourbons, Cuban cigars, Italian shoes or Belgian chocolate. Then some consumers display an 'import bias' reflected by a preference for purchasing foreign branded goods. In these examples a single particular variety tends to be regarded as superior to its competitors, but more complicated patterns are possible. For instance, in the industry of cultural goods studied by François and Ypersele (2002), US movie buffs display a preference for French auteur films while simultaneously there is an audience in France for US block-busters.

In the presence of an import bias, a lower domestic tax inducing import biased customers to purchase home goods implies a loss in consumers' surplus that is detrimental to domestic social welfare. Our paper shows that this loss may be enough to overcome the impact of the race to the bottom and restore efficiency of tax competition under the origin principle. This result thus complements the few studies identifying circumstances where tax competition under the origin principle can be efficient (see section 18.2.6 in Hindriks and Myles (2006)).

This result obtains in the configuration where taste heterogeneity is symmetric both within and across two identical countries. In each country consumers are assumed to differ according to the magnitude of their home or import bias. The distribution of these biases is symmetric within countries if the number of consumers with a certain home bias equals in each country the number of consumers who display an import bias of the same magnitude, whatever the magnitude is. The distribution of these biases is symmetric across countries when the within country bias distribution is the same in every country. This pattern of taste heterogeneity is akin to some form of vertical differentiation in the absence of agreement about the ranking of quality. Following the terminology introduced by Di Comite, Thisse and Vandenbussche (2015), taste heterogeneity within destination countries is coupled with taste heterogeneity across producer countries to give rise to 'verti-zontal' differentiation.

Symmetry in taste heterogeneity seems more plausible at the level of aggregate categories comprising different varieties of similar goods, rather than the fine level of specific goods. The movies category discussed by François and Ypersele (2002) consists of auteur films and block-busters. In the beer industry the proportion of drinkers from Belgium (resp., the Netherland) who prefer the Heineken variant may be approximately equal to the proportion of those who prefer the Leffe (Di Comite, Thisse and Vandenbussche, 2015). Aizenman and Brooks (2005) consider an aggregate category of low-alcohol beverages consisting of wine and beer and conclude that some symmetry also applies to trade between France and Germany: in both countries there are consumers who indeed prefer the domestic variety of low-alcohol beverage, but there are also Germans who prefer French wine while some French symmetrically prefer German beer. More generally symmetry possibly contributes to account for intra-trade industry, i.e., the existence of very large simultaneous exports and imports within the same industries, which is a well known stylized fact of contemporaneous international trade between countries of similar development (Disdier, Tai, Fontagne and Mayer, 2010).

At equal production costs, the first-best trade pattern between two countries of equal size involves allocating the home good to those who display a home bias and the foreign good to the others. We find that, under symmetry in taste heterogeneity, the first-best world optimum is a Nash equilibrium of a game between tax authorities subject to the origin principle and maximizing their own social surplus, taking into account the impact of their tax policy on the prices charged by firms in equilibrium. The property holds under perfect competition among firms and when firms' behavior is strategic. It also applies to eBay mediated transactions, where price discrimination based on consumers' location is not feasible. Symmetry is a crucial requirement: the equilibrium no longer coincides with the first-best optimum in the configuration considered in the main strand of the literature where consumers' preferences exhibit no import bias.

The paper is organized as follows: Section 2 presents the general setup, Sections 3, 4 and 5 characterize Nash equilibria and show that the first-best world optimum is a Nash equilibrium under the origin principle. Further characterization of the set of equilibria, some robustness checks and variants, including discussions about the case of e-commerce, are finally examined in Section 6.

2 General setup

We consider a model of spatial differentiation where two firms i and j compete against each other for selling the same physical good in two different tax jurisdictions. The firms are immobile, respectively located in jurisdictions i and j, and selling goods i and j. Each jurisdiction is populated with a continuum of immobile consumers (with total unit mass) who all have unit demand. Consumers differ according to the relative strength of their preference for purchasing from the firm located in their own jurisdiction, measured by the real parameter θ. A consumer θ has gross utility $v+\theta$ when she consumes the home good but only v when shopping abroad.

Assumption A1. In each jurisdiction θ takes values in the finite interval $[-\theta^{\sup}, \theta^{\sup}]$. The cumulative distribution function F of θ is symmetric around 0, i.e., $F(-\theta) = 1 - F(\theta)$, and it is associated with a positive log-concave density f.[1]

Good i is sold at net-of-tax price p_{ii} to the domestic consumers (those from jurisdiction i) and p_{ij} to the foreign consumers (those from jurisdiction j). Under the origin principle, taxes depend on the location of the producers: good i (resp., j) is subject to an excise t_i (resp., t_j), independently of the consumers' locations.[2] The tax collected in jurisdiction i is used to finance a uniform lump-sum transfer T_i toward domestic consumers. A consumer θ located in jurisdiction i thus has net utility $v + \theta + T_i - (p_{ii} + t_i)$ if she consumes the home good, and $v + T_i - (p_{ji} + t_j)$ if she instead opt for the foreign good.[3]

Consumers from jurisdiction i who are indifferent between the two goods have $\theta = \bar{\theta}_i = (p_{ii} + t_i) - (p_{ji} + t_j)$. Assuming that the value v is large enough so that every consumer always buys one unit of the good, the total consumers' surplus in this jurisdiction is

$$v + \int_{\bar{\theta}_i}^{\theta^{\sup}} \theta dF(\theta) + T_i - (p_{ji} + t_j) F(\bar{\theta}_i) - (p_{ii} + t_i) \left[1 - F(\bar{\theta}_i)\right].$$

The profit of firm i is, assuming zero cost,

$$p_{ii} \left[1 - F(\bar{\theta}_i)\right] + p_{ij} F(\bar{\theta}_j)$$

where $\bar{\theta}_j = (p_{jj} + t_j) - (p_{ij} + t_i)$. Finally, from the budget constraint in jurisdiction i,

$$T_i = t_i \left[1 - F(\bar{\theta}_i) + F(\bar{\theta}_j)\right].$$

Therefore the social surplus in jurisdiction i is

$$S_i(p, t_i, t_j) = v + \int_{\bar{\theta}_i}^{\theta^{\sup}} \theta dF(\theta) - (p_{ji} + t_j) F(\bar{\theta}_i) + (p_{ij} + t_i) F(\bar{\theta}_j), \tag{1}$$

[1]See Heckman and Honore (1990) or Bagnoli and Bergstrom (2004) for examples of log-concave distributions and their properties.

[2]Fujiwara (2016) suggests usefulness of a tariff coupled with origin-based consumption taxes. We do not consider this richer set of tax instruments.

[3]The transfer could be interpreted as an amount of a publicly provided (unit cost) local public good, assuming that consumers have a constant marginal utility for this good.

where p stands for the vector of four prices $(p_{ii}, p_{ij}, p_{ji}, p_{jj})$.

The surplus in jurisdiction j is derived in a similar way, permuting the indexes i and j. It follows that the social world surplus (the sum of the surpluses in the two jurisdictions) is

$$2v + \int_{\bar{\theta}_i}^{\theta^{\sup}} \theta dF(\theta) + \int_{\bar{\theta}_j}^{\theta^{\sup}} \theta dF(\theta). \tag{2}$$

Proposition 1. *The first-best social world optimum involves* $\bar{\theta}_i = \bar{\theta}_j = 0$.

The first-best world optimum obtains by choosing the thresholds $\bar{\theta}_i$ and $\bar{\theta}_j$ maximizing (2). The solution to this program is to allocate the domestic good to those who display a home bias ($\theta \geq 0$) and the foreign good to the others.

3 Efficient Nash equilibria

We study whether the first-best world optimum may be reached as the outcome of a sequential game between firms and tax authorities under the origin principle. The timing of the game is as follows:

1. Tax authorities first set t_i and t_j maximizing the social surplus in their jurisdiction.

2. Firms then charge profit maximizing prices (p_{ii}, p_{ij}) and (p_{jj}, p_{ji}) and consumers buy the good that gives them the highest utility.

The tax authority of jurisdiction i chooses t_i maximizing (1), taking t_j as given, with prices (p^*_{ii}, p^*_{ij}) and (p^*_{jj}, p^*_{ji}) satisfying

$$p^*_{ii} = \arg\max_{p_{ii}} p_{ii} \left[1 - F(p_{ii} - p^*_{ji} + \Delta t)\right], \quad p^*_{ji} = \arg\max_{p_{ji}} p_{ji} F(p^*_{ii} - p_{ji} + \Delta t), \tag{3}$$

and p^*_{ij} and p^*_{jj} are defined analogously (permuting the indexes i and j), where $\Delta t = t_i - t_j$ and

$$\bar{\theta}^*_i = p^*_{ii} - p^*_{ji} + \Delta t, \qquad \text{and} \qquad \bar{\theta}^*_j = p^*_{jj} - p^*_{ij} - \Delta t. \tag{4}$$

The solution to this program gives the tax rates chosen by jurisdiction i that are a best-response to t_j. Jurisdiction j solves a similar program, permuting the indexes i and j. Since the second stage equilibrium prices p^* are function of Δt, a (subgame perfect pure strategy) Nash equilibrium is a pair of taxes (t^*_i, t^*_j) such that $S_i(p^*(t^*_i - t^*_j), t^*_i, t^*_j) \geq S_i(p^*(t_i - t^*_j), t_i, t^*_j)$ for all t_i, and $S_j(p^*(t^*_i - t^*_j), t^*_j, t^*_i) \geq S_j(p^*(t^*_i - t_j), t_j, t^*_i)$ for all t_j.

The following lemma provides a necessary and sufficient condition for a Nash equilibrium to implement the first-best world optimum.

Lemma 1. *The first-best social world optimum obtains in a pure strategy subgame perfect Nash equilibrium if and only if firms charge the same prices independently of consumers' location,*

$$p_{ii}^{**} = p_{ji}^{**} = p_{ij}^{**} = p_{jj}^{**} = m(0), \tag{5}$$

where

$$m(\theta) = \frac{1 - F(\theta)}{f(\theta)}$$

is the Mills ratio of θ, *and tax authorities set the same taxes*

$$t_i^{**} = t_j^{**} = -\frac{1}{2}\frac{F(0)}{f(0)} < 0. \tag{6}$$

Proof. The first-best optimum obtains in a Nash equilibrium if and only if $\bar{\theta}_i^* = \bar{\theta}_j^* = 0$. Equivalently, from (4),

$$p_{ii}^* - p_{ji}^* + \Delta t = p_{jj}^* - p_{ij}^* - \Delta t = 0. \tag{7}$$

In the first-best world optimum the system (3) must have an interior solution where prices belong to the interval $]-\theta^{\sup}, \theta^{\sup}[$ excluding boundaries. Indeed only one firm would serve the whole world market in (corner) solutions where $\bar{\theta}_i^*$ and $\bar{\theta}_j^*$ equal either $-\theta^{\sup}$ or $\theta^{\sup}$. In an interior (trade) solution prices are given by the first-order conditions,

$$p_{ii}^* = \frac{1 - F(\bar{\theta}_i^*)}{f(\bar{\theta}_i^*)}, \quad p_{ji}^* = \frac{F(\bar{\theta}_i^*)}{f(\bar{\theta}_i^*)}, \quad p_{ij}^* = \frac{F(\bar{\theta}_j^*)}{f(\bar{\theta}_j^*)}, \quad p_{jj}^* = \frac{1 - F(\bar{\theta}_j^*)}{f(\bar{\theta}_j^*)}.$$

From (7), $\bar{\theta}_i^* = \bar{\theta}_j^* = 0$, which yields

$$p_{ii}^* = p_{jj}^* = \frac{1 - F(0)}{f(0)}, \quad p_{ji}^* = p_{ij}^* = \frac{F(0)}{f(0)}.$$

By Assumption A1,

$$\frac{1 - F(0)}{f(0)} = \frac{F(0)}{f(0)} = m(0).$$

This proves the first part of the lemma.

Observe now that, from (7), Δt is 0 at equal net-of-tax prices. Suppose that given t_j the tax authority i changes its tax from $t_i = t_j$ (and prices given by (5)) by a small amount $dt_i \equiv dt \neq 0$. The change in social surplus in jurisdiction i is

$$\left[\left(\frac{\partial p_{ij}^*}{\partial t_i} - \frac{\partial p_{ji}^*}{\partial t_i} + 1\right) F(0) + \left(\frac{\partial \bar{\theta}_j^*}{\partial t_i} - \frac{\partial \bar{\theta}_i^*}{\partial t_i}\right)\left(\frac{F(0)}{f(0)} + t_j\right) f(0)\right] dt.$$

By Assumption A1, we have

$$\frac{F(\theta)}{f(\theta)} = \frac{1 - F(-\theta)}{f(-\theta)} \equiv m(-\theta).$$

The equilibrium prices in jurisdiction i thus solve

$$p_{ii}^* = m(p_{ii}^* - p_{ji}^* + \Delta t), \quad p_{ji}^* = m(p_{ji}^* - p_{ii}^* - \Delta t). \tag{8}$$

By Assumption A1, $f(\theta)$ is log-concave and thus it is single peaked in θ. By symmetry it reaches its global maximum at $\theta = 0$. Using $f'(0) = 0$ it is readily checked that $m'(0) = -1$. Differentiating the system of equilibrium prices at the first-best world optimum then yields

$$dp_{ii}^* = dp_{ij}^* = -dp_{ji}^* = -dp_{jj}^* = -\frac{dt}{3}.$$

The definition of $\bar{\theta}_i^*$ and $\bar{\theta}_j^*$ in (4) finally gives

$$d\bar{\theta}_i^* = -d\bar{\theta}_j^* = \frac{dt}{3}.$$

The change in social surplus thus simplifies as

$$\left[\frac{1}{3}F(0) - \frac{2}{3}\left(\frac{F(0)}{f(0)} + t_j\right) f(0)\right] dt.$$

There is no unilateral locally improving deviation if and only if t_j is given as stated in the lemma. ■

Under Assumption A1 the first-best world optimum obtains in equilibrium only if each firm decides not to use price discrimination based on consumers' location. Equal thresholds $\bar{\theta}_i^* = \bar{\theta}_j^*$ then require equal taxes. The last part of Lemma 1 shows that the tax indeed should be a (distortionary) subsidy financed a (lump-sum) income tax paid by residents. If the foreign tax authority were charging a positive tax, then the domestic tax authority would find it profitable to deviate from equal taxes by lowering its own tax. Starting from equal taxes, a marginal reduction in the domestic tax has no first-order impact on the gross surplus of the domestic consumers. Only a race to the bottom operates: the deviation is profitable if it yields higher net cash inflows. A lower tax reorients the world demand toward the domestic firm, which benefits from the undercutting if taxes were initially positive.

4 Price competition

4.1 Best response prices

In the second stage firms take Δt as given and charge two prices: one is designed for domestic consumers and the other for foreign consumers. Consider for instance firm i in its jurisdiction. For all p_{ii} such that $\bar{\theta}_i < -\theta^{\text{sup}}$ this firm gets the whole demand from jurisdiction i and thus finds it profitable to exercise its monopoly power on an inelastic demand by raising its price until $\bar{\theta}_i = -\theta^{\text{sup}}$. Similarly, for all p_{ii} such that $\bar{\theta}_i > \theta^{\text{sup}}$, firm

i now faces zero demand so that there is no loss to set p_{ii} such that $\bar{\theta}_i = \theta^{\text{sup}}$. One can therefore focus on prices that yield $\bar{\theta}_i \in [-\theta^{\text{sup}}, \theta^{\text{sup}}]$ to characterize firms' best responses in jurisdiction i.

Since, by Assumption A1, the profit realized by each firm in each jurisdiction is single peaked in its own price, we have:

1. Given Δt and p_{ji} the best price p_{ii} is such that $\bar{\theta}_i \in]-\theta^{\text{sup}}, \theta^{\text{sup}}[$ if and only if the profit $p_{ii}\left[1 - F(p_{ii} - p_{ji} + \Delta t)\right]$ is both locally increasing at $p_{ii} = p_{ji} - \Delta t - \theta^{\text{sup}}$ and decreasing at $p_{ii} = p_{ji} - \Delta t + \theta^{\text{sup}}$. These two monotony conditions are equivalent to $1 - (p_{ji} - \Delta t - \theta^{\text{sup}})\, f(\theta^{\text{sup}}) > 0$ and $p_{ji} - \Delta t + \theta^{\text{sup}} > 0$. The best response of firm i in jurisdiction i is then to charge $p_{ii} = m(p_{ii} - p_{ji} + \Delta t)$.

2. If $1 - [p_{ji} - \Delta t - \theta^{\text{sup}}]\, f(\theta^{\text{sup}}) \leq 0$, then the profit of firm i is always decreasing in p_{ii} and its best response is to charge the lowest admissible price $p_{ii} = p_{ji} - \Delta t - \theta^{\text{sup}}$.

3. Finally, if $p_{ji} - \Delta t + \theta^{\text{sup}} \leq 0$, then the profit of firm i is always increasing in p_{ii} and so the best response of firm i is either the highest admissible price $p_{ji} - \Delta t + \theta^{\text{sup}}$ or 0 (since firms are free to set a zero price, which we interpret as the decision to remain inactive). The best response is to charge $p_{ii} = 0$.

In the first regime, which occurs for intermediate values of the tax differential Δt, there is international trade, with both firms competing in jurisdiction i. In the last two regimes the large difference between the two taxes implies eviction of one firm from the world market and then best prices are corner solutions of firms' program. The other best responses are derived in an analogous way. They are spelled out in the proof of Lemma 2 below.

4.2 Second stage Nash equilibria

In line with the form taken by the best responses, Lemma 2 shows that for extreme values of the tax differential, only one single firm acts as a world monopoly and serves both jurisdictions in equilibrium.

Lemma 2. Pure strategy Nash equilibria with only one worldwide active firm. *Let Δt be given. If*

$$\Delta t \leq -\theta^{\text{sup}} - 1/f(\theta^{\text{sup}}),$$

then there exists a unique pure strategy Nash equilibrium of the second stage game. In this equilibrium $\bar{\theta}_j^* = -\bar{\theta}_i^* = \theta^{\text{sup}}$ so that the world demand is satisfied by firm i only. In this equilibrium $p_{ii}^* = p_{ij}^* = -\theta^{\text{sup}} - \Delta t$ and $p_{jj}^* = p_{ji}^* = 0$.

If

$$\Delta t \geq \theta^{\text{sup}} + 1/f(\theta^{\text{sup}}),$$

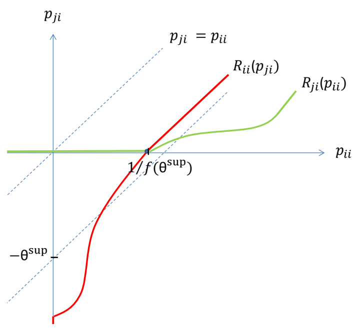

Figure 1: Firm j as a world monopoly

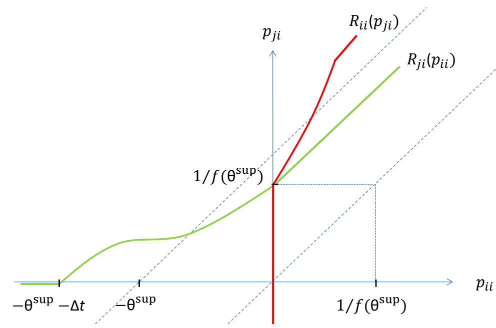

Figure 2: Firm i as a world monopoly

then there exists a unique pure strategy Nash equilibrium of the second stage game. In this equilibrium $\bar{\theta}_j^* = -\bar{\theta}_i^* = -\theta^{\sup}$ *so that the whole world demand is satisfied by firm* j*. In this equilibrium* $p_{ji}^* = p_{jj}^* = -\theta^{\sup} + \Delta t$ *and* $p_{ii}^* = p_{ij}^* = 0$*.*

Proof. The best response of firm j in jurisdiction i is

$$p_{ji} = \begin{cases} 0 & \text{if } p_{ii} \leq -\theta^{\sup} - \Delta t, \\ m(p_{ji} - p_{ii} - \Delta t) & \text{if } -\theta^{\sup} - \Delta t < p_{ii} < \theta^{\sup} - \Delta t + 1/f(\theta^{\sup}), \\ p_{ii} - \theta^{\sup} + \Delta t & \text{if } p_{ii} \geq \theta^{\sup} - \Delta t + 1/f(\theta^{\sup}). \end{cases}$$

In this jurisdiction all the consumers are served by firm j if $\bar{\theta}_i = \theta^{\sup} = p_{ii} - p_{ji} + \Delta t$. From i's best response, this happens if and only if $p_{ii} \geq \theta^{\sup} - \Delta t + 1/f(\theta^{\sup})$. From j's best response, it must be that $p_{ji} \leq \Delta t - \theta^{\sup}$. We have then $p_{ii}^* = 0$ and $p_{ji}^* = -\theta^{\sup} + \Delta t$. Hence such an equilibrium exists if and only if $\Delta t \geq \theta^{\sup} + 1/f(\theta^{\sup})$.

In the regime where all the consumers in jurisdiction i are served by firm i, $\bar{\theta}_i = -\theta^{\sup} = p_{ii} - p_{ji} + \Delta t$, it must be that both $p_{ji} \geq \theta^{\sup} + \Delta t + 1/f(\theta^{\sup})$ and $p_{ii} \leq -\theta^{\sup} - \Delta t$. Then $p_{ji}^* = 0$ and $p_{ii}^* = -\theta^{\sup} - \Delta t$. Such an equilibrium exists if and only if $\Delta t \leq -\theta^{\sup} - 1/f(\theta^{\sup})$. The same arguments apply in jurisdiction j. ■

In Figure 1 the tax differential Δt is set at $-\theta^{\sup} - 1/f(\theta^{\sup})$, firm i (depicted in red) serves the whole world market in the equilibrium and firm j (depicted in green) is inactive. In Figure 2, where $\Delta t = \theta^{\sup} + 1/f(\theta^{\sup})$, this is now firm i that is inactive in equilibrium. In either case the competitive advantage due to taxes leads to outcomes that are inconsistent with the first-best world optimum.

Lemma 3. Pure strategy Nash equilibria with both firms active in each jurisdiction. *Let* Δt *be given. If*

$$-\theta^{\sup} - 1/f(\theta^{\sup}) < \Delta t < \theta^{\sup} + 1/f(\theta^{\sup}), \tag{9}$$

then there exists a unique pure strategy Nash equilibrium of the second stage game. In this equilibrium,

$$p_{ii}^* = m(p_{ii}^* - p_{ji}^* + \Delta t), \quad p_{ji}^* = m(p_{ji}^* - p_{ii}^* - \Delta t),$$

$$p_{ij}^* = m(p_{ij}^* - p_{jj}^* + \Delta t) \quad \text{and } p_{jj}^* = m(p_{jj}^* - p_{ij}^* - \Delta t).$$

When $\Delta t = 0$, $p_{ii}^* - p_{ji}^* = p_{jj}^* - p_{ij}^* = 0$. *The net-of-tax prices, either designed for domestic or foreign consumers, decreases (increases) with the domestic (foreign) tax. The tax inclusive prices, either designed for domestic or foreign consumers, increase with both the domestic and foreign taxes.*

Proof. Suppose that there is one interior (trade) solution. From (8), we have

$$\bar{\theta}_i^* - m(\bar{\theta}_i^*) + m(-\bar{\theta}_i^*) - \Delta t = 0. \tag{10}$$

The function $\theta - m(\theta) + m(-\theta)$ is continuous and increasing in θ. There is therefore at most one $\bar{\theta}_i^*$ solution to (10). Existence of a solution implies

$$-\theta^{\sup} - m(-\theta^{\sup}) + m(\theta^{\sup}) < \Delta t < \theta^{\sup} - m(\theta^{\sup}) + m(-\theta^{\sup}).$$

Since $m(-\theta^{\sup}) = 1/f(\theta^{\sup})$ and $m(\theta^{\sup}) = 0$, the above inequality rewrites

$$-\theta^{\sup} - 1/f(\theta^{\sup}) < \Delta t < \theta^{\sup} + 1/f(\theta^{\sup}).$$

Hence (9) is a necessary condition for existence of a trade equilibrium.

To prove sufficiency of (9), suppose that the price equilibrium instead is a corner equilibrium with only one active firm. Then, either (a) $p_{ji} = 0$ and $p_{ii} = p_{ji} - \theta^{\sup} - \Delta t$ or (b) $p_{ji} = p_{ii} - \theta^{\sup} + \Delta t$ and $p_{ii} = 0$. In the first case $1/f(\theta^{\sup}) + \Delta t + \theta^{\sup} \leq p_{ji} = 0$, or equivalently, $\Delta t \leq -\theta^{\sup} - 1/f(\theta^{\sup})$. In the last case $p_{ii} = 0 \geq \theta^{\sup} - \Delta t + 1/f(\theta^{\sup})$, or equivalently, $\Delta t \geq \theta^{\sup} + 1/f(\theta^{\sup})$.

The condition given in the lemma is satisfied for $\Delta t = 0$. There is therefore a symmetric Nash equilibrium in prices associated with $\Delta t = 0$. From (10) it is such that $\bar{\theta}_i^* = 0$ and $\Delta p_i^* = p_{ii}^* - p_{ji}^* = 0$. The comparative statics properties obtain by differentiating the system (8),

$$\begin{pmatrix} dp_{ii}^* \\ dp_{ji}^* \end{pmatrix} = \frac{1}{D} \begin{pmatrix} m'(\theta_i^*) \\ -m'(-\theta_i^*) \end{pmatrix} d\Delta t$$

$$\Rightarrow \begin{pmatrix} d\left(p_{ii}^* + t_i\right) \\ d\left(p_{ji}^* + t_j\right) \end{pmatrix} = \frac{1}{D} \begin{pmatrix} \left[1 - m'(-\theta_i^*)\right] dt_i - m'(\theta_i^*) dt_j \\ \left[1 - m'(-\theta_i^*)\right] dt_j - m'(-\theta_i^*) dt_i \end{pmatrix}.$$

where $m'(\theta) \leq 0$ for all θ and $D \equiv 1 - m'(\theta_i^*) - m'(-\theta_i^*) > 0$. ■

When taxes are close enough to each other there exists a unique pure strategy Nash equilibrium. This equilibrium involves international trade. Figure 3 represents the equilibrium in jurisdiction i when $\Delta t < 0$. By Lemma 3 firm i then charges a higher price than does firm j, but its tax inclusive price remains below the one charged by the foreign firm. This discourages the domestic consumers from purchasing the foreign good, and encourages the foreign consumers to purchase the domestic good. In our setup, however, this does not necessarily result in a welfare improvement since some domestic consumers who display an import bias turn to purchase the home good.

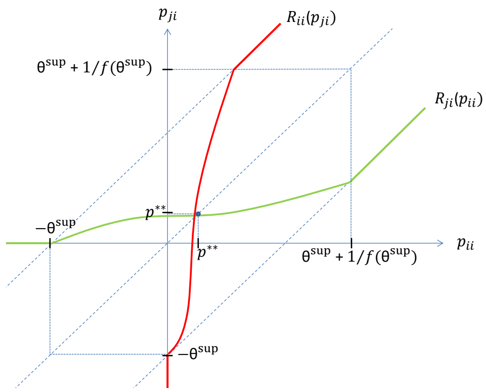

Figure 3: Equilibrium prices when $\Delta t = 0$

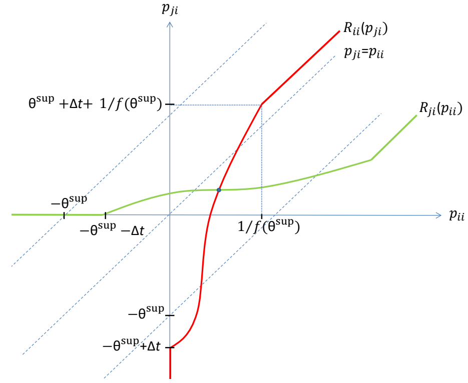

Figure 4: Equilibrium prices when $\Delta t < 0$

5 Tax competition under the origin principle

By Lemma 1 the first-best world optimum is the outcome of fiscal competition under the origin principle if and only if tax authorities set the same tax rates in the first stage. First we show that a tax authority never benefits unilaterally from implementing some equilibrium of the second stage price game characterized in Lemma 2, with only one worldwide active firm.

Lemma 4. *Given $t_j = t_j^{**}$ the tax authority from jurisdiction i prefers to set $t_i = t_i^{**}$ rather than some tax t_i that yields a worldwide monopoly in the pure strategy Nash equilibrium of the second stage.*

Proof. Suppose that $t_j = t_j^{**}$. If the tax authority i sets $t_i = t_i^{**} = t_j^{**}$, then the surplus in its jurisdiction is

$$v + \int_0^{\theta^{\sup}} \theta dF(\theta). \tag{11}$$

Suppose that tax authority i contemplates a deviation implying that only firm i will be active in the second stage equilibrium. Using Lemma 2, this authority must set t_i such that

$$-\theta^{\sup} - \frac{1}{f(\theta^{\sup})} \geq \Delta t.$$

Then $\bar{\theta}_j^* = -\bar{\theta}_i^* = \theta^{\sup}$, and $p_{ji}^* = 0$ and $p_{ij}^* = -\theta^{\sup} - \Delta t$. The social surplus in jurisdiction i is therefore

$$v + \int_{-\theta^{\sup}}^{\theta^{\sup}} \theta dF(\theta) + \left(p_{ij}^* + t_i\right) = v - \theta^{\sup} - \frac{1}{2}\frac{F(0)}{f(0)} < v + \int_0^{\theta^{\sup}} \theta dF(\theta).$$

If the tax authority of jurisdiction i instead chooses t_i such that

$$\Delta t \geq \frac{1}{f(\theta^{\sup})} + \theta^{\sup}, \tag{12}$$

then the whole world demand is now satisfied by firm j ($\bar{\theta}_i = -\bar{\theta}_j = \theta^{\sup}$) and equilibrium prices are $p^*_{ji} = -\theta^{\sup} + \Delta t$ and $p^*_{ij} = 0$. The social surplus in jurisdiction i is

$$v + \int_{\theta^{\sup}}^{\theta^{\sup}} \theta dF(\theta) - \left(p^*_{ji} + t^{**}_j\right) = v + \theta^{\sup} - t_i.$$

From (12) this surplus is lower than

$$v + \theta^{\sup} - \left(t^{**}_j + \frac{1}{f(\theta^{\sup})} + \theta^{\sup}\right) = v + \frac{1}{2}\frac{F(0)}{f(0)} - \frac{1}{f(\theta^{\sup})} < v + \int_0^{\theta^{\sup}} \theta dF(\theta),$$

where we have used

$$\frac{1}{2}\frac{F(0)}{f(0)} - \frac{1}{f(\theta^{\sup})} = \frac{1}{4}\frac{1}{f(0)} - \frac{1}{f(\theta^{\sup})} < 0$$

since, by Assumption A1, $f(0) > f(\theta^{\sup})$. ■

The first-best level of social world surplus is shared among the tax authorities when they set $t^{**}_i = t^{**}_j$. Given $t_j = t^{**}_j$ the tax authority in jurisdiction i cannot improve upon this level by deviating unilaterally in such a way that either firm i decides to remain inactive or serve the whole world market, as in Lemma 2. If the taxes are so that firm i becomes a worldwide monopoly, the social gain (in terms of domestic profit and collected tax) due to the purchase of the domestic good by the foreigners is dominated by the social loss that comes from the fall in gross surplus of import biased domestic consumers who now opt for the home good.

The main result of this paper is to show that the absence of improving deviation extends to tax differentials yielding a trade equilibrium in the second stage price game, such as characterized in Lemma 3.

Proposition 2. *The first-best world optimum is a pure strategy subgame perfect Nash equilibrium of the sequential two stage game of tax competition under the origin principle.*

Proof. In view of Lemma 4 it remains to show that there is no unilateral tax deviation satisfying (9) that yields a social welfare improvement. Let $t_j = t^{**}_j$. When (9) is satisfied, the definition of the thresholds yields

$$\bar{\theta}_i - m(\bar{\theta}_i) + m(-\bar{\theta}_i) = \Delta t = -\left[\bar{\theta}_j - m(\bar{\theta}_j) + m(-\bar{\theta}_j)\right].$$

Given Δt, since $\theta - m(\theta) + m(-\theta)$ is increasing in θ, there is at most one solution $(\bar{\theta}_i, \bar{\theta}_j)$. By Lemma 3 there exists a unique equilibrium for all Δt satisfying (9). It must consequently be that $\bar{\theta}_i = -\bar{\theta}_j$ in equilibrium. By Assumption A1, $F(-\bar{\theta}_i^*) = 1 - F(\bar{\theta}_i^*)$, so that the surplus in jurisdiction i is

$$v + \int_{\bar{\theta}_i^*}^{\theta^{\sup}} \theta dF(\theta) - \left(\frac{F(\bar{\theta}_i^*)}{f(\bar{\theta}_i^*)} + t_j^{**} \right) F(\bar{\theta}_i^*) + \left(\frac{1 - F(\bar{\theta}_i^*)}{f(\bar{\theta}_i^*)} + t_i \right) \left[1 - F(\bar{\theta}_i^*) \right],$$

The characterization of the threshold $\bar{\theta}_i$ allows us to express

$$t_i = \bar{\theta}_i^* - \frac{1 - F(\bar{\theta}_i^*)}{f(\bar{\theta}_i^*)} + \frac{F(\bar{\theta}_i^*)}{f(\bar{\theta}_i^*)} + t_j^{**}.$$

The surplus in jurisdiction i thus rewrites

$$v + \int_{\bar{\theta}_i^*}^{\theta^{\sup}} \theta dF(\theta) + \left(\frac{F(\bar{\theta}_i^*)}{f(\bar{\theta}_i^*)} + t_j^{**} \right) \left[1 - 2F(\bar{\theta}_i^*) \right] + \bar{\theta}_i^* F(-\bar{\theta}_i^*).$$

Since the surplus equals (11) if $t_i = t_j^{**}$, a deviation $t_i \neq t_j^{**}$ yields a social welfare change in jurisdiction i equal to

$$\Delta(\bar{\theta}_i^*) = \int_{\bar{\theta}_i^*}^{0} \theta dF(\theta) + \left(\frac{F(\bar{\theta}_i^*)}{f(\bar{\theta}_i^*)} + t_j^{**} \right) \left[1 - 2F(\bar{\theta}_i^*) \right] + \bar{\theta}_i^* F(-\bar{\theta}_i^*)$$

This deviation is not profitable if and only if $\Delta(\bar{\theta}_i^*) < 0$ for all $\bar{\theta}_i^*$ consistent with the existence of an interior price equilibrium in the second stage game. To show this property, note that $\Delta(0) = 0$ and compute the first derivative of the welfare change,

$$\Delta'(\theta) = \left(2 - \frac{F(\theta)}{f(\theta)} \frac{f'(\theta)}{f(\theta)} \right) [1 - 2F(\theta)] - \left(\frac{F(\theta)}{f(\theta)} - \frac{F(0)}{f(0)} + 2\theta \right) f(\theta).$$

By Assumption A1, log-concavity of F implies that $f(\theta)/F(\theta)$ is decreasing in θ, and so $F(\theta)/f(\theta)$ is increasing in θ. It follows that $\theta + F(\theta)/f(\theta)$ is also increasing in θ. We have therefore

$$\frac{\partial}{\partial \theta} \left(\theta + \frac{F(\theta)}{f(\theta)} \right) = 2 - \frac{F(\theta)}{f(\theta)} \frac{f'(\theta)}{f(\theta)} > 0 \text{ for all } \theta. \tag{13}$$

Using the symmetry of F in Assumption A1, we have $1 - 2F(\theta) > 0$ if and only if $\theta < 0$. In addition, the function

$$\frac{F(\theta)}{f(\theta)} - \frac{F(0)}{f(0)} + 2\theta$$

is also increasing in θ and it equals 0 when $\theta = 0$. It follows that $\theta \Delta'(\theta) < 0$ for all $\theta \neq 0$. That is, the welfare change is single peaked in θ with a global maximum at $\theta = 0$. Hence $\Delta(0) = 0$ and $\Delta(\theta) < 0$ for all $\theta \neq 0$. This completes the proof. ■

6 Discussion

Remark 1. *Firms' competition.* If there is perfect competition among firms in the second stage, prices equal the marginal cost. Thus (rescaled) net-of-tax prices are 0 and $\bar{\theta}_i = t_i - t_j = \Delta t = -\bar{\theta}_j$. By Assumption 1 the social surplus in jurisdiction i is

$$v + \int_{\Delta t}^{\theta^{\sup}} \theta dF(\theta) - t_j F(\Delta t) + t_i \left[1 - F(\Delta t)\right].$$

Given t_j the social surplus is $v + t_i$ for all t_i such that $\Delta t \leq -\theta^{\sup}$ so that all such taxes are dominated by $t_i = t_j - \theta^{\sup}$. Similarly, for all t_i such that $\Delta t \geq \theta^{\sup}$ the surplus is $v - t_j$ so that there is no loss to set $t_i = t_j + \theta^{\sup}$. The set of undominated strategies is consequently $[-\theta^{\sup}, \theta^{\sup}]$, as in the 'strategic' case where firms have market power in the second stage.

Proposition 3. *If there is perfect competition among firms in the second stage game, then there exists a unique pure strategy subgame perfect Nash equilibrium. In this equilibrium,*

$$t_i = t_j = \frac{1}{2}\frac{F(0)}{f(0)}.$$

This equilibrium implements the first-best world optimum.

Proof. A change in the tax dt_i in jurisdiction i implies a change in surplus equal to $\left[1 - F(\Delta t) - 2f(\Delta t)t_i\right] dt_i$. An interior (first-stage) Nash equilibrium satisfies the first-order condition

$$t_i = \frac{1}{2}\frac{1 - F(\Delta t)}{f(\Delta t)},$$

and by symmetry,

$$t_j = \frac{1}{2}\frac{F(\Delta t)}{f(\Delta t)}.$$

It follows that

$$2\Delta t - m(\Delta t) + m(-\Delta t) = 0.$$

By log-concavity, the left-hand side of this equality is continuous increasing in Δt, ranging from $-2\theta^{\sup} - m(-\theta^{\sup}) < 0$ to $2\theta^{\sup} + m(-\theta^{\sup}) > 0$. There is therefore a unique interior equilibrium. In this equilibrium, both tax authorities set the same taxes. These taxes are those given in Proposition 3.

It remains to prove that $\Delta t \neq \{-\theta^{\sup}, \theta^{\sup}\}$ in equilibrium. We proceed by contradiction. Suppose first that in equilibrium tax authorities set t_i^0 and t_j^0 such that $\Delta t^0 = \theta^{\sup}$. We have then $S_i = S_i^0 = v - t_j^0$ and $S_j = S_j^0 = v + t_j^0$. If, given $t_j = t_j^0$, firm i deviates and sets $t_i = t_i^1 = t_j^0$, then social surplus in country i equals $S_i^1 = v + \mathbb{E}[\tilde{\theta} \mid \tilde{\theta} \geq 0]$. We have

$$S_i^1 > S_i^0 \Leftrightarrow t_j^0 > -\mathbb{E}[\tilde{\theta} \mid \tilde{\theta} \geq 0].$$

Similarly, if given $t_i = t_i^0$, tax authority j deviates from t_j^0 and sets instead $t_j^1 = t_i^0$, then the social surplus in country i will also be $v + \mathbb{E}[\tilde{\theta} \mid \tilde{\theta} \geq 0]$. Hence

$$S_j^1 > S_j^0 \Leftrightarrow t_j^0 < \mathbb{E}[\tilde{\theta} \mid \tilde{\theta} \geq 0].$$

Since $\mathbb{E}[\tilde{\theta} \mid \tilde{\theta} \geq 0] \geq 0$, there is always one tax authority that has a unilateral incentive to deviate from (t_i^0, t_j^0). The configuration where $\Delta t^0 = -\theta^{\sup}$ is treated analogously. ■

By Lemma 1, if tax authorities were prevented from using consumption subsidies, the first-best would not obtain in the strategic case. In the presence of such a constraint, Proposition 3 suggests usefulness of policies implying a lower market power in the good market, since equilibrium taxes become positive in the competitive regime.

In the strategic regime, the net-of-tax prices all equal $m(0)$ and by Lemma 1 tax inclusive prices are

$$\frac{F(0)}{f(0)} - \frac{1}{2}\frac{F(0)}{f(0)} = \frac{1}{2}\frac{F(0)}{f(0)}.$$

Thus tax inclusive prices coincide in the competitive and strategic regimes. Market power in the second stage allows firms to raise their net-of-tax prices but the tax authorities set subsidies that eventually yield the competitive inclusive prices in equilibrium: competition among firms leads to higher commodity taxes.

Remark 2. *Nash equilibria.* In Proposition 1 we have restricted our attention to pure strategy Nash equilibria. The fact that tax authorities tend to display some risk aversion, since their domestic gross surplus is log-concave in the domestic tax, does not prevent the existence of profitable deviations from the first-best optimum where tax authorities expect firms to play mixed strategies.

The paper neither characterizes the whole set of pure strategy Nash equilibria in taxes. Our next result shows that all such equilibria have to involve international trade.

Proposition 4. *In equilibrium tax authorities never set taxes yielding a worldwide monopoly.*

Proof. Consider any situation where tax rates t_i^0 and t_j^0 would imply that firm i decides to remain inactive, $\Delta t^0 \equiv t_i^0 - t_j^0 \geq \theta^{\sup} + 1/f(\theta^{\sup})$, i.e., the whole world demand is satisfied by firm j ($\bar{\theta}_j^* = -\bar{\theta}_i^* = -\theta^{\sup}$). By Lemma 2 the second-stage equilibrium prices are $p_{ii}^* = p_{ij}^* = 0$ and $p_{ji}^* = p_{jj}^* = -\theta^{\sup} + \Delta t^0$. By (1) the social surplus S_i is country i equals $v - \left(p_{ji}^* + t_j^0\right) = v - t_i^0 + \theta^{\sup}$. Suppose that given $t_j = t_j^0$ the tax authority in country i deviates from $t_i = t_i^0$ by reducing its tax rate to $t_i = t_i^1 = t_j^0$. The resulting tax differential, which is 0, fits the condition given in Lemma 3 for a trade equilibrium. All the prices are then equal to $m(0)$ and the surplus in country i is $S_i = v + \mathbb{E}[\tilde{\theta} \mid \tilde{\theta} \geq 0]$. The deviation from t_i^0 to t_i^1 yields a gain in social surplus in country i if and only if

$$\theta^{\sup} - \mathbb{E}[\tilde{\theta} \mid \tilde{\theta} \geq 0] < t_i^0.$$

A similar argument applied to tax authority j shows that given $t_i = t_i^0$ it is better for country j to set $t_j = t_i^0$ than t_j^0 if and only if, using $\mathbb{E}[\tilde{\theta}] = 0$,

$$v + \mathbb{E}[\tilde{\theta}] + p_{ji}^* + t_j^0 = v + t_i^0 - \theta^{\sup} < v + \mathbb{E}[\tilde{\theta} \mid \tilde{\theta} \geq 0]$$

$$\Leftrightarrow t_i^0 < \theta^{\sup} + \mathbb{E}[\tilde{\theta} \mid \tilde{\theta} \geq 0].$$

Since $\theta^{\sup} - \mathbb{E}[\tilde{\theta} \mid \tilde{\theta} \geq 0] \leq \theta^{\sup} + \mathbb{E}[\tilde{\theta} \mid \tilde{\theta} \geq 0]$, for every t_i^0 there is at least one tax authority that has a unilateral incentive to deviate from the no international trade situation. ■

Remark 3. *Destination principle.* If international commodity taxation is ruled by the destination principle, then taxes rely on consumers' location, $t_{ii} = t_{ji} \equiv t_i$ and $t_{ij} = t_{jj} \equiv t_j$. A consumer θ located in country i has utility $v + T_i + \theta - p_{ii} - t_i$ when she buys the home good, while her utility is $v + T_i - p_{ji} - t_i$ otherwise. Thus $\bar{\theta}_i = p_{ii} - p_{ji}$ independently of Δt. Competition among firms in the second stage is therefore independent of taxes. The income transfers are financed by the tax collected from domestic consumers, $T_i = t_i \left[1 - F(\bar{\theta}_i) + F(\bar{\theta}_i)\right] = t_i$ so that the social surplus in country i

$$v + \int_{\bar{\theta}_i^*}^{\theta^{\sup}} \theta dF(\theta) - p_{ji}^* F(\bar{\theta}_i^*) - p_{ii}^* \left[1 - F(\bar{\theta}_i^*)\right]$$

is also independent of taxes. We have therefore:

Proposition 5. *The first-best world social optimum is a subgame perfect Nash equilibrium when international taxes are ruled by the destination principle.*

Remark 4. *eBay mediated transactions.* A seller using the eBay platform simultaneously advertises its product in several countries at the same net-of-tax price: under the origin principle the consumer prices are necessarily equalized across countries. As shown in Lemma 1 the Nash equilibrium that implements the first-best world optimum involves non discriminatory prices. Since the set of admissible deviations from the first-best in the absence of price discrimination is a subset of those considered in the paper, eBay mediated competition also yields the first-best world optimum. A sketch of the argument proceeds as follows. Let p_i and p_j be the prices charged by firm i and j, respectively. The profit of firm i is $p_i \left[1 - F(\bar{\theta}_i) + F(\bar{\theta}_j)\right]$, where

$$\bar{\theta}_i = (p_i + t_i) - (p_j + t_j), \quad \text{and } \bar{\theta}_j = (p_j + t_j) - (p_i + t_i).$$

It follows that $\bar{\theta}_j = -\bar{\theta}_i$ and since, by Assumption A1, $F(-\bar{\theta}_i) = 1 - F(\bar{\theta}_i)$, the profit of firm i actually is $2p_i \left[1 - F(\bar{\theta}_i)\right]$ and the profit of firm j is $2p_j F(\bar{\theta}_i)$. The profit of each firm using eBay mediated transactions merely is twice the profit they would obtain in one jurisdiction when price discrimination is feasible. Given Δt the set of pure strategy Nash equilibria of the second stage game are thus given by Lemma 2 and 3. Hence the social surplus in jurisdiction i is still given by (1) with $p_{ij} = p_i$ and $p_{ji} = p_j$. Proposition 1 therefore remains valid for eBay mediated transactions.

Proposition 6. *When price discrimination based on consumers' location is not feasible, as is the case for eBay mediated transactions, the first-best world social optimum is a subgame perfect Nash equilibrium under the origin principle.*

REMARK 5. *eBay mediated transactions and home bias.* If, as is assumed in the main strand of the literature, $\theta \geq 0$ for every consumer, the first-best world social optimum involves no international trade. There is then no symmetric pure Nash equilibrium: at equal prices, all the consumers have a strict preference for the home good, and so each firm has a local unilateral incentive to raise its price to enjoy its monopoly power in the domestic market. More generally a firm will enter the foreign market only if it already serves all the domestic consumers. At the prices that trigger entry in the foreign market, a slight increase in the tax inclusive foreign price yields a discrete downward jump of the domestic price to overcome the high home biases of foreign consumers. Such a discontinuity is common in the models of tax competition (Kambur and Keen, 1993) and may make existence of equilibria problematic. In the special case where θ is uniformly distributed, we have found examples of nonexistence of pure strategy Nash equilibria if $\theta^{\inf}$ and $\theta^{\sup}$ are close to each other, and existence asymmetric pure strategy Nash equilibria otherwise. This suggests that under eBay mediated transactions, taste homogeneity translate into price instability (when there is no pure strategy equilibrium prices), while enough diversity in consumers' tastes give rise to persistent price and tax differentials across countries. This may accord with the observations in Baye, Morgan and Scholten (2004).

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