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ABSTRACT

Destination- versus Origin-based Commodity Taxation and the Location of Industry*

This Paper studies the positive aspects of destination vs. origin principles of commodity taxation as well as tax harmonization, with an emphasis on the international implications of these measures when firms are mobile. We investigate the tax incidence of these two principles on price levels and uncover how taxes and trade costs interact. While under the destination principle an increase in the tax rate of a country always causes some firms to relocate to the other, this effect may get reversed under the origin principle when economic integration is deep enough, so that a tax increase leads to an inflow of capital.

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1 Introduction

The question of VAT harmonization within the European Union (henceforth, EU) has attracted considerable attention and generated heated debates in the political arena (European Commission, 2000). Similar issues arise within federations such as the United States, where e-commerce has created significant pressures on existing cross-border tax systems (Goolsbee, 2001). More broadly speaking, the choice of a tax principle and the question as to whether tax rates should be harmonized are becoming increasingly important as global economic integration steadily proceeds. This confirms some of the recent conclusions reached by IMF researchers, for whom

> "Some of the deepest design issues for the VAT in the coming years are likely to be those arising from intensifying international economic integration and continued pressure to decentralize tax powers." (Ebrill *et al.*, 2001, p. 176)

According to Keen *et al.* (2002, p. 1567), two key questions in designing indirect taxes in the international context are: (i) should taxes be levied according to the destination or the origin principle, and (ii) should rates be harmonized across countries? As observed by the European Commission (2000, p. 18), these two questions are difficult to resolve in practice:

> "Members States have shown little enthusiasm for the proposals in Council meetings and [...] have been reluctant to accept the greater harmonization of VAT rates and tax structures".

As a result, the EU has not settled yet on a definitive VAT system for the Single Market.

Besides these fiscal objectives, the EU is also committed to a social cohesion objective. As indicated by Article 130a of the Amsterdam Treaty of 1997, the

> "Community shall aim at reducing disparities between the levels of development of the various regions and the backwardness of the least favoured regions or islands, including rural areas."

The Treaty explicitly foresees that this will be achieved by financial transfers from the EU budget and through lending by the European Investment Bank. Despite such an explicit concern, most research devoted to tax reform disregards the potential impacts of such measures on the spatial distribution of economic activities. It is our contention that such neglect might be crucial. Indeed, roughly 35% of the EU budget is spent on structural funds aimed at leveling regional disparities, and 40% of that budget is raised by VAT. Should the way VAT is currently collected within the EU worsen regional inequalities, it would not be a surprise that European regional policies do not seem to deliver the expected results (Boldrin and Canova, 2001).

To shed some light on these questions, this paper studies the *positive aspects* of destination vs. origin principles as well as tax harmonization, with a special emphasis on the international implications of these measures when firms are mobile. To investigate such issues within fairly well-integrated economies, characterized by a large share of intraindustry trade between countries with similar relative endowments, we build on an idea developed in new trade theory, namely that market size matters for the location of industry (Helpman and Krugman 1985; Head *et al.*, 2002). Specifically, we address these issues in a general equilibrium model featuring increasing returns, product differentiation, and trade costs. To date, as we still lack a general equilibrium model with oligopolistic firms, such a task can be accomplished only within the framework of monopolistic competition. The foremost example is Krugman's (1980) application of the Dixit and Stiglitz (1977) model to the fields of international trade and economic geography.

Moving within the Dixit-Stiglitz tradition, a recent paper by Haufler and Pflüger (2004) deals with international commodity taxation under imperfect competition and investigates the issue of tax competition when firms are internationally mobile. To obtain tractable results for the tax game, those authors combine a quasi-linear CES specification with iceberg transport costs. When taken together, their assumptions imply that equilibrium prices are independent of tax rates, transport costs, wages, and the spatial distribution of the consumers and firms.[1] Such an approach significantly simplifies the tax game and the corresponding normative analysis. However, it eliminates important features of the positive analysis of industrial location under imperfect competition and commodity taxation.

In this paper, we take a somewhat different approach to monopolistic competition. Our model, presented in Section 2, builds on the framework developed by Ottaviano and Thisse (2004) by integrating commodity taxation. Production takes place in two countries and two sectors, a perfectly competitive sector and a monopolistically competitive one. The former employs only labor, which is immobile between countries, whereas the latter

[1] Specifically, the quasi-linear CES specification with iceberg transport costs leads to a very special case in which freight and tax absorption is always 100 per cent.

employs both immobile labor and internationally mobile capital. Our assumptions on factor mobility fit the EU quite well, where capital is fairly mobile whereas labor mobility remains low despite the absence of formal barriers (Braunerhjelm *et al.*, 2000). Our primary concern being federations such as the EU and the US, we assume that countries share a common currency, thus disregarding the potential impacts of taxes on exchange rates.

Using Ottaviano and Thisse (2004) allows us to account for the existence of two *direct competition effects*: (i) local prices decrease with the number of local producers, in accordance with the theory of industrial organization, and (ii) lower trade costs lead to lower prices, as suggested by Hotelling (1929, p. 50) for whom "merchants would do well, instead of organizing improvement clubs and booster associations to better the road, to make transportation as difficult as possible". In addition, our modelling framework captures the fact stressed by Keen *et al.* (2002, p. 1567) that "by assuming that there are no costs to the movement of goods other than those related to tax, the analysis has precluded price discrimination between the two countries." Yet, empirical evidence shows that market segmentation is more the rule than the exception, even within fairly well-integrated federations like the EU (Head and Mayer, 2000; Haskel and Wolf, 2001). Unlike the Dixit-Stiglitz-Krugman framework used in new trade theory, our setting allows explicitly for firms to price discriminate across national markets. Further, there are weak interactions among firms in that *each firm plays against the market.* More precisely, even though our model lacks pairwise strategic interactions, it captures most of the main features of oligopolistic competition through mark-ups that vary with the number of firms, their spatial distribution, and the level of trade costs.

In Section 3, we analyze the market equilibrium with a fixed international distribution of firms, which is the usual focus of the existing literature. In particular, we take a closer look at the tax incidence of the destination and origin principles on price levels and uncover that taxes and trade costs are intertwined in nontrivial ways. Under the origin principle, as in the no-tax case, the market with more producers is always more competitive, while tax differentials may reverse this under the destination principle. We show that in contrast to the case with perfectly competitive markets, the principles are never equivalent in the absence of full harmonization.

Section 4 studies the case in which firms are free to move from one country to another in response to profit differentials. We find that under the destination principle an increase in a country's tax rate always causes some firms to relocate to the other country, while under the origin principle a tax increase may lead to an inflow of firms. Furthermore, under the origin principle there may exist a "reverse home market effect", in the sense that the larger country hosts a less than proportional share of the industry. Finally, we consider the effects of full tax harmonization on the spatial distribution of industry. Our key results are that countries of different sizes will always disagree on the tax principle to be applied, and that the incentive to deviate from harmonization is stronger under the origin than under the destination principle. Section 5 concludes and discusses further research directions.[2]

A final remark is in order. Some of the policy issues relating to the structure of VAT concern intermediate good transactions. However, we do not deal with the impact of taxation principles on the organization of the supply chain. Instead, we focus on the impact of such principles on trade and location. This allows us to abstract from possible distortions that might arise due to breaks in the VAT chain under the origin principle. A by-product of our approach is that a commodity tax under the destination principle resembles a consumption tax, whereas the origin principle more closely resembles a production tax. Thus, our analysis has implications beyond VAT structures.

2 The model

Consider an economy with 2 countries, labeled H and F, and a unit total mass of consumers. Each consumer is endowed with one unit of labor and one unit of capital. Let $\theta \in (0,1)$ denote the share (and mass) of consumers in country H, which implies that θ also measures that country's shares (and masses) of labor and capital. Consumers are immobile and can supply labor only in the country where they reside. In contrast, they are free to supply capital wherever they want. The share of capital invested in country H, denoted by $\lambda \in [0,1]$, is thus *endogenous* and will be determined as an equilibrium outcome.

All consumers share the same preferences over the consumption of two types of goods, a homogeneous good Z and a continuum of horizontally differentiated varieties indexed by $v \in [0,N]$. Such preferences are captured by a quasi-linear utility function with a quadratic subutility, a setting which allows us to abstract from the way the proceeds of taxation are used. A typical

[2]There is a substantial literature in fiscal federalism that deals with tax incidence in a federation (see, e.g. Mintz and Tulkens, 1986) or even in the international context (see, e.g. Kanbur and Keen, 1993). However, it typically disregards the impact of tax competition or coordination on the location of firms. In addition, that literature focuses on either general equilibrium models under perfect competition or partial equilibrium models with oligopolistic competition.

resident of country $i = H, F$ solves the following consumption problem:

$$\begin{cases} \max\limits_{q_i(v),\, v\in[0,N];Z} \alpha \displaystyle\int_0^N q_i(v)\mathrm{d}v - \frac{\beta-\gamma}{2}\int_0^N [q_i(v)]^2\mathrm{d}v - \frac{\gamma}{2}\left[\int_0^N q_i(v)\mathrm{d}v\right]^2 + Z_i \\ \qquad\qquad \text{s.t.} \quad \displaystyle\int_0^N p_i(v)q_i(v)\mathrm{d}v + p_i^Z Z_i = r_i + w_i + p_i^Z \overline{Z}_0 \end{cases}$$

where $q_i(v)$ and $p_i(v)$ are the consumption and the price of variety v; Z_i and p_i^Z are the consumption and the price of the homogeneous good; r_i is the rental rate of capital and w_i is the wage. As to parameters, $\alpha > 0$ expresses the intensity of preference for the differentiated product, $\gamma > 0$ measures the substitutability between varieties, whereas $\beta - \gamma > 0$ expresses the intensity of the preference for variety, i.e. the consumer's bias toward a dispersed consumption of varieties. Finally, $\overline{Z}_0 > 0$ is the initial endowment of the traditional good, which we assume to be sufficiently large for consumption of this good to be strictly positive at the market outcome.

Turning to technologies, good Z is produced under constant returns to scale and perfect competition by using labor as the only input. Without loss of generality, we normalize the unit input requirement to 1. As for the differentiated varieties, each of them is produced under increasing returns to scale and monopolistic competition by using both a fixed requirement ϕ of capital and a constant marginal requirement m of labor. Due to the fixed input requirement ϕ, capital market clearing implies that the total mass of firms is determined by $N = K/\phi$. In what follows, we denote by $n_H = \lambda N$, and $n_F = (1-\lambda)N$ the masses of firms located in each of the two countries. In accord with empirical evidence, national markets are assumed to be *segmented*. This means that firms are free to set prices on the two markets independently. Finally, while good Z is freely traded, international shipments of any variety of the differentiated good incur a trade cost of $\tau \geq 0$ units of good Z per unit of variety shipped.

In equilibrium, consumers maximize utility, firms maximize profits, and markets clear. In addition, no consumer has any incentive to change her international allocation of capital and no firm has any incentive to enter or exit the market. This is the case when consumers cannot get higher rental rates by relocating their capital and when rental rates exactly absorb firms' operating profits. Since the equilibrium rental rate is determined by a bidding process for capital, no firm can earn a strictly positive profit in equilibrium. Formally, at any interior spatial equilibrium such that $\lambda \in (0, 1)$ we must have $r_H = r_F$ with $r_H = \pi_H/\phi$ and $r_F = \pi_F/\phi$, where π_i is the operating profit of a firm located in country i.

In solving the model, for parsimony, we write all expressions for country H only. Mirror expressions holding for country F are understood. Since all varieties produced in the same country are treated symmetrically by consumers, utility maximization implies that the demands in countries H and F for a variety produced in country H can be expressed as follows:

$$\begin{aligned} q_{HH} &= a - (b + cN)p_{HH} + cP_H \\ q_{HF} &= a - (b + cN)(p_{HF} + \tau) + cP_F \end{aligned} \tag{1}$$

where a, b and c are positive coefficients given by

$$a \equiv \frac{\alpha}{\beta + (N-1)\gamma} \qquad b \equiv \frac{1}{\beta + (N-1)\gamma} \qquad c \equiv \frac{\gamma}{(\beta - \gamma)[\beta + (N-1)\gamma]}$$

and

$$\frac{P_H}{N} \equiv \lambda p_{HH} + (1 - \lambda)(p_{FH} + \tau) \tag{2}$$

is the average price of the differentiated good in country H. With this notation, p_{ij} is the *mill price* paid by a consumer residing in country j for a variety produced in country i, which includes sales tax but not trade costs. Therefore, $p_{ij} + \tau$ stands for the tax inclusive *delivered price*.[3] Throughout this paper, we assume that marginal production cost m and trade costs τ are sufficiently low so that international demands q_{HF} and q_{FH} remain strictly positive for all firm distributions. The precise conditions for this to hold will be derived below.

Due to perfect competition, profit maximization in the supply of the homogeneous good Z implies that $p_i^Z = w_i = p^Z$ in both countries $i = H, F$. Such factor price equalization always holds when each country has enough labor to support some production of Z for any international allocation of capital. We assume this holds henceforth and choose good Z as numéraire, so that $w_i = p^Z = 1$.[4] Turning to the differentiated good, because of increasing returns to scale each firm produces a single variety, but any two

[3] In the foregoing, we assume that trade costs are not subject to sales taxes or VAT, as in many jurisdictions in the US. In this case, which we choose for analytical convenience, it is immaterial whether firms or consumers bear these costs. Yet, this no longer holds true when taxes are levied on trade costs. In addition, note that the question of *where* shipping should be taxed is unclear, since part of it may take place in consumers' jurisdictions, whereas the rest takes place in producers' jurisdictions.

[4] Due to the absence of choice between labor and leisure, taxing the homogeneous good in this model would make the tax equivalent to a lump-sum tax on endowments. Either zero rating of the homogenous good or viewing this good as leisure makes it appropriate not to tax it.

firms produce different varieties as required by the Principle of Differentiation in industrial organization (Tirole, 1988). In our model of monopolistic competition, firms play a noncooperative game with a continuum of players in which prices are the firms' strategies.[5] As they face the same demand and cost conditions, firms located in the same country charge the same profit-maximizing price; hence, we may drop the firm index v. Accordingly, firms maximize their profits given by

$$\begin{aligned} \Pi_H &= \theta[p_{HH}(1-t_a) - m]q_{HH} \\ &\quad +(1-\theta)[p_{HF}(1-\bar{t}_a) - m]q_{HF} - r_H\phi \\ \Pi_F &= \theta[p_{FH}(1-\bar{t}_b) - m]q_{FH} \\ &\quad +(1-\theta)[p_{FF}(1-t_b) - m]q_{FF} - r_F\phi, \end{aligned} \tag{3}$$

where $t_a = \bar{t}_b = t_H$ and $\bar{t}_a = t_b = t_F$ under the *destination principle*, and $t_a = \bar{t}_a = t_H$ and $t_b = \bar{t}_b = t_F$ under the *origin principle*. In other words, under the destination principle tax is paid in the country where goods are consumed at the rate applied there, while under the origin principle tax is paid in the country where goods are produced at that country's rate. Note that our specification of the profit functions agrees with the standard EU value-added tax, as well as with the US sales tax, because both labor and capital are primary production factors.[6] In what follows, we write all expressions for firms established in country H only and, accordingly, drop the indices a and b.

From now on, we write the profit functions using a convenient device that allows us to treat an ad valorem tax as a specific tax and a pure profits tax. Since the latter one is not distortionary when the number of firms is constant (see Anderson *et al.*, 2001, p. 176), it only affects the level of profits and allows for much simpler algebra. Using this device, (3) can be rewritten as follows:

$$\begin{aligned} \Pi_H &= (1-t)\theta\left[p_{HH} - \frac{m}{(1-t)}\right]q_{HH} \\ &\quad +(1-\bar{t})(1-\theta)\left[p_{HF} - \frac{m}{(1-\bar{t})}\right]q_{HF} - r_H\phi. \end{aligned}$$

As can be seen from this expression, we have de facto converted our tax

[5] Observe that the game in which firms' strategies are quantities yields the same equilibrium because, under monopolistic competition, each firm, being negligible to the market, behaves as a monopolist on its residual demand.

[6] Alternatively, we could view $r_H\phi$ as returns to entrepreneurship, which is not deductible from the VAT base.

problem into a problem with production cost asymmetries.[7] We may now redefine the ad valorem tax using the relationships

$$t \equiv \frac{s}{1+s} \quad \text{and} \quad s \equiv \frac{t}{1-t}$$

which transforms the sales tax t into an specific tax equal to ms and a pure profits tax whose rate is $1/(1+s)$. As $(1+s)^{-1} = 1-t$ and $(1+\bar{s})^{-1} = 1-\bar{t}$, the profit function then becomes:

$$\begin{aligned} \Pi_H &= \frac{1}{1+s}\theta\left[p_{HH} - m(1+s)\right]q_{HH} \\ &\quad + \frac{1}{1+\bar{s}}(1-\theta)\left[p_{HF} - m(1+\bar{s})\right]q_{HF} - r_H\phi, \end{aligned} \tag{4}$$

which will be our working specification. Clearly, increasing t amounts to increasing s. Moreover, $s = s_H$ and $\bar{s} = s_F$ corresponds to the destination principle, whereas $s = s_H$ and $\bar{s} = s_H$ corresponds to the origin principle. Among other things, this shows that a commodity tax under the origin principle can be thought of as being a production tax, because it is formally equivalent to a rise in marginal production costs.

3 Commodity taxes and the market outcome

As discussed in the introduction, we investigate the equilibrium outcomes under the different tax principles in two steps. In this section, we derive the optimal prices and the corresponding profits for a given distribution λ of firms. In the next section we characterize the spatial equilibrium through the endogenous determination of λ. However, before discussing the different tax regimes, we present the no-tax outcome as a natural benchmark.

3.1 The no-tax case

Since markets are segmented, each firm maximizes its local and distant profits by maximizing each term in (4) independently. Furthermore, because a firm is negligible to the market, each takes the price index (2) as given in its optimization problem. Hence, setting $s = \bar{s} = 0$ and maximizing (4) with respect to prices yields the following profit-maximizing prices:

$$p_{ii}(P_i) = \frac{a + (b+cN)m + cP_i}{2(b+cN)} \qquad p_{ji}(P_i) = p_{ii}(P_i) - \frac{\tau}{2} \tag{5}$$

[7] To the best of our knowledge, this is the first time that such a specification is used with asymmetric tax rates. See, however, Skeath and Trandel (1994) for asymmetric ad valorem taxes.

which can be viewed as a firm's reaction function to its local market conditions, given by:

$$P_i = n_i p_{ii}(P_i) + n_j \left[p_{ji}(P_i) + \tau \right]. \tag{6}$$

Note that the price index P_i depends on the prices set by all other firms. Because there is a continuum of firms, each firm is negligible and chooses its optimal price, taking aggregate market conditions as given. However, aggregate market conditions must be consistent with firms' optimal pricing decisions. The equilibrium price index can thus be found by solving (6) for P_i after using (5). Plugging the resulting expression back into (5), the (Nash) equilibrium *intranational* and *international mill prices* are:

$$p^*_{HH} = \frac{2[a + (b + cN)m] + c(1 - \lambda)N\tau}{2(2b + cN)} \qquad p^*_{FH} = p^*_{HH} - \frac{\tau}{2} \tag{7}$$

so that the *international delivered price* is given by $p^*_{FH} + \tau = p^*_{HH} + \tau/2$. The difference in average prices may then be obtained from (2) as follows:

$$\frac{P^*_H}{N} - \frac{P^*_F}{N} = \frac{b + cN}{2b + cN}\tau(1 - 2\lambda).$$

Hence, having a lower price index, the country hosting the larger mass of firms is more competitive. It is also readily verified that:

$$\frac{\partial p^*_{HH}}{\partial \lambda} < 0 \qquad \text{and} \qquad \frac{\partial \left(p^*_{FH} + \tau\right)}{\partial \lambda} < 0$$

which captures the competition effect in that a larger number of local producers exacerbates price competition. Furthermore,

$$(p^*_{HF} + \tau) - p^*_{HH} = \tau \frac{b + c\lambda N}{2b + cN}$$

which is positive, yet smaller than τ: firms absorb freight on distant sales ('dumping'), the more so the larger the country they ship to. The reason is that the country that host more firms has a lower price index, thus leading firms' demands in that market to be more elastic at any given price level.

For bilateral trade to occur for any $\lambda \in [0, 1]$, international demands q_{ij} evaluated at the equilibrium prices must be positive. This is the case if trade costs are low enough. Specifically, it must be that:

$$\tau < \tau_{trade} \equiv \frac{2\,(a - bm)}{2b + cN} \tag{8}$$

Plugging the equilibrium quantities into (4) and using the zero profit condition allows us to express the equilibrium rental rate of capital in country H as follows:

$$r_H^* = \frac{b+cN}{\phi}\left[\theta(p_{HH}^* - m)^2 + (1-\theta)(p_{HF}^* - m)^2\right] \tag{9}$$

3.2 The destination principle

We now study the market equilibrium when taxes are levied according to the destination principle; all relevant variables are denoted by the superscript d. Setting $s = s_H$ and $\bar{s} = s_F$, maximizing (4) with respect to prices, and plugging the resulting expressions into the price index, the (Nash) equilibrium mill prices are:

$$\begin{aligned} p_{HH}^d &= p_{HH}^* + \frac{b+cN}{2b+cN} m s_H^d \\ p_{FH}^d &= p_{FH}^* + \frac{b+cN}{2b+cN} m s_H^d \end{aligned} \tag{10}$$

where p_{HH}^* and p_{FH}^* are the equilibrium prices (7) in the no-tax case. The corresponding international delivered price equals $p_{FH}^d + \tau$. Using (2), the difference in average prices may then be written as:

$$\frac{P_H^d}{N} - \frac{P_F^d}{N} = \left(\frac{P_H^*}{N} - \frac{P_F^*}{N}\right) + \frac{b+cN}{2(2b+cN)} m(s_H^d - s_F^d).$$

Hence, when compared to the no-tax case, the relative intensity of competition now depends on the tax rate differential. In particular, we have:

Proposition 1 *Under the destination principle, when the tax rate in the country with more producers is sufficiently larger than the tax rate in the other country, the price index may be lower in the latter country.*

It is also readily verified that

$$\frac{\partial p_{HH}^d}{\partial s_H^d} > 0 \qquad \frac{\partial p_{HH}^d}{\partial s_F^d} = 0 \qquad \frac{\partial p_{HH}^d}{\partial \lambda} < 0,$$

whereas

$$\frac{\partial\left(p_{FH}^d + \tau\right)}{\partial s_H^d} > 0 \qquad \frac{\partial\left(p_{FH}^d + \tau\right)}{\partial s_F^d} = 0 \qquad \frac{\partial\left(p_{FH}^d + \tau\right)}{\partial \lambda} < 0.$$

Hence, under the destination principle, increasing the tax rate leads to the same rise in the equilibrium price of each variety, regardless of their country of production.[8] However, the tax rate chosen in a country has no impact on the equilibrium prices of the other country. Stated differently, a tax change in one jurisdiction does not spill over the other, so that *tax decisions are strategically independent when firms' locations are given and markets are segmented*. That such a result no longer holds under the origin principle will be shown in the next section. We further have

$$(p_{HF}^d + \tau) - p_{HH}^d = [(p_{HF}^* + \tau) - p_{HH}^*] - \frac{b + cN}{2b + cN} m(s_H^d - s_F^d).$$

This shows three important points that are all driven by the fact that a lower price index leads firms' demands to be more elastic at any given price level. First, consumers living in country F buy varieties produced in H at a price lower than the price paid by the consumers residing in H when the tax differential $s_H^d - s_F^d$ is sufficiently large compared to the level of trade costs. In this case, there is *negative pass-through* of trade costs, implying that firms 'dump' their products into the foreign market. This is because the tax rate in country H is sufficiently large for the price index prevailing there to be much larger than the price index in country F, so that a firm's demand in F is much more elastic than what it is in H. For exactly the opposite reason, firms charge *phantom freight* to their foreign customers when $s_F^d - s_H^d$ is sufficiently large compared to the level of trade costs (see, e.g., Bryan, 2000). Thus, the presence of a large tax differential either exacerbates or reverses the practice of freight absorption, showing that tax rates and trade costs interact in a nontrivial way at the market equilibrium. Last, there is *incomplete freight absorption* $0 \le (p_{HF}^d + \tau) - p_{HH}^d \le \tau$ when the tax differential takes intermediate values, i.e. when

$$-\tau \frac{b + c(1-\lambda)N}{b + cN} \le m(s_H^d - s_F^d) \le \tau \frac{b + c\lambda N}{b + cN}.$$

Since both bounds depend positively on the spatial distribution λ, we may conclude that, for a given tax differential $s_H^d - s_F^d$, the larger country is more likely to charge phantom freight, whereas the smaller country is more likely to practice negative pass-through.

Using (1) and (10), it is readily verified that international demands are positive for all distributions $0 \le \lambda \le 1$ if and only if

$$\tau < \tau_{trade} - \frac{2bm}{2b + cN} \max\left\{s_H^d, s_F^d\right\} \quad (11)$$

[8]Note that such a result cannot be obtained with iso-elastic demands and iceberg trade costs. Indeed, it is well known that tax absorption is perfect in such a setting.

thus implying that $\max\left\{s_H^d, s_F^d\right\} < (a-bm)/bm$ must hold: *the larger the higher tax rate, the lower trade costs must be for firms to export.*

Plugging the equilibrium quantities and prices into (4) and using the zero profit condition allows us to express the equilibrium rental rate of capital in country H as:

$$\begin{aligned} r_H^d &= \frac{b+cN}{\phi}\left[\frac{\theta}{1+s_H^d}\left(p_{HH}^* - m - \frac{b}{2b+cN} m s_H^d\right)^2\right. \\ &\quad \left. + \frac{1-\theta}{1+s_F^d}\left(p_{HF}^* - m - \frac{b}{2b+cN} m s_F^d\right)^2\right]. \end{aligned} \tag{12}$$

3.3 The origin principle

Under the origin principle, taxes are levied in the country of production; all relevant variables are denoted by the superscript o. Setting $s = \bar{s} = s_H$, maximizing (4) with respect to prices, and plugging the resulting expressions into the price index yields the equilibrium tax-inclusive mill prices:

$$\begin{aligned} p_{HH}^o &= p_{HH}^* + \frac{b+cN}{2b+cN} m s_H^o - \frac{c(1-\lambda)N}{2(2b+cN)} m(s_H^o - s_F^o) \\ p_{FH}^o &= p_{FH}^* + \frac{b+cN}{2b+cN} m s_F^o + \frac{c\lambda N}{2(2b+cN)} m(s_H^o - s_F^o), \end{aligned} \tag{13}$$

whereas the corresponding delivered price is given by $p_{FH}^o + \tau$. These prices already stress *the central role played by the tax differential under the origin principle*, which was absent under the destination principle. Some straightforward analysis yields:

$$\frac{\partial p_{HH}^o}{\partial s_H^o} > 0 \qquad \frac{\partial p_{FH}^o}{\partial s_H^o} > 0 \qquad \frac{\partial p_{FH}^o}{\partial s_F^o} > 0 \qquad \frac{\partial p_{HH}^o}{\partial s_F^o} > 0$$

which show that, under the origin principle, *an increase in either tax raises prices in both countries.* When plugged into (2), they yield a difference in average prices that is identical to the no-tax case, thus implying that:

Proposition 2 *Under the origin principle, the country with more producers is always more competitive regardless of the tax rates.*

Considering now an increase in the number of firms located in country H, we have:

$$\frac{\partial p_{HH}^o}{\partial \lambda} = \frac{\partial p_{FH}^o}{\partial \lambda} \gtreqless 0 \qquad \text{as} \quad m(s_H^o - s_F^o) \gtreqless \tau.$$

Thus, *contrary to what we have seen in the destination principle case, the competition effect can be reversed when taxes are levied according to the origin principle*. Indeed, since τ may be small relative to $m(s_H^o - s_F^o)$, the competition effect may get reversed in that both the prices p_{HH}^o and p_{FH}^o may increase with the number of local producers in country H. The reason for this unexpected result lies in the fact that the price index of country H may now rise with λ. How can we explain such a reversed effect under the origin principle?

To answer this question, observe first that

$$p_{HH}^o - p_{FH}^o = \frac{\tau + m(s_H^o - s_F^o)}{2}.$$

When compared to the destination principle, we thus see that the difference between the tax-inclusive mill prices is corrected for the difference in the comparative cost advantage induced by the tax differential. Assume that H is the high-tax country, i.e. $s_H^o > s_F^o$. In this case, we have $p_{HH}^o > p_{FH}^o$. Since

$$\frac{\partial P_H^o}{\partial \lambda} = N\frac{b + cN}{2b + cN}\left[m(s_H^o - s_F^o) - \tau\right]$$

we see that the price index in country H rises with λ as long as $m(s_H^o - s_F^o)$ exceeds τ. This is because, when some firms move from F to H, they now face a higher marginal production cost ($m(1 + s_H^o)$ instead of $m(1 + s_F^o)$), which may offset the trade cost savings due to local production. Further, we have

$$(p_{HF}^o + \tau) - p_{HH}^o = \frac{(b + cN)\tau + c(1-\lambda)Nm(s_H^o - s_F^o)}{2b + cN}$$

so that

$$\begin{aligned}
(p_{HF}^o + \tau) - p_{HH}^o &\gtreqqless 0 &\quad \Leftrightarrow \quad& m(s_F^o - s_H^o) \lesseqqgtr \tau\frac{b + cN}{c(1-\lambda)N} \\
(p_{HF}^o + \tau) - p_{HH}^o &\gtreqqless \tau &\quad \Leftrightarrow \quad& m(s_H^o - s_F^o) \gtreqqless \tau\frac{b}{c(1-\lambda)N}.
\end{aligned}$$

Again, both negative pass-through of trade costs or phantom freight may arise under the origin principle but, when compared to the destination principle, they require the opposite ranking of tax rates.

Finally, due to free entry the rental rate of capital in country H is equal to the operating profit per unit of capital employed:

$$
\begin{aligned}
r_H^o \quad = \quad & \frac{b+cN}{\phi\left(1+s_H^o\right)}\left\{\theta\left[p_{HH}^* - m - \frac{b}{2b+cN}ms_H^o\right.\right. \\
& \left.+\frac{c(1-\lambda)N}{2(2b+cN)}m(s_F^o - s_H^o)\right]^2 + (1-\theta)\left[p_{FH}^* - m\right. \\
& \left.\left.-\frac{b}{2b+cN}ms_F^o + \frac{c\lambda N}{2(2b+cN)}m(s_H^o - s_F^o)\right]^2\right\}.
\end{aligned} \tag{14}
$$

3.4 The impact of a change in tax regime

It is well known that the destination and origin principles are equivalent under fairly restrictive assumptions only (see, e.g., Lockwood *et al.*, 1994). That the two regimes cannot be equivalent when there is product differentiation and market segmentation, except under full tax harmonization, is shown in what follows.

Proposition 3 *When commodity taxes are not harmonized across countries, the destination and origin principles are never equivalent, no matter the spatial distribution of the industry.*

Proof. Consider any given industry distribution λ as well as some given tax rates s_H^d and s_F^d for which trade occurs. For the consumption of each variety under one principle to remain the same once we switch to the other, a sufficient condition is that the equilibrium prices are the same under the two principles. This is also a necessary condition because there is a one-to-one relationship between prices and quantities. Hence, the following four conditions are necessary and sufficient for the equivalence to hold:

$$
\begin{aligned}
p_{HH}^d - p_{HH}^o &= \kappa\left(s_H^d - s_H^o\right) + \frac{cm(1-\lambda)N}{2(2b+cN)}\left(s_H^o - s_F^o\right) = 0 \\
p_{FF}^d - p_{FF}^o &= \kappa\left(s_F^d - s_F^o\right) + \frac{cm\lambda N}{2(2b+cN)}\left(s_F^o - s_H^o\right) = 0 \\
p_{FH}^d - p_{FH}^o &= \kappa\left(s_H^d - s_F^o\right) - \frac{cm\lambda N}{2(2b+cN)}\left(s_H^o - s_F^o\right) = 0 \\
p_{HF}^d - p_{HF}^o &= \kappa\left(s_F^d - s_H^o\right) - \frac{cm(1-\lambda)N}{2(2b+cN)}\left(s_F^o - s_H^o\right) = 0
\end{aligned}
$$

where $\kappa \equiv m(b+cN)/(2b+cN) > 0$ is a constant. Subtracting the third condition from the first (resp. the fourth from the second), we see that

$s_H^o = s_F^o$ (resp. $s_H^d = s_F^d$) is necessary for the equivalence to possibly hold. It then follows immediately that the two principles are equivalent if and only if $s_H^o = s_F^o = s_H^d = s_F^d = s$. ■

Proposition 3 shows that, in the absence of full harmonization, *any switch of tax regime has an impact on the allocation of resources in the economy.* A regime change that leaves the current resource allocation unchanged, therefore, requires taxes to be harmonized. However, as shown below in Proposition 9, once harmonization has been achieved, the trade partners will in general disagree on the principle to be used.

The price differences in the proof above can be used to evaluate the impact of a regime change in the absence of tax harmonization, holding tax rates constant ($s_H^d = s_H^o \neq s_H^o = s_F^o$). Indeed, the difference in the price indices prevailing in country H under the two regimes is equal to $\kappa(1-\lambda)(s_H^o - s_F^o)$, whereas the same difference in country F is given by $-\kappa\lambda(s_H^o - s_F^o)$. Clearly, this implies that *a move from the destination to the origin principle leads to a price increase in the country with the higher tax rate and to a price decrease in the other.*

4 Commodity taxes and the spatial distribution of the industry

In the previous section we have described the optimal choices of consumers and firms for a given spatial allocation λ of capital. Now we complete the characterization of the spatial equilibrium by determining the value of λ such that no consumer has any incentive to change her international allocation of capital. As we discussed above, this is the case if consumers cannot get higher rental rates by relocating their capital: $r_H = r_F$. In so doing, we start with the no-tax case.

4.1 The no-tax case

In the no-tax case the rental rate of capital in country H is given by (9) with a symmetric expression holding for country F. Solving $r_H^* = r_F^*$ for λ gives the corresponding equilibrium allocation of capital:

$$\lambda^* = \frac{1}{2} + \frac{2\,(2a - b\tau - 2bm)}{cN\tau}\left(\theta - \frac{1}{2}\right). \tag{15}$$

Under (8) the no-tax allocation exhibits a *home market effect*, meaning that the country with the larger share of consumers attracts a more than proportionate share of firms (Ottaviano and Thisse, 2004). To gain insight about this result, we may rewrite (15) as follows:

$$2(2a - 2bm - b\tau)(\theta - 1/2) - c\tau N(\lambda^* - 1/2) = 0 \qquad (16)$$

which shows that in equilibrium the distribution of firms is determined by the interaction of two opposing effects. The first term in (16) measures the *market access advantage* of the larger country, whereas the second term measures the *competition disadvantage* of the country that hosts the larger number of firms. An equilibrium requires these two effects to be balanced. Note finally that the home market effect is stronger the more differentiated varieties are (smaller c) and the lower the trade cost (smaller τ).

4.2 The destination principle

Under the destination principle, the rental rate of capital in country H is given by (12). Rewriting this expression for country F and solving the equation $r_H^d = r_F^d$ for λ gives the corresponding equilibrium distribution of capital:

$$\begin{aligned}\lambda^d &= \frac{1}{2} + \frac{2\left[2a - b\tau - 2bm(1+s_H^d)(1+s_F^d)\right]}{cN\tau\left[1+\theta s_F^d + (1-\theta)s_H^d\right]}\left(\theta - \frac{1}{2}\right) \\ &\quad + \frac{2a - b\tau}{cN\tau\left[1+\theta s_F^d + (1-\theta)s_H^d\right]}[\theta s_F^d - (1-\theta)s_H^d]. \qquad (17)\end{aligned}$$

As we will see soon, the first term in (17) captures the market size effect, whereas the second term captures the tax effect. As also shown by (17), the equilibrium distribution of firms depends on three key parameters: the tax rates s_H^d and s_F^d, as well as the market size θ. The impact of the latter one has been analyzed and repeatedly highlighted in the literature on the home market effect. Yet, the impact of commodity taxes on the home market effect has been disregarded until now. Such a neglect is likely to have important implications for two main reasons. First, price differences due to tax differentials may well exceed trade costs in modern economies.[9] Second, the home market effect and the tax rates interact in a non-trivial way to determine the location of the industry.

[9]Within the EU, the differences in national VAT rates are very significant. Indeed, they range from a low 15% in Luxembourg to a high 25% in Denmark (Ebrill *et al.*, 2001), which shows that they are both higher and more dispersed when compared to state sales taxes in the US.

In order to gain some insights, we start by investigating two special, but meaningful, cases. In Case 1, by imposing $s_H^d = s_F^d = s$, we sterilize the tax effect and fall back on a home market effect-type model. In Case 2, by setting $\theta = 1/2$, we sterilize the home market effect and fall back on a pure tax model. Albeit particular, these two cases are useful for our subsequent discussion of tax harmonization.

Case 1 (Pure Home Market Effect) We first abstract from the potential impact of different tax rates. Letting $s_H^d = s_F^d = s$ in (17), it is easily seen that

$$\lambda(s) = \frac{1}{2} + \frac{2[2a - 2bm(1+s) - b\tau]}{cN\tau}\left(\theta - \frac{1}{2}\right) \tag{18}$$

which for $s = 0$ boils down to λ^* derived in Section 4.1. It is readily verified that $\lambda(s) > \theta$, which means that the large country hosts a more than proportional share of capital. Yet, (18) also reveals that *the presence of a commodity tax attenuates the home market effect.* A higher commodity tax leads to higher prices in both markets. Since the elasticity of demand is larger in the larger market than in the smaller market, firms' demands fall more in the former than in the later, thus making the smaller market (relatively) more attractive.

Case 2 (Pure Tax Effect) We next turn to the impact of tax differences on the location of industry when the countries have the same size. Letting $\theta = 1/2$ in (17), we readily get

$$\lambda_{tax}^d = \frac{1}{2} - \frac{2a - b\tau}{cN\tau}\frac{s_H^d - s_F^d}{2 + s_H^d + s_F^d}. \tag{19}$$

Given (11), it follows from (19) that, under the destination principle with equally-sized markets, *the country with the lower tax rate hosts a larger share of the industry.* This confirms the idea that low tax rates exacerbate the home market effect, whereas high tax rates attenuate it. As can also be seen from (19), it is not just the tax differential that matters, but also, as in Case 1, the level of taxes.

The analysis of the foregoing two cases suggests that the home market effect is driven by the interplay between market sizes and tax differentials. Indeed, countries with large market size but high taxes need not necessarily attract a more than proportional share of capital. On the other hand, low taxes may exacerbate the home market effect.[10]

[10]For example, this may explain why Davis and Weinstein (1999) find empirical support for the home market effect in Japan, where the standard VAT rate of 5% is very low by international standards.

The general case, as given by (17), is more difficult to analyze because it encapsulates both the home market effect and the tax effect. Disentangling these two effects turns out to be quite a difficult task. Yet, it appears possible to derive some clear-cut comparative static results:

$$
\begin{aligned}
\operatorname{sgn}\left(\frac{\partial \lambda^d}{\partial \theta}\right) &= \operatorname{sgn}\left[2a - 2bm - b\tau - bm\left(s_H^d + s_F^d\right)\right] \\
&> 0 \\
\operatorname{sgn}\left(\frac{\partial \lambda^d}{\partial s_H^d}\right) &= -\operatorname{sgn}\left[\theta bm\left(1 + s_F^d\right) + (1-\theta)\left(2a - b\tau - bm\left(1 + s_F^d\right)\right)\right] \\
&< 0 \\
\operatorname{sgn}\left(\frac{\partial \lambda^d}{\partial s_F^d}\right) &= \operatorname{sgn}\left[(1-\theta)bm\left(1 + s_H^d\right) + \theta\left(2a - b\tau - bm\left(1 + s_H^d\right)\right)\right] \\
&> 0.
\end{aligned}
$$

These effects can be unambiguously signed on the basis of (11). As expected, an increase in market size always increases the capital share of the corresponding country, whereas the last two inequalities imply:

Proposition 4 *Under the destination principle, when a government increases its tax rate, it always loses some capital to the other country.*

Last, the impact of trade costs on the spatial allocation of capital, given by

$$
\operatorname{sgn}\left(\frac{\partial \lambda^d}{\partial \tau}\right) = \operatorname{sgn}\left[-(2\theta-1)(1+s_H^d)\left[a - b(1+s_F^d)m\right] - a\theta(s_F^d - s_H^d)\right], \quad (20)
$$

can no longer be signed unambiguously. In the no-tax case, we know that the home market effect is magnified by a decrease in trade costs. By continuity, when tax rates are sufficiently low, the impact will remain the same. Furthermore, when $s_F^d > s_H^d$, the same conclusion holds because both terms in (20) are negative. By contrast, it may change should the tax rate s_H^d be sufficiently larger than s_F^d. Indeed, for $\theta > 1/2$ and $s_H^d > s_F^d$, *lowering trade costs may decrease the capital share of the large country.* Indeed, as trade costs fall, if the larger country has higher taxes, its consumption edge is smaller so that more production may take place in the small country. Last, when countries have the same size (i.e. $\theta = 1/2$), the first term in (20) vanishes, thus implying that decreasing trade costs favor the country with higher per capita consumption.

4.3 The origin principle

Under the origin principle, the rental rate of capital in country H is given by (15) and the equilibrium allocation of capital λ^o equalizes that expression to the analogue for country F. This yields a quadratic equation in λ, whose coefficients are too involved to allow for a detailed analytical investigation. Consequently, we focus on the special case in which trade costs are negligible (formally, $\tau = 0$), while assuming markets are still segmented because consumer arbitrage is prohibitively costly.[11] The basic results obtained here then carry by continuity over to cases with small, yet non-zero, trade costs. Stated differently, the results highlighted in this section will hold when the economy has reached a sufficient degree of economic integration.

Letting $\tau = 0$, we get

$$r_H^o - r_F^o = \kappa_2\lambda^2 + \kappa_1\lambda + \kappa_0 = 0 \tag{21}$$

where

$$\begin{aligned}
\kappa_2 &\equiv -c^2N^2m^2(s_H^o - s_F^o)^3 \\
\kappa_1 &\equiv -2cNm(s_H^o - s_F^o)^2\left[2a + cNm(1+s_F^o)\right] < 0 \\
\kappa_0 &\equiv (s_H^o - s_F^o)\Big\{m^2(1+s_F^o)\left[4b(b+cN)(1+s_H^o) + c^2N^2(s_H^o - s_F^o)\right] \\
&\quad -4acNm(1+s_F^o) - 4a^2\Big\}
\end{aligned}$$

are bundles of parameters and tax rates. Note that the sign of κ_2 depends on whether H or F is the high tax country. Straightforward calculation shows that the discriminant of this expression is always strictly positive. Assume, without loss of generality, that $s_H^o < s_F^o$, i.e. F is the high tax country. Under this assumption, the two solutions of (21) are as follows:

$$\lambda^{\pm} = \frac{2a + cNm(1+s_F^o) \pm (2b+cN)m\sqrt{(1+s_H^o)(1+s_F^o)}}{cNm(s_F^o - s_H^o)} \tag{22}$$

It is readily verified that $\lambda^+ > 1$ so that this root must be ruled out as an equilibrium. Further, as shown in Appendix A, $\lambda^- > 0$, so that this root is an interior equilibrium whenever it is smaller than 1. This will be the case if and only if $s_F^o < \overline{s}(s_H^o, c) - 1$, where

$$\overline{s}(s_H^o, c) \equiv \frac{[2a + cNm(1+s_H^o)]^2}{(2b+cN)^2m^2(1+s_H^o)} > 1 \tag{23}$$

[11] Note also that the existence of a tax differential is sufficient for firms to price discriminate across national markets.

is a threshold on country F's tax rate, which depends in particular on country H's tax rate and the degree of product differentiation c. It is worth noting that λ^- does not depend on the consumer distribution θ. Therefore, even when all consumers are concentrated in country F (i.e. when $\theta = 0$), the low tax country H may still host a strictly positive share of the industry. This suffices to show that:

Proposition 5 *Under the origin principle, a reverse home market effect may arise when tax rates are sufficiently different.*

How can we explain such a result that runs against conventional wisdom in trade theory? It is a by-product of the reverse price index effect we have highlighted in Section 3. Recall that, under the origin principle, a firm that moves from the low tax to the high tax country switches from being a low cost to a high cost producer. This increases the price index in the high tax country, thus shifting up firms' demand curves there. Because the elasticity of demand decreases with an increase in the price index, firms' revenues from selling in the high tax country may actually increase, despite their higher prices. Higher revenues lead to a higher rental rate of capital, thus providing an explanation of why the high tax country may actually attract more firms. This last result, established in quite a different context, provides a neat illustration of the 'Baldwin-Krugman conjecture' that states that "we would see the high tax nation being an importer of capital" (Baldwin and Krugman, 2004, p. 19). Stated differently, we have a setting in which *raising taxes unilaterally may attract firms*, a result that runs against what is know in standard models of tax competition (see Wilson, 1999). Thus,

Proposition 6 *When economic integration is deep enough, a government may attract capital under the origin principle by raising its tax rate.*

Propositions 4 and 6 show that the way commodity taxes are collected may have a significant impact on industry location in the absence of tax harmonization, a fact that has been overlooked in the existing literature.

Straightforward comparative statics on (23) show that

$$\frac{\partial \overline{s}}{\partial s_H^o} \gtreqless 0 \qquad \Leftrightarrow \qquad 1 + s_H^o \gtreqless \frac{2a}{cNm}$$

thus revealing the existence of three different cases according to the degree of product differentiation: (i) when products are sufficiently close substitutes (i.e. $c > 2a/mN$), $\overline{s}$ is always increasing with respect to s_H^o; (ii) when products are sufficiently differentiated (i.e. $c < 2b/N$), $\overline{s}$ is always decreasing with respect to s_H^o;[12] and (iii) finally, when $c \in [2b/N, 2a/mN]$, the threshold $\overline{s}$ is first decreasing for $s_H^o \in [0, 2a/cNm - 1]$ and then increasing.

To illustrate, assume that varieties are close substitutes so that case (i) arises. Country H is the industrial core (i.e. $\lambda^o = 1$) provided that its tax rate s_H^o is sufficiently lower than s_F^o. Raising s_H^o beyond some threshold triggers a process of partial redispersion once $s_H^o < s_F^o < \overline{s}(s_H^o) - 1$ holds. This is because the rise in s_H^o increases local as well as export prices and, hence, decreases profits. Recall, indeed, that a high tax rate s_H^o is formally equivalent to a high production cost in country H as well as to a high pure profits tax. When varieties are sufficiently close substitutes, the decrease in the demand elasticity due to the increase in the price index P_H does not compensate for the negative impact of higher prices. In other words, operating profits in country H decrease, thus leading to the departure of some firms.

Assume now that varieties are poor substitutes as in case (ii). Country F may then retain some firms when its tax rate is not too large compared to that of country H. Yet, somewhat unexpectedly, when country H increases its tax rate, it may attract more firms. This is again due to the reverse price index effect. When varieties are sufficiently differentiated, the decrease in the elasticity of demand caused by the increase in the price index is large enough to compensate for the negative impact of higher prices. Stated differently, country H-firms' revenues now increase, which leads to an inflow of firms from country F. Unlike Baldwin *et al.* (2003) and Baldwin and Krugman (2004) who base their argument on agglomeration rents, *the tax-setting agent has here a direct influence on the monopoly rents captured by firms through the manipulation of their demand elasticities.* Raising taxes increases monopoly rents, which can then be taxed away. Hence, there is a positive correlation between tax rates, the degree of agglomeration, and tax revenues.

4.4 Tax harmonization

This section deals with the potential impacts of tax harmonization on the spatial distribution of industry. Without loss of generality, we may assume that initially $s_H < s_F$. A process of full tax harmonization results in a new common tax rate $s \in [s_H, s_F]$. Recall that, for equal tax rates, the distinction between the destination and origin principles is immaterial in that the

[12]This inequality comes from the assumption that trade always occurs for all firm distributions, that is, $a - bm(1 + s_H^o) > 0$.

market outcome is the same (Lockwood *et al.*, 1994).[13] Clearly, the impact of the harmonization process depends on the initial tax rates and the consumer distribution θ. First of all, observe that the spatial equilibrium that prevails after harmonization is given by (18), which is clearly a decreasing function of the common tax rate s. We can then conclude that:

Proposition 7 *Regardless of the tax principle, when taxes are harmonized, a higher common tax rate leads to a more even distribution of firms across countries, whereas a lower common tax rate exacerbates inequalities across countries.*

So, if a major objective is to promote balanced regional development, as in the EU, *harmonization should occur at the upper bound of the tax range.*

It is worth studying the impact of a country's unilateral tax rate deviation on the distribution of industry once taxes have been harmonized. Indeed, it is often argued by opponents of harmonization that setting a common tax rate deprives national governments of an important policy instrument. This in turn suggests that the potential losers from a process of harmonization may have incentives to unilaterally deviate from the common tax rate in response to national political and economic pressures. It is then of interest to examine how such a deviation may impact on the space-economy and whether the consequences vary according to the chosen tax principle. Letting $s \equiv s_H = s_F$, we have $\Delta r^d(s, \lambda) = \Delta r^o(s, \lambda)$ where $\Delta r^d \equiv r_H^d - r_F^d$ and $\Delta r^o \equiv r_H^o - r_F^o$. Thus, when $\Delta r^d = \Delta r^o = 0$, it must be that $\lambda^d = \lambda^o = \lambda(s)$ (see (18)), implying that *the two principles are also spatially equivalent in that the distribution of firms is the same.* As shown in Appendix B, this allows us to prove that:

Proposition 8 *Under harmonization, a unilateral tax decrease by a country leads to a larger capital inflow from the other country under the origin than under the destination principles.*

Hence, the incentive to deviate from harmonization is stronger under the origin principle, thus suggesting that tax harmonization is easier to sustain under the destination principle.

Finally, we know that the home market effect prevails under harmonization (see (18)), so that $\lambda > \theta$ whenever $\theta > 1/2$. The tax revenues collected under the two principles are given by

$$T_H^d = \theta N \frac{s}{1+s}\left[\lambda p_{HH} q_{HH} + (1-\lambda) p_{FH} q_{FH}\right]$$

[13] However, as discussed below, regional tax revenues and, therefore, regional welfare differ under the two principles even after harmonization.

and

$$T_H^o = \lambda N \frac{s}{1+s}\big[\theta p_{HH} q_{HH} + (1-\theta) p_{HF} q_{HF}\big].$$

Tax harmonization implies that the first terms in each bracketed expression are identical so that

$$\begin{aligned} T_H^d - T_H^o &= \frac{sN}{1+s}[\theta(1-\lambda) p_{FH} q_{FH} - \lambda(1-\theta) p_{HF} q_{HF}] \\ &= \frac{sN}{1+s}(b+cN)\Big\{\theta(1-\lambda)\left(p_{HH} - \frac{\tau}{2}\right)\left[p_{HH} - \frac{\tau}{2} - m(1+s)\right] \\ &\quad -\lambda(1-\theta)\left(p_{FF} - \frac{\tau}{2}\right)\left[p_{FF} - \frac{\tau}{2} - m(1+s)\right]\Big\}. \end{aligned}$$

Since $p_{FF} > p_{HH}$ whenever $\lambda > 1/2$, we have:

$$T_H^d \gtreqless T_H^o \qquad \Leftrightarrow \qquad \theta \lesseqgtr 1/2.$$

As shown by the foregoing argument, this result is the joint outcome of the home market effect and the competition effect.

Moreover, it is easy to show that the total tax revenue $T_H^d + T_F^d = T_H^o + T_F^o$ does not depend on the tax principle used after harmonization. Thus, the larger country is better off, and the smaller country is worse off, under the origin principle than under the destination principle. We may therefore conclude that:

Proposition 9 *Under tax harmonization, the total revenue raised in the federation does not depend on the tax principle used. Yet, smaller countries raise more tax revenue under the destination principle, whereas larger countries raise more tax revenue under the origin principle.*

Consequently, *when countries have different sizes, they always disagree on the principle to be applied once tax harmonization is enforced.* This is because larger countries produce a more than proportional share of total output in the presence of the home market effect, which implies that they raise more revenue under a production tax than under a consumption tax. Thus, Proposition 9 might explain why the harmonization of commodity taxes is so difficult to implement in a federation in reality (European Commission, 2000).

Finally, under the destination principle, it is worth noting that per capita tax revenue is higher in the larger country. So, even if this principle were established, small countries would still prefer to set higher rates.

5 Concluding remarks

Our first objective was to study the impact of national-level taxation in a model of trade within a federation and to compare the market outcomes under the origin and destination principles. As in the no-tax case, under the origin principle the country with more producers has always lower prices, whereas this need not hold under the destination principle. We have shown that the origin and destination principles are not equivalent in this model with segmented markets.

We have further analyzed the effects of taxes on the spatial distribution of the industry. Under the destination principle, a tax increase always generates an outflow of firms, but this does not always hold under the origin principle. The choice of a specific principle is thus likely to have *major long run implications regarding the spatial pattern of a federation of countries like the EU.*

Our secondary purpose was to assess the implications of tax harmonization. There are some widespread beliefs that tax harmonization should favor the law of a single price. In our spatial model, tax harmonization does not eliminate price differences. Harmonizing at the low end of pre-existing tax rates exacerbates inequalities across members of the federation. In addition, we find that small countries raise more revenue under the destination principle. The spatial distribution of industry is also more sensitive to tax rate differentials under the origin principle. These two sources of conflict between countries of different sizes in the choice of a tax principle suggests that *settling on a definitive tax regime may be out of reach.*

One reason for the break down of the previous consensus in the EU on the origin principle is the growth of e-commerce and the problems it creates for tax administrations. Our results uncover some difficulties in moving to an origin system. In the US, the formal destination-based system is threatened by widespread use tax evasion. A move to origin-based taxation would solve the evasion problem but the transition would yield winners and losers. Therefore, we do not anticipate any resolution of these issues on either side of the Atlantic in the coming years.

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Appendix A: Existence of a positive root

When $\lambda^- < 0$, it must be that

$$\frac{[2a + cNm(1 + s_F^o)]^2}{m^2(2b + cN)^2(1 + s_F^o)} < 1 + s_H^o < 1 + s_F^o$$

because $s_H^o < s_F^o$. This condition may be rewritten as

$$\frac{a}{bm}[a + cNm(1 + s_F^o)] < (b + cN)m(1 + s_F^o)^2. \tag{24}$$

Using (11), we also have $bm(1 + s_F) < a$, which implies together with (24) that

$$(1 + s_F^o)[a + cNm(1 + s_F^o)] < (b + cN)m(1 + s_F^o)^2.$$

Thus, $a < bm(1 + s_F^o)$, a contradiction.

Appendix B: Proof of Proposition 8

Under harmonization, we have $\lambda^d = \lambda^o = \lambda(s)$. Then, the implicit function theorem gives

$$\left.\frac{\partial \lambda^d}{\partial s_H^d}\right|_{s_H^d = s_F^d = s} - \left.\frac{\partial \lambda^o}{\partial s_H^o}\right|_{s_H^o = s_F^o = s} = -\frac{\left[\frac{\partial \Delta r^d}{\partial s_H^d} - \frac{\partial \Delta r^o}{\partial s_H^o}\right]}{\frac{\partial \Delta r^d}{\partial \lambda}}$$

where all derivatives are evaluated at s and $\lambda(s)$. As shown in Section 4.1, $\partial\lambda(s)/\partial s_H^d < 0$ holds. Because Δr^d is linear and decreasing in λ, we have $\partial \Delta r^d/\partial\lambda < 0$. Therefore, it must be that

$$\left.\frac{\partial \lambda^o}{\partial s_H^o}\right|_{s_H^o = s_F^o = s} < \left.\frac{\partial \lambda^d}{\partial s_H^d}\right|_{s_H^d = s_F^d = s} < 0 \qquad \text{iff} \qquad \frac{\partial \Delta r^d}{\partial s_H^d} - \frac{\partial \Delta r^o}{\partial s_H^o} > 0.$$

Using (12) and (15), we obtain

$$\begin{aligned}
\Delta r^d \quad \equiv \quad & r_H^d - r_F^d = \frac{b + cN}{\phi\left(1 + s_H^d\right)\left(1 + s_F^d\right)}\left[\left(1 + s_F^d\right)\theta\left(p_{HH}^d - m(1 + s_H^d)\right)^2\right. \\
& +(1 + s_H^d)(1 - \theta)\left(p_{HF}^d - m(1 + s_F^d)\right)^2 - \left(1 + s_F^d\right)\theta\left(p_{FH}^d - m(1 + s_H^d)\right)^2 \\
& \left. - \left(1 + s_H^d\right)(1 - \theta)\left(p_{FF}^d - m(1 + s_F^d)\right)^2\right]
\end{aligned}$$

while

$$
\begin{aligned}
\Delta r^o \quad \equiv \quad & r_H^o - r_F^o = \frac{b+cN}{\phi\left(1+s_H^o\right)\left(1+s_F^o\right)}\Big[\left(1+s_F^o\right)\theta\left(p_{HH}^o - m(1+s_H^o)\right)^2 \\
& + \left(1+s_F^o\right)(1-\theta)\left(p_{HF}^o - m(1+s_H^o)\right)^2 - \left(1+s_H^o\right)\theta\left(p_{FH}^o - m(1+s_F^o)\right)^2 \\
& - \left(1+s_H^o\right)(1-\theta)\left(p_{FF}^o - m(1+s_F^o)\right)^2\Big].
\end{aligned}
$$

Differentiating Δr^d with respect to s_H^d, evaluating it at $s_H^d = s_F^d = s$ and $\lambda^d = \lambda^o = \lambda(s)$, and using

$$
\frac{\partial p_{HH}^d}{\partial s_H^d} = \frac{\partial p_{FH}^d}{\partial s_H^d} = \frac{(b+cN)\,m}{2b+cN}
$$

as well as

$$
\frac{\partial p_{HF}^d}{\partial s_H^d} = \frac{\partial p_{FF}^d}{\partial s_H^d} = 0
$$

we get

$$
\begin{aligned}
\frac{\partial \Delta r^d}{\partial s_H^d} \quad = \quad & \frac{b+cN}{\phi\,(1+s)^2}\Big\{-2\frac{bm}{2b+cN}(1+s)\,\theta\left[p_{HH}^d - m(1+s)\right] \\
& +(1-\theta)\left[p_{HF}^d - m(1+s)\right]^2 - (1-\theta)\left[p_{FF}^d - m(1+s)\right]^2 \\
& + \frac{bm}{2b+cN}2\,(1+s)\,\theta\left[p_{FH}^d - m(1+s)\right]\Big\}.
\end{aligned}
$$

Similarly, using

$$
\frac{\partial p_{HH}^o}{\partial s_H^o} = \frac{\partial p_{HF}^o}{\partial s_H^o} = \frac{2m(b+cN) - c(1-\lambda(s))Nm}{2(2b+cN)}
$$

and

$$
\frac{\partial p_{FH}^o}{\partial s_H^o} = \frac{\partial p_{FF}^o}{\partial s_H^o} = \frac{c\lambda(s)Nm}{2(2b+cN)}
$$

we obtain

$$
\begin{aligned}
\frac{\partial \Delta r^o}{\partial s_H^o} \quad = \quad & \frac{b+cN}{\phi\,(1+s)^2}\Big\{-\frac{2bm + c(1-\lambda(s))Nm}{2b+cN}(1+s)\,\theta\left[p_{HH}^o - m(1+s)\right] \\
& -\frac{2bm + c(1-\lambda(s))Nm}{2b+cN}(1+s)(1-\theta)\left[p_{HF}^o - m(1+s)\right] \\
& -\theta\left[p_{FH}^o - m(1+s)\right]^2 - \frac{c\lambda(s)Nm}{2b+cN}(1+s)\,\theta\left[p_{FH}^o - m(1+s)\right] \\
& -(1-\theta)\left[p_{FF}^o - m(1+s)\right]^2 \\
& -\frac{c\lambda(s)Nm}{2b+cN}(1+s)(1-\theta)\left[p_{FF}^o - m(1+s)\right]\Big\}.
\end{aligned}
$$

Putting everything over a common denominator and noting that at equal taxes (and at $\lambda(s)$) $p_{ii} \equiv p_{ii}^{d} = p_{ii}^{o}$ and $p_{ij} \equiv p_{ij}^{d} = p_{ij}^{o}$ for $i = H, F$, we obtain:

$$
\begin{aligned}
\frac{\partial \Delta r^{d}}{\partial s_{H}^{d}} - \frac{\partial \Delta r^{o}}{\partial s_{H}^{o}} = \; & \frac{b + cN}{\phi \left(1+s\right)^{2} \left(2b + cN\right)} \Big\{ c(1-\lambda) Nm \left(1+s\right) \theta \big[p_{ii} - m(1+s)\big] \\
& + \left(2b + cN\right) \left(1-\theta\right) \big[p_{ij} - m(1+s_{j})\big]^{2} \\
& + \left(2b + cN\right) \theta \big[p_{ji} - m(1+s)\big]^{2} \\
& + \left(1+s\right) \left(1-\theta\right) \big[p_{ij} - m(1+s)\big] \big[2bm + c(1-\lambda(s)) Nm\big] \\
& + \left(2bm + c\lambda(s) Nm\right) \left(1+s\right) \theta \left[p_{ji} - m(1+s)\right] \\
& + c\lambda(s) Nm \left(1+s\right) \left(1-\theta\right) \big[p_{jj} - m(1+s)\big] \Big\}.
\end{aligned}
$$

As each term is positive, we finally conclude that

$$
\frac{\partial \Delta r^{d}}{\partial s_{H}^{d}} - \frac{\partial \Delta r^{o}}{\partial s_{H}^{o}} > 0.
$$