Tax Competition and Tax Co-Ordination Under Destination and Origin Principles: A Synthesis[*]

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Abstract

This paper proposes a general framework for analysing commodity tax competition under destination and origin principles, based on three possible tax spillovers, the consumer price spillover, the producer price/terms of trade spillover, and rent spillovers. A model is presented which can be extended to accommodate all three spillovers. Using this model, many of the results in the existing literature can be derived, compared, and extended.

Keywords: tax competition, tax reform, destination and origin principles

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1. Introduction

The literature on the destination and origin principles of commodity taxation has expanded enormously in recent years, along with an increase of interest in the economics of tax competition more generally. This increased interest is partly due to developments within the EU, such as the completion of the single market and EMU, which have made tax di¤erences between countries clearer and more important to consumers and …rms, but also to the reduction of trade barriers more generally. One can identify three di¤erent branches of this literature. The the earliest branch compares destination and origin principles at …xed tax rates, and has grown considerably since the important paper of Shibata(1967). For example, there are contributions by Whalley(1980), Grossman(1980), Georgakopoulos and Hitiris (1991), (1992), Bovenberg(1994), Lockwood, de Meza and Myles(1994), Lockwood, de Meza and Myles(1994a),Hau‡er and Nielsen(1997). Two papers extend this explicit comparison to the case where for each principle, taxes are endogenously determined in non-cooperative Nash equilibrium [Lockwood(1993), Keen and Lahiri (1998)].

The second branch, initiated by the seminal paper of Mintz and Tulkens(1986), may be called the literature on commodity tax competition. These papers characterize Nash equilibrium in origin-based taxes in a class of models where consumers can cross-border shop at a cost, and include Crombrugghe and Tulkens(1990), Kanbur and Keen(1993), Trandel(1994), Hau‡er(1996), (1998), and Nielsen(1998). These papers also study welfare- and Pareto-improving tax reforms in these settings.

A third branch of the literature studies the welfare properties of a particular form of tax reform, tax harmonization. The formal literature in this area was initiated by Keen(1987),(1989), and subsequent papers include Keen and Lahiri(1993), Lopez-Garcia(1996), Delipalla(1997), Lockwood(1997), Lopez-Garcia (1996), (1997), Lahiri and Raimondos(1998), Lahiri, Keen and Raimondos(1998). Most of this literature deals with destination-based taxes, but Lopez-Garcia (1996) studies harmonization of origin-based taxes, and this issue is also brie‡y addressed in Kanbur and Keen(1993).

Despite the research e¤ort that has been expended in the last decade, it is not clear that this literature has yielded general or robust insights. One problem here is that the models used in the various papers have been extremely diverse, and some of them have been rather complex, especially those where cross-border shopping costs have been modelled. The obvious contrast here is with the even larger literature on capital tax competition, where the simplicity and flexibility of the original Wilson-Zodrow-Miezowski model of tax competition [Wilson(1986), Zodrow-Miezowski(1986)] has lead to a situation where most researchers use this model as a vehicle for their analysis, and consequently, their results can be more easily contrasted and compared that in the commodity tax case.

Two particular problems are the following. First, the models of tax competition typically assume a homogenous commodity produced in both countries, whereas the literature on tax harmonization assumes differentiated commodities, and generally the structure of preferences over commodities is crucial in determining whether Pareto-improving tax reforms exist (Keen(1989), Lockwood(1997)). Second, tax competition models (especially Mintz and Tulkens(1986)) are made complex by the fact that transport costs are explicitly modelled (and consequently the models are highly simplified in other respects), whereas the otherwise much more general models used in the tax harmonization sub-literature abstract from transport costs.

The purpose of this paper is two-fold. First, we will argue that the results in the existing literature can be interpreted by reference to three basic tax spillovers that can arise when countries are linked by international trade and production; consumer price spillovers, producer price/terms of trade spillovers, and rent spillovers. A consumer price spillover arises when the price that a consumer pays in the home country changes directly (i.e. at fixed producer prices) following a change in a foreign commodity tax. A producer price spillover arises when producer prices change following a change in a foreign commodity tax. A rent spillover arises when the pure profit (rent) from production accruing to the home country changes following a change in a foreign commodity tax.

Second, I will present a model that is simple and flexible enough so that these three spillovers can be modelled by changing the assumptions about factor mobility and price-setting in the model. An analysis of this model allows us to generate, compare and extend many of the results in the literature, and crucially, isolate special assumptions in some of the models that are required for some results. This allows some reasonably robust conclusions that can form the basis for policy recommendations (See Section 6).

Almost all the models in the papers referred to above assume two countries[1],

[1] There is a literature on the restricted origin principle (see e.g. Lockwood de Meza and Myles(1994a) and the references therein) which considers the choice between destination and origin principles (at fixed tax rates), where taxes on goods that are traded with the rest of the world are destination-based. This literature is beyond the scope of the synthesis presented here.

with an identical agent in each country. The main additional simplifying features of the model of this paper are:

- no transport costs
- two traded goods[2]
- Ricardian production technology; one factor of production, constant returns to scale
- countries are symmetric[3].

These features can be defended as follows. It will be argued in this paper that what is crucial for the destination and origin principles is how tax spillovers operate (if at all) under the two principles. None of the above assumptions closes down any of these three spillover effects. On the other hand, the assumptions of perfect factor mobility (often made, explicitly or implicitly), and perfect competition (made in all the literature except Keen and Lahiri (1993),(1998)) close down the producer price and rent externalities respectively. This model can easily accommodate perfect or imperfect competition, and immobile or mobile factors of production. It is of course an issue to what extent the specific results of this paper depend on these four assumptions, and this issue is discussed in Section 7.2 below; some of the results are quite robust.

It should be noted that the identification of these spillovers is not new; the consumer price and producer price spillovers are discussed in the well-known paper of Gordon(1983), albeit under different names[4]. Mintz and Tulkens(1986) discuss at length the "private consumption" and "public consumption" spillovers, which I have aggregated into the consumer price spillover[5]. What is new in this paper is

[2] In the variant of the model where we allow for imperfect competition, there are n varieties of each good.

[3] That is, the two countries have identical preferences and production technologies given a permutation of the two traded goods.

[4] The consumer and producer price spillovers correspond to the externalities (1) and (6) on the list on page 580 of Gordon's paper.

[5] Mintz and Tulkens (1986), distinguish between the impact of another country's tax change on domestic tax revenue, which they call the "public consumption effect", and on domestic household utility, which they call the "private consumption effect". This classification emphasizes the distributional effects (public vs. private) of tax spillovers. My defense of my own classification of spillovers relative to Mintz-Tulkens (MT), is that mine captures a key difference between destination and origin taxation (namely, consumer price spillovers only occur with ori-

the systematic attempt to integrate a diverse literature using these spillovers as organizing principles.

The layout of the rest of the paper is as follows. A basic model, in which only consumer price externalities are present, is presented in section 2. Also in that section, Nash equilibrium in taxes under destination and origin principles, and welfare-improving tax reforms starting from that equilibrium, are characterized. In section 3, the assumption of factor mobility is dropped; this has the effect of introducing producer price externalities. Again, Nash equilibrium in taxes under destination and origin principles, and welfare-improving tax reforms starting from that equilibrium, are characterized. Section 4 has the same structure as Section 3, except that the assumption of perfect competition is dropped, generating rent spillovers. Section 5 studies tax harmonization, and Section 6 compares destination and origin principles directly by comparing equilibrium tax rates and welfare levels in the two regimes.

The main results of the paper are summarized in the Table below. In the first column, three permutations of the two key assumptions (factor mobility, nature of product market competition) are given.

Table 1 in here

Each of these permutations gives rise to one or more of the basic spillovers, either in the destination (D) case, or the origin (O) case. In each of the three cases, results about tax reform, tax harmonization and global comparisons of destination and origin principles are given.

Looking across the different types of spillover, it can be seen that some quite general themes emerge, which have not yet been noted in the literature. First, in the destination case, tax reforms that lower (resp. raise) taxes on imports (resp. exports) are generally desirable. Second, the conventional wisdom that taxes are too low in origin-based tax equilibrium (and should therefore be raised) is only true if goods are sufficiently strong substitutes. Finally, some very simple conditions for tax harmonization to be desirable emerge; namely, whenever a good is taxed more heavily by the importer than by the exporter. It is particularly striking that this conclusions hold both in the case with an endogenous terms of trade (producer price externalities) and with imperfect competition (rent externalities). The policy implications of these robust findings are discussed in Section 7 below.

gin taxation, whereas the other two spillovers occur with both), whereas private consumption and public consumption spillovers occur with both origin- and destination-based taxation.

2. The Basic Model

2.1. Preliminaries

There are two countries $i = a, b$ each of which produces only a single commodity[6] from a single input, labor, using a constant-returns technology. Country a produces good 1, and country b good 2. We choose units so that one unit of labor produces one unit of the commodity in each country. Each country can also produce a public good, with again one unit of labor producing one unit of the public good in each country. There are no public good spillovers between countries.

Each country is populated by a number of identical individuals, with population normalized to unity. Every agent in i is endowed with one unit of leisure, and has preferences

$$u^i = u(X^i, l^i) + h(g^i) \tag{2.1}$$

where l^i and g^i are the levels of leisure and the public good consumed in country i. Also, X^i is the level of an aggregate consumption index (or sub-utility function) in country i which can be written

$$X^i = \left[0.5(x_1^i)^{\frac{\sigma-1}{\sigma}} + 0.5(x_2^i)^{\frac{\sigma-1}{\sigma}}\right]^{\frac{\sigma}{\sigma-1}}$$

where x_1^i, x_2^i are the consumption levels of goods 1 and 2 respectively in country i, and $\sigma > 0$ is the elasticity of substitution. We assume that u is strictly quasi-concave and strictly increasing in both arguments, and h is strictly increasing and concave in g^i.

We now state three key assumptions.

A0. Both consumers and firms face zero transport costs.

A1. Labor is perfectly internationally mobile.

A2. Firms are price-takers.

Under these three assumptions, only consumer price spillovers are operative. Specifically, assumption A0 implies that with origin-based taxation, consumers can costlessly cross-border shop, and so consumer price externalities are operative in this case. Assumption A1 implies that the wage in both countries is the same, and we set this common wage equal to unity. As the wage is equal to the

[6] The assumption of complete specialization at all producer prices is just made for presentational convenience, and could be relaxed.

producer price, the producer price of either good is also fixed at unity, and so there are no producer price spillovers unless A1 is relaxed. Assumption A2 plus the assumptions on technology implies that pure profits are zero, and so there are no rent spillovers unless A2 is relaxed.

Assumption A1 deserves further comment. It does not imply that households are mobile - otherwise, the equilibrium condition would be that utilities of representative households would be equal in the two countries - but that wage-earners can "commute" costlessly to work in the foreign country. There is no claim that this assumption is in any way realistic. Rather, it is the assumption also made in the seminal paper of Mintz and Tulkens(1986), and so facilitates comparison with that paper, and also is analytically the cleanest way of fixing producer prices exogenously.

Let q_j^i be the consumer price[7] of good j in country i. So, given A0-A2, we may write the budget constraint of the consumer in i as

$$q_1^i x_1^i + q_2^i x_2^i + l^i = y^i$$

where y^i is the full income of the resident of i; equal to 1 in the base model (i.e. the leisure endowment times the wage of unity). Standard two-stage budgeting arguments imply that the demand for good j is

$$x_j^i = \left[\frac{q_j^i}{Q^i}\right]^{-\sigma} X(Q^i, y^i)$$

where $Q^i = [0.5(q_1^i)^{1-\sigma} + 0.5(q_2^i)^{1-\sigma}]^{\frac{1}{1-\sigma}}$ is the CES price index, and $X(Q^i, y^i)$ is demand for aggregate consumption as a function of Q^i and full income of unity.

For future reference, note that for either country, when prices are equal ($q_1^i = q_2^i$), own and cross price elasticities are

$$\varepsilon_{own} = \frac{q_j}{x_j}\frac{\partial x_j}{\partial q_j} = -\frac{1}{2}[\sigma + \varepsilon] < 0 \tag{2.2}$$

$$\varepsilon_{cross} = \frac{q_k}{x_j}\frac{\partial x_j}{\partial q_k} = \frac{1}{2}[\sigma - \varepsilon], \; k \neq j \tag{2.3}$$

where $\varepsilon = \frac{Q}{X}\frac{\partial X}{\partial Q}$ is the aggregate elasticity of demand for goods. So, the two goods are substitutes if $\sigma > \varepsilon$. Note also that while σ is a constant, ε will generally vary

[7] This is the price inclusive of tax, either origin- or destination-based. Also, we assume as is usual in the optimal commodity tax literature, that labour income is not taxed. It is well-known that this is without loss of generality.

with the value of Q. Moreover, indirect utility over the two goods and leisure may be written

$$v^i = v(q_1^i, q_2^i, y^i) \tag{2.4}$$

where $\partial v^i/\partial y^i = \lambda^i$ is the marginal utility of income for the household in country i, and $\partial v^i/\partial q_j^i = -\lambda^i x_j^i$, $i = a, b$, $j = 1, 2$. Also, for future reference, define $\eta^i = h'(g^i)$ to be the marginal benefit of public funds - i.e. the household's marginal utility of the public good - in country i.

Following the literature, we allow government to have two possible objectives. The first possibility is that the government is welfaristic, in which case it maximizes $v^i + h(g^i)$. The second is that it is a Leviathan, in which case it maximizes tax revenue g^i. A convenient way of dealing with these two cases is to write a more general objective

$$\Omega^i(\beta) = \beta v(q_1^i, q_2^i, y^i) + h(g^i) \tag{2.5}$$

Then, the welfaristic government maximizes $\Omega(1)$ and the Leviathan maximizes $\Omega(0) = h(g^i)$ which is equivalent to maximizing g^i itself.

A key focus of the following analysis will be on "Pareto-improving" tax reforms, starting from Nash equilibrium taxes. By "Pareto-improving", we mean that the reform increases the objective function Ω^i of each government. So, such reforms are Pareto-improving in the conventional sense (i.e. increasing the welfare of the representative agent in both countries) only in the welfaristic case ($\beta = 1$).

In choosing taxes, the government respects the non-negativity constraint that $g^i \geq 0$. We will also assume:

A3. $\sigma > 1$, $\varepsilon > 1$, all Q

This assumption ensures that equilibrium taxes are well-defined i.e. that tax bases are not too inelastic, and we assume it holds throughout. We also make one of two alternative assumptions on h. The first is that the government wishes to raise a positive amount of revenue i.e. the marginal benefit of the public good at $g = 0$ exceeds the cost ($h'(0) > \partial v(1, 1, 1)/\partial y$, where the latter is the marginal cost of public funds when $g^i = 0$). This assumption rules out a corner solution for g^i. However, a number of papers (especially Keen(1987), (1989), Keen and Lahiri(1993), (1998)) abstract from public good provision and suppose that all tax revenue is returned as a lump-sum to the consumer. This case can be captured in our model by assuming that $h' \equiv \partial v/\partial y$. To distinguish these cases, we refer to the first as the case with a positive revenue requirement and the second as the case with a zero revenue requirement.

This basic model is quite close[8] to the model of Mintz and Tulkens(1986). The main[9] differences are; (i) we have relaxed their assumption that the goods produced in the two countries are perfect substitutes in consumption; (ii) we have assumed zero transport costs for consumers.

It is a claim of this paper (to be demonstrated below) that it is the degree of substitution between the two goods, rather than the presence of transport costs, that is crucial for the sign of key spillover effects in the model. Moreover, elimination of transport costs does away with the corner solutions for cross-border shopping that induce discontinuities in reaction functions and make characterization of Nash equilibrium complex.

2.2. Destination-Based Taxes

Here, each country levies a tax on each good[10] consumed by any of its residents. Moreover, the producer price of any good is unity, so

$$q_j^i = 1 + t_j^i \tag{2.6}$$

Also, the government budget constraint in country i can be written

$$g^i = t_1^i x_1^i + t_2^i x_2^i \tag{2.7}$$

Combining (2.5), (2.6) and (2.7) we can write the objective of the government of country i as

$$\Omega^i = \beta v(1 + t_1^i, 1 + t_2^i, 1) + h(t_1^i x_1^i + t_2^i x_2^i) \tag{2.8}$$

Note first that Ω^a is independent of b's taxes, and vice versa i.e. there are no tax spillovers of any kind. Consequently, each country solves a standard Ramsey optimal tax problem independently of the other (i.e. to maximise Ω^i with respect

[8] There are also similarities to Kanbur and Keen(1993) and Haufler(1996). Kanbur and Keen present their model as partial equilibrium, but it can be interpreted as a general equilibrium model where the import of the consumption good in the high-tax country (due to cross-border shopping) is matched by an export of a mobile factor of production. Haufler(1996) has a general equilibrium model with trade in one good (cross hauling), where consumers in the high-tax country import the good, and it is simultaneously exported by producers in the high-tax country, so there is no internationally mobile factor of production.

[9] A third difference is that I assume additive separability between X, l on the one hand and g on the other, but this is not crucial, and is done simply to ease the exposition.

[10] In practice, levying this tax on imports requires border tax adjustments, which will incur administrative costs - these costs are abstracted from in this paper.

to $t_1^i; t_2^i$) and the unique Nash equilibrium in taxes is simply a list of these optimal taxes for each country[11]. It follows immediately that the Nash equilibrium will be second-best efficient. We record this well-known fact formally for convenience;

Proposition 2.1. With perfect factor mobility, perfect competition in product markets, and destination-based taxes, there are no tax spillovers. Consequently, the Nash equilibrium in taxes is second-best efficient.

2.3. Origin-Based Taxes

Here, as taxes are imposed in the country of origin, each country has effectively only one tax instrument, the tax rate on the good it produces. This is an consequence of the complete specialization in production, which in turn is due to our "Ricardian" assumptions on production technology. So, to lighten notation slightly, we set $t_1^a = t_1; t_2^b = t_2$: Then; consumer prices are the same across countries;

$$q_1^i = 1 + t_1;\ q_2^i = 1 + t_2,\ i = a; b \tag{2.9}$$

As the tax base is now the value of production, rather than consumption, the government budget constraint of country a is now[12]

$$g^a = t_1[x_1^a + x_1^b] \tag{2.10}$$

So, combining (2.5),(2.9),(2.10), the government objective as a function of the two tax rates can now be written as

$$\Omega^a = \beta v(1 + t_1; 1 + t_2; 1) + h\left[t_1(x_1^a + x_1^b)\right] \tag{2.11}$$

Note that now there is a consumer price spillover, as t_2; which is set by country b, directly affects the price that the household in country a pays for good 2. Formally;

$$\frac{\partial \Omega^a}{\partial t_2} = \frac{\partial \Omega^a}{\partial q_2}\frac{\partial q_2}{\partial t_2}$$

[11] Note that due to the symmetry of the model, at the solution to the Ramsey tax problem, $t_1^a = t_2^b; t_2^a = t_1^b$ i.e. the Nash equilibrium is symmetric. These Nash equilibrium taxes are derived explicitly in Section 6 below.

[12] Due to the symmetry of the model, we need only analyse the spillovers from country b to country a:

Noting that $\partial q_2/\partial t_2 = 1$ from (2.9), and calculating $\partial \Omega^a/\partial q_2$ explicitly from (2.11), and using the properties of the indirect utility function v^a given above, we get

$$\frac{\partial \Omega^a}{\partial t_2} = -\beta \lambda^a x_2^a + \tau^a t_1 \left[\frac{\partial x_1^a}{\partial q_2} + \frac{\partial x_1^b}{\partial q_2} \right] \tag{2.12}$$

We wish to identify desirable tax reforms starting from the symmetric Nash equilibrium $t_1 = t_2 = t$; which is characterized in Section 6 below. So, it is convenient to evaluate this spillover effect at the symmetric Nash equilibrium where $\lambda^i = \lambda$, $\tau^i = \tau$; $x_j^i = x$; $q_2 = 1 + t$: Rearranging (2.12) we get

$$\begin{aligned} \frac{1}{x}\frac{\partial \Omega^a}{\partial t_2} &= -\beta \lambda + \tau \frac{t}{1+t} \left[\frac{q_2}{x_1^a}\frac{\partial x_1^a}{\partial q_2} + \frac{q_2}{x_1^b}\frac{\partial x_1^b}{\partial q_2} \right] \\ &= -\beta \lambda + \tau \frac{t}{1+t}(\varepsilon_{cross} + \varepsilon_{cross}) \\ &= -\beta \lambda + \tau \frac{t}{1+t}[\sigma - \varepsilon] \end{aligned} \tag{2.13}$$

where in the third line we have used (2.3).

Following Mintz and Tulkens, we can decompose the consumer price spillover (2.13) as follows. The first part, measured by $-\beta\lambda$; is the private consumption effect. This captures the fact that when t_2 is raised, good 2 becomes more expensive for residents of a. The private consumption effect is clearly always negative.

The second, effect, measured by $\tau \frac{t}{1+t}[\sigma - \varepsilon]$; is the public consumption effect. This is the effect of an increase in t_2 via q_2 on country a's tax base, and thus ultimately on country a's supply of the public good. In Mintz and Tulkens, this effect is positive i.e. an increase in t_2 always boosts country a's tax base if the transactions cost of cross-border shopping is not too convex in the quantity bought[13]. The intuition for this is that (absent transport costs), the two goods in the Mintz-Tulkens model are perfect substitutes in consumption. For σ high enough in our model, we see that public consumption effect will indeed be positive.

However, our more general set-up allows the public consumption effect to be negative. Specifically, this will occur if the two goods are complements, which in turn occurs if the elasticity of substitution is less than the elasticity of aggregate consumption demand i.e. $\sigma < \varepsilon$:

So, this gives us a number of alternative possibilities about the desirable direction of tax reform, the first two of which follow directly from (2.13), and the

[13] This follows from formula (9) in Haufler(1997).

last of which follows by combining (2.13) with an explicit formula for t obtained in Section 6 below, (6.6).

Proposition 2.2. With perfect factor mobility, perfect competition in product markets, and origin-based taxes, starting from the Nash equilibrium, the following tax reforms are strictly Pareto-improving. (i) If governments are Leviathans, a small increase (decrease) in both taxes if the two goods are substitutes (complements). (ii) If governments are welfaristic, and the two goods are complements, a small decrease in both taxes. (iii) If governments are welfaristic, and the two goods are substitutes, a small increase (decrease) in both taxes as $\sigma > (<)\ \underline{\sigma}$; where $\underline{\sigma} = \eta\varepsilon/(\eta - \lambda) > 0$.

Proof. Statement (i) follows immediately from the fact that if $\beta = 0$, only the public consumption effect matters. Statement (ii) follows from the fact that if goods are complements, both spillover effects are negative, so a strict Pareto-improvement requires both taxes to be reduced. Part (iii) is demonstrated as follows. Note that combining (6.6) and (2.13), we get

$$\begin{aligned} \frac{1}{x}\frac{\partial \Omega^a}{\partial t_2} &= -\lambda + \eta\left(\frac{2\eta - \lambda}{\eta}\right)\frac{(\sigma - \varepsilon)}{\sigma + \varepsilon} \\ &= \frac{2}{\sigma + \varepsilon}\left[(\sigma - \varepsilon)\eta - \sigma\lambda\right] \end{aligned} \tag{2.14}$$

By assumption, as goods are substitutes, $\sigma - \varepsilon > 0$. So, from (2.14),

$$\frac{\partial \Omega^a}{\partial t_2} \gtreqless 0 \iff \frac{\eta}{\lambda} \gtreqless \frac{\sigma}{\sigma - \varepsilon} \iff \frac{\sigma}{\varepsilon} \gtreqless \frac{\eta}{\eta - \lambda}$$

Part (iii) then follows directly from these last inequalities. Also, $\eta - \lambda > 0$ from (6.6). ∎

2.4. Related Literature

The relation of these results to the literature is as follows. First, Crombrugghe and Tulkens (1990) show that in the Mintz and Tulkens model, starting at Nash equilibrium, and under some regularity conditions[14], an increase in the commodity

[14] The regularity condition required is that the high-tax country welfare be concave in the tax of the other region. Haufler(1998) shows that this condition is not general, in the sense that it cannot hold when the elasticity of marginal transport cost with respect to the volume of cross-border shopping is sufficiently high.

tax by both countries is Pareto-improving. Recalling that (absent transport costs) the Mintz and Tulkens model is a special case of ours with $\sigma = 1$, we see from Proposition 2, that with σ large, and welfaristic governments, an increase in both taxes is welfare-improving. So, our result is certainly consistent with Mintz and Tulkens(1986) and Crombrugghe and Tulkens (1990). Moreover, an increase in the commodity tax by both countries is always Pareto-improving in the Kanbur-Keen model[15], as it is in Nielsen's variant of this model [Nielsen(1998), result 5]. Again, this is consistent with our result, bearing in mind that in the Kanbur-Keen model, government is a Leviathan, and absent transport costs, goods produced in the two countries are perfect substitutes. In Haufler's model, a similar result is proved (Proposition 3).

Proposition 2 above makes the novel point, therefore, that (in the case of welfaristic governments), if different goods are produced in both countries, tax increases are Pareto-improving only if the two goods are sufficiently strong substitutes.

3. Factor Immobility and Producer Price Spillovers

We now drop the strong assumption that the factor of production (labor) is costlessly mobile. So, the relative wage (which is also the relative producer price of the two goods) must adjust to ensure that trade balances between the two countries. As import demands are affected by taxes, a change in a tax in country a can now impact country b via a change in the equilibrium relative producer price[16]. We refer to these spillovers as producer price spillovers[17]. These spillovers are conceptually identical to the spillover effects of tariffs in models of tariff wars (on the latter, see Kennan and Riezman(1988), McMillan(1986)).

To analyze these spillovers, we choose country a's wage as the numeraire. So, noting that wages in the two countries are also producer prices of the two goods, we have

$$p_1 = 1; \; p_2 = p$$

[15] This is not proved, but is obvious by inspection of equations (4a), (4b) in their paper.

[16] It follows this argument that when choosing its taxes, each country can manipulate the terms of trade to its advantage, so the tax functions like a tariff. This point was noted long ago by Friedlander and Vandendorpe(1968).

[17] An alternative name would be terms of trade spillovers.

Note that the terms of trade (producer price of the exported good relative to imported good) is $1/p$ for country a, and p for country b.

3.1. Destination-Based Taxes

Here, each country levies a tax on each good consumed by any of its residents. So, consumer prices[18] are

$$q_1^i = 1 + t_1^i,\ q_2^i = p(1 + t_2^i) \tag{3.1}$$

Also, while the full income of the consumer in country a is still unity, the full income of the consumer in country b is now p. Consequently, we may write commodity demands in each country as

$$
\begin{aligned}
x_j^a &= x_j^a(1 + t_1^a,\ p(1 + t_2^a), 1);\ j = 1, 2 && (3.2)\\
x_j^b &= x_j^b(1 + t_1^b, p(1 + t_2^b), p) = x_j^b\left(\frac{1 + t_1^b}{p},\ 1 + t_2^b, 1\right);\ j = 1, 2 && (3.3)
\end{aligned}
$$

where in the second line, we have multiplied each argument of the demand function by $1/p$ and used the fact that the demand function is homogenous of degree zero in prices and income.

Now p is determined by the trade balance condition that the value of exports (at producer prices) equals the value of imports i.e. $x_1^b = px_2^a$. Writing this in full, using (3.2), (3.3), we get

$$x_1^b\left(\frac{1 + t_1^b}{p},\ 1 + t_2^b, 1\right) = px_2^a(1 + t_1^a,\ p(1 + t_2^a), 1) \tag{3.4}$$

So, the spillover effect from b to a in this setting is that a change in (say) t_j^b changes p, and impacts on the welfare or tax revenue of country a i.e. there is a producer price spillover. In particular, one can calculate from (3.4) that;

$$
\begin{aligned}
\frac{\partial p}{\partial t_1^b} &= -\frac{(\partial x_1^b/\partial q_1^b)}{pD} && (3.5)\\
\frac{\partial p}{\partial t_2^b} &= -\frac{(\partial x_2^b/\partial q_1^b)}{D} && (3.6)
\end{aligned}
$$

[18] We assume for analytical convenience that taxes are ad valorem; however, the qualitative features of the spillover effects would be the same if taxes were specific.

where D is the effect of an decrease in p, country b's terms of trade, on b's trade balance, and the usual stability condition requires D to be positive. In turn, D is positive[19] if $\sigma + \varepsilon > 1$, which follows from A3, so we have $D > 0$. So, $\partial p/\partial t_1^b$ will always be positive, and $\partial p/\partial t_2^b$ will be negative (positive) if the two goods are substitutes (complements).

How does this change in p impact on country a? As taxes are ad valorem, the government budget constraint in country a is now

$$g^a = t_1^a x_1^a + t_2^a p x_2^a \tag{3.7}$$

So, substituting (3.1),(3.7) in (2.5), we can write the objective of the government of country a as

$$\Omega^a = \beta v(1 + t_1^a, p(1 + t_2^a), 1) + h(t_1^a x_1^a + t_2^a p x_2^a) \tag{3.8}$$

So, from (3.8), we have

$$\frac{\partial \Omega^a}{\partial t_j^b} = \frac{\partial \Omega^a}{\partial p}\frac{\partial p}{\partial t_j^b}, \ j = 1, 2 \tag{3.9}$$

The term $\partial \Omega^a/\partial p$ is the impact on country a's welfare arising from a deterioration in its terms of trade (a rise in p). It is natural to assume that this is negative. If this is the case, then it is clear from (3.9), (3.5),(3.6), that an increase in t_1^b always makes country a worse off, and an increase in t_2^b makes country a better (worse) off as the two goods are substitutes (complements).

This discussion implies the following result.

Proposition 3.1. *Assume that at the Nash equilibrium, an improvement in either country's terms of trade increases welfare Ω^i in that country. Then, starting from the Nash equilibrium destination-based taxes, the following tax reforms are strictly Pareto-improving, whether governments are Leviathans or welfaristic. First, a decrease in taxes on imported goods. Second, an increase (decrease) in taxes on exported goods if the two goods are substitutes (complements).*

---

[19] In fact, from (3.4),

$$D = -\frac{1}{p^2}\frac{\partial x_1^b}{\partial q_1^b}(1 + t_1^b) - p^2\frac{\partial x_2^a}{\partial q_2^a}(1 + t_2^a) - x_2^a$$

At the symmetric equilibrium, $D = x[\sigma + \varepsilon - 1]$, so the stability condition is that $\sigma + \varepsilon > 1$.

The intuition for this result is simple. In the Nash equilibrium, imports are taxed at an inefficiently high rates, because countries use import taxes like tariffs, in an attempt to manipulate the terms of trade in their favor. So, a co-ordinated decrease in taxes on imported goods must benefit both countries. Also, if the tax on the exported good is changed in such a way as to increase the quantity imported in that country, the deadweight loss from overtaxation of imports will be lowered, even though taxes on imports are unchanged. If the two goods are substitutes, this involves increasing the tax on the exported good.

3.2. Origin-Based Taxes

Here, each country a levies production tax on the good produced domestically. So, consumer prices are $q_1 = 1 + t_1$, $q_2 = p(1 + t_2)$. Also, as in the destination case, the full income of the consumer in country a is unity, and the full income of the consumer in country b is p. Consequently, we may write commodity demands in each country as

$$x_j^a = x_j^a(1 + t_1, p(1 + t_2); 1), \; j = 1, 2 \tag{3.10}$$

$$x_j^b = x_j^b\left(\frac{1 + t_1}{p}, 1 + t_2; 1\right), \; j = 1, 2 \tag{3.11}$$

where in the second line, we have used homogeneity of degree zero of demand in prices and income, as in the destination case.

As before, p is determined by the trade balance condition that the value of exports equals the value of imports. However, the key difference is that imports and exports are now evaluated at tax-inclusive consumer prices. Writing this trade balance condition in full, using (3.10), (3.11), we get

$$(1 + t_1)x_1^b\left(\frac{1 + t_1}{p}, 1 + t_2; 1\right) = p(1 + t_2)x_2^a(1 + t_1, p(1 + t_2); 1) \tag{3.12}$$

So, the producer price spillover from b to a in this setting is that a change in t_2 changes p, thus impacts on the welfare or tax revenue of country a. In particular, one can calculate from (3.12) that;

$$\frac{\partial p}{\partial t_2} = \frac{1}{D}\left[p x_2^a - (1 + t_1)\frac{\partial x_1^b}{\partial q_2} + p^2(1 + t_2)\frac{\partial x_2^a}{\partial q_2} \right] \tag{3.13}$$

Again stability requires $D > 0$, which in turn requires $\sigma + \varepsilon > 1$ as in the destination case, and this is certainly satisfied thanks to assumption A3. In symmetric equilibrium, where $x_j^i = x$, $q_i = 1 + t$, $p = 1$; (4.14) can be rewritten

$$\begin{aligned}
\frac{\partial p}{\partial t_2} &= \frac{x}{D}\left[1 - \frac{q_2}{x_1^b}\frac{\partial x_1^b}{\partial q_2} + \frac{q_2 \partial x_2^a}{x_2^a \partial q_2}\right] \\
&= \frac{x}{D}[1 - 0.5(\sigma + \varepsilon) - 0.5(\sigma - \varepsilon)] \\
&= \frac{x}{D}[1 - \sigma]
\end{aligned}$$

From A3, $\sigma > 1$, so we see that an increase in country b's production tax improves the terms of trade of country a. Some intuition for this is as follows. First, an increase in t_2 decreases country a's demand for good 2. Second, an increase in t_2 increases country b's demand for the good 1 (if goods are substitutes). Both of these effects lead to a deterioration in b's trade balance[20], leading to a fall in b's terms of trade.

Following previous arguments, we can write the objective of the government of country a as

$$\Omega^a = \beta v(1 + t_1, p(1 + t_2), 1) + h(t_1(x_1^a + x_1^b)) \tag{3.14}$$

So, differentiating (3.14), in general, we can write the overall spillover effect of a change in the foreign tax as the sum of two spillovers;

$$\frac{\partial \Omega^a}{\partial t_2} = \underbrace{\frac{\partial \Omega^a}{\partial q_2}\frac{\partial q_2}{\partial t_2}\Big|_{p\text{ const.}}}_{\text{consumer price spillover}} + \underbrace{\frac{\partial \Omega^a}{\partial p}\frac{\partial p}{\partial t_2}}_{\text{producer price spillover}} \tag{3.15}$$

So, we note that the consumer price spillover is still present, as in the base case, but it is augmented by the producer price spillover. As $\partial p/\partial t_2 < 0$; the producer price spillover will be positive as long as $\partial \Omega^a/\partial p < 0$; i.e. the impact on country a's welfare of a deterioration in its terms of trade (a rise in p) is negative.

Note that at equilibrium, the consumer price rises one-for-one with the tax, and the consumer price spillover is exactly the same as in the base case;

$$\frac{\partial q_2}{\partial t_2}\Big|_{p\text{ const.}} = p = 1; \quad \frac{1}{x}\frac{\partial \Omega^a}{\partial q_2} = -\beta\lambda + \eta\frac{t}{1+t}[\sigma - \varepsilon] \tag{3.16}$$

So from (3.15),(3.16), we see that at the symmetric Nash equilibrium, the overall tax spillover can be written

$$\frac{1}{x}\frac{\partial \Omega^a}{\partial t_2} = -\beta\lambda + \eta\frac{t}{1+t}[\sigma - \varepsilon] + \theta; \quad \theta = \frac{1}{x}\frac{\partial \Omega^a}{\partial p}\frac{\partial p}{\partial t_2} \tag{3.17}$$

---

[20] Of course, an increase in t_2 also increases the price of a's imports, improving b's trade balance, as $\sigma > 1$; this price effect is dominated by the quantity effect.

It is then possible to prove the following result;

Proposition 3.2. Assume that (starting from the Nash equilibrium), an improvement in either country's terms of trade increases welfare Ω^i in that country. Then, starting from the Nash equilibrium origin-based taxes, the following tax reforms are strictly Pareto-improving. (i) If governments are Leviathans, a small increase in both taxes. (ii) If governments are welfaristic, a small increase in both taxes if σ is large enough i.e. $\sigma > (\epsilon\eta - \theta)/(\eta - \lambda) = \underline{\sigma}$.

Proof. See Appendix. $\square$

Note that in the Leviathan case, the qualitative results on tax reform are identical to the case with perfect factor mobility and follow immediately from (3.17). In the welfaristic case, the only difference from the benchmark case of perfect factor mobility is that the degree of substitutability between goods, σ, does not need to be so high before raising taxes becomes Pareto-improving (indeed the lower bound on σ, $\underline{\sigma}$; may be negative). This is because the sign of the producer price/terms of trade spillover θ is positive, and so tends to make the overall spillover positive when goods are substitutes.

3.3. Related Literature

Much of the literature on international harmonizing tax reforms works with models where producer prices are endogenous [Delipalla(1996), Keen(1987),(1989), Lopez-Garcia(1996), (1998)]. However, none of these papers explicitly characterizes spillover effects in the Nash equilibrium and the Pareto-improving tax reforms that are implied by them; rather, they restrict their attention to looking for harmonizing Pareto-improving reforms, which only exist under quite special conditions (see Section 5.2 below). Lockwood(1997) gives a general characterization of Pareto-improving destination-based tax reforms, starting from Nash equilibrium, in a model more general than the one of this paper (n goods, non-identical preferences in the different countries). His result is that a reform is Pareto-improving iff it increases the (compensated) demand for imports in each country. This is certainly consistent with Proposition 3.

4. Imperfect Competition and Rent Spillovers

In general, introducing imperfect competition will generate both rent and producer price spillovers. Rent spillovers arise because, (except in the very long run, with free entry), there will be pure profits (rents). Producer price spillovers arise because in general, the mark-up of price over cost is not constant, and will depend inter alia, on consumer prices, and hence on taxes. In this section, for analytical clarity, we focus on rent spillovers only. To keep producer prices constant, we revert to our initial assumption A1 that labor is perfectly mobile, and in addition, we must introduce imperfect competition into the model in such a way that every firm faces iso-elastic demand, and hence chooses a constant mark-up over marginal cost[21].

The second requirement can be achieved cleanly following a standard approach in the international trade literature (e.g. Venables(1982)). We suppose that there are M firms located in country a, each one of whom supplies a single variety of good 1 to both countries, and similarly M firms located in country b, each one of whom supplies a single variety of good 2. So, we allow firms to sell into foreign markets, but we do not allow them to locate in foreign countries[22].

We suppose that preferences are as in (2.1), except that x_j^i is now a CES index of $(x_{j;m}^i)_{m=1}^{M}$; where $x_{j;m}^i$ is the level of consumption of variety m produced in country j by a resident of country i;

$$x_j^i = M^{\frac{1}{1-\alpha}} \left[\sum_{m=1} (x_{j;m}^i)^{\frac{\alpha-1}{\alpha}} \right]^{\frac{\alpha}{\alpha-1}} ; \ \alpha > 1 \tag{4.1}$$

Here, α is the (fixed) elasticity of demand for variety j, which will determine the fixed mark-up in equilibrium. The factor $M^{\frac{1}{1-\alpha}}$ ensures that in symmetric equilibrium, the index is not increasing in variety per se. This simplifies both the exposition and interpretation of the model.

Without loss of generality, we can assume that all varieties of a single good are taxed at the same ad valorem[23] rate, no matter whether taxes are destination or origin-based. On the other hand, we must allow different firms in the same industry to set different prices (although in equilibrium, they will all set the same price). So let $q_{1;m}^i$ be the consumer price of variety m of good 1 in country i.

[21] In Keen and Lahiri (1993), (1998) a quite general, yet simple model of tax competition with imperfect product market competition is developed. We do not make use of it; (i) because generally, producer prices in their model are endogenous to taxes, and hence there are producer price spillovers, and (ii) their model has a homogenous product - extending their model to differentiated products is very complex.

[22] An analysis of location decisions is a topic for further work.

[23] We assume ad valorem taxation for technical convenience.

Then, standard two-stage budgeting results imply that demand for variety m of good 1 in country i is

$$x^i_{1,m} = \left[\frac{q^i_{1,m}}{Q^i_1}\right]^{-\alpha} x^i_1 \tag{4.2}$$

where Q^i_1 is the CES index of prices $q^i_{1,m}$; $m = 1,\ldots M$ corresponding to the quantity index x^i_1 defined in (4.1). The demands $x^i_{2,m}$ can be written similarly. The indices (x^i_1, x^i_2) are of course optimally chosen by the consumer resident in country i at the second stage of the budgeting, but depend only on aggregate price indices Q^i_1, Q^i_2 and income y^i in country i. However, any individual firm rationally takes them as fixed if M is large, so its (rationally) perceived demand curve in either market is iso-elastic with elasticity α.

So, by the usual arguments[24], the producer price set by firm m selling product 1 in country i will be a constant mark-up $\mu = 1/(1 - 1/\alpha) > 1$ over the cost of production. But the latter is simply unity, as the world price of labor is unity. So, the firm m located in country a sets the same producer price[25] in both of its markets:

$$p^a_{1,m} = p^b_{1,m} = \mu;\ \mu = \left(1 - \frac{1}{\alpha}\right)^{-1} > 1 \tag{4.3}$$

Consequently, all firms located in country a sell the same amount $x^i_{1,m} = z^i_1$ in country i; and make profit of $\mu - 1$ on each unit sold. So, from ,(4.3), the aggregate profit of these firms is

$$\pi^a = (\mu - 1)(Mz^a_1 + Mz^b_1) = (\mu - 1)(x^a_1 + x^b_1) \tag{4.4}$$

where we have used $x^i_1 = M^{\frac{1}{1-\alpha}}\left[M(z^i_1)^{\frac{\alpha-1}{\alpha}}\right]^{\frac{\alpha}{\alpha-1}} = Mz^i_1$ from (4.1). An exactly similar analysis applies to firms in country b producing varieties of good 2, so $p^a_{2,m} = p^b_{2,m} = \mu$; $\pi^b = (\mu - 1)(x^a_2 + x^b_2)$.

[24] The formal details are as follows. As all varieties are taxed at the same ad valorem rate, the tax term $1 + t^i_1$ nets out of the fractions in (4.2), so we may write $x^i_{1,m} = \left[\frac{p^i_{1,m}}{P^i_1}\right]^{-\alpha} x^i_1$. Also, the profit of firm m in country a may be written $\pi^a_m = \left(p^a_{1,m} - 1\right)x^a_{1,m} + (p^b_{1,m} - 1)x^b_{1,m}$. The firm chooses $p^a_{1,m}, p^b_{1,m}$ to maximize π^a_m subject to the above demand function and P^a_1; P^b_1, x^a_1, x^b_1 fixed, which results in (4.3).

[25] Note that under destination-based taxation, costless mobility of consumers requires that the producer price of a variety be the same in both countries (otherwise, it would pay the consumer to buy it in the low-price country, as it bears the same tax wherever it is bought). So, the assumption that the α is the same in both countries is crucial.

We now wish to write down formulae for full after-tax income in each country. In general, this will depend on (i) the extent to which firms are domestically owned, and (ii) whether the profit tax rate is fixed or optimized. For the moment, assumed a fixed profit tax rate $0 \leq \tau \leq 1$; the same in both countries, in order to maintain the symmetry of the model. Note that the optimal profit tax is unity as long as marginal utility of the public good (at the level provided for by a 100% profit tax) exceeds the private marginal utility of income, and the latter is an assumption often made in the literature[26]. Note also that the existing literature (Keen and Lahiri (1993), (1998)) assumes that firms are 100% domestically owned.

It is easily checked that the spillovers are qualitatively the same with either optimal (100%) profit taxes, or 100% domestic ownership, in both cases, the welfare Ω^i of country i depends only on the profits of firms located in that country. So, we focus on this case of 100% domestic ownership in what follows. Then, the full income of the representative consumer in a can be written;

$$y^a = 1 + (1 - \tau)\pi^a \tag{4.5}$$

where $\pi^i = \sum_{m=1}^{M} \pi^i_m$: Also, y^b is defined similarly.

Note that in the general case, y^i and π^i are determined simultaneously; $y^a; y^b$ determine $\pi^a; \pi^b$ through demands x^i_j, and then $\pi^a; \pi^b$ determine $y^a; y^b$ from the identities (4.5). This circularity is analytically complex and does not add much of substance, so we cut though it by assuming away income effects on goods 1 and 2 (as do Keen and Lahiri(1993), (1998)). It is convenient to do this by specializing utility to $u(X; l) = u(X) + \lambda l$; so that λ is now the constant marginal utility of income.

4.1. Destination-based Taxes

In this case, the relationship between producer and consumer prices for varieties of goods 1 and 2 in country i is

$$q^i_{1;m} = \mu(1 + t^i_1); \; q^i_{2;m} = \mu(1 + t^i_2) \tag{4.6}$$

The government budget constraint in the home country a now includes profit tax revenue from domestically based firms, $\tau\pi^a$: Also, the tax base for commodity t^a_j is now μx^a_j: So;

$$g^a = t^a_1 \mu x^a_1 + t^a_2 \mu x^a_2 + \tau\pi^a \tag{4.7}$$

[26] See e.g. Huizinga and Nielsen(1997) for more discussion on this point.

Using (2.5), (4.5),(4.6),(4.7), we can write the objective of the government of country a as

$$\Omega^a = \beta v(\mu(1+t^a_1), \mu(1+t^a_2), 1+(1-\tau)\pi^a) + h(t^a_1 \mu x^a_1 + t^a_2 \mu x^a_2 + \tau\pi^a) \tag{4.8}$$

The key finding from (4.8) is now is that there are spillovers, even with destination-based taxes. As is clear from (4.8), these spillovers[27] work through the impact of a tax change in one country on the profit in the other country, and so I call them rent spillovers. Specifically,

$$\frac{\partial\Omega^a}{\partial t^b_i} = \frac{\partial\Omega^a}{\partial\pi^a}\frac{\partial\pi^a}{\partial t^b_i}, \quad i = 1, 2 \tag{4.9}$$

Note that from (4.8), at the symmetric Nash equilibrium, $\partial\Omega^a/\partial\pi^a = (\beta\lambda(1-\tau)+\eta\tau) > 0$. Also, note that the effects of changes in t^b_1, t^b_2 on π^a can be calculated explicitly from (4.4) as

$$\frac{\partial\pi^a}{\partial t^b_1} = \mu(\mu-1)\frac{\partial x^b_1}{\partial q^b_1} < 0, \quad \frac{\partial\pi^a}{\partial t^b_2} = \mu(\mu-1)\frac{\partial x^b_1}{\partial q^b_2} \tag{4.10}$$

So, an increase in country b's tax on its imported good, good 1, causes profit of firms located in country a to decrease, and an increase in country b's tax on good 2 causes profit of firms located in country a to increase iff the two goods are substitutes.

From the above discussion, we have some very simple results about Pareto-improving tax reforms, starting at Nash equilibrium.

Proposition 4.1. Starting from the Nash equilibrium destination-based taxes, the following tax reforms are strictly Pareto-improving, whether governments are Leviathans or welfaristic; a small decrease on the tax on the imported good, and an increase (decrease) on the exported good if the two goods are substitutes (complements).

[27] Following Mintz and Tulkens, we could decompose these rent spillovers into "private consumption" and "public consumption" components. For example, the private consumption component of the first spillover is $\lambda(1-\tau)\frac{\partial\pi^a}{\partial t^b_1}$, which measures the impact of an increase in t^b_1, via profit π^a, on the consumer's income from profit. The public consumption component is $\eta\tau\frac{\partial\pi^a}{\partial t^b_1}$, which measures the impact of an increase in t^b_1 via profit π^a, on tax revenue, and hence on the supply of public goods.

Note that this result is qualitatively identical to Proposition 3 in the case of producer price externalities, and follows from the fact that rent and producer price externalities generate qualitatively identical tax spillovers, but though different channels. Note that again, the conventional wisdom that taxes should be increased is not implied here. Again, the intuition is clear enough; a decrease in tax on the imported good by the home country raises imports from the foreign country, and therefore profits of firms located in the foreign country. This raises profit tax revenue of the foreign country, and also (as firms are 100% domestically owned) raises the utility of the foreign household.

4.2. Origin-Based Taxes

In this case, the relationship between producer and consumer prices for varieties of goods 1 and 2 in country i is

$$q^i_{1,m} = \mu(1+t_1);\ q^i_{2,m} = \mu(1+t_2) \tag{4.11}$$

with country a choosing t_1, and country b choosing good t_2. In this case, for simplicity, we focus on the leading case of 100% domestically owned firms and/or 100% profit taxation. So, the government budget constraint in country a is;

$$g^a = t_1\mu(x^a_1 + x^b_1) + \tau\pi^a \tag{4.12}$$

Using (2.5), (4.5),(4.11), (4.12), we can write the objective of the government of country a as

$$\Omega^a = \beta v(\mu(1+t_1), \mu(1+t_2), 1 + (1-\tau)\pi^a) + h(t_1\mu(x^a_1 + x^b_1) + \tau\pi^a) \tag{4.13}$$

From (4.13), there are two spillovers, the consumer price and rent spillovers, so the overall spillover can be written:

$$\frac{\partial\Omega^a}{\partial t_2} = \underbrace{\frac{\partial\Omega^a}{\partial q_2}\frac{\partial q_2}{\partial t_2}}_{\text{consumer price spillover}} + \underbrace{\frac{\partial\Omega^a}{\partial\pi^a}\frac{\partial\pi^a}{\partial t_2}}_{\text{rent spillover}} \tag{4.14}$$

First note that the consumer price spillover is present, as in the base case. Second, note that there is an additional spillover effect though profits (rents).

Can we sign this rent spillover at the symmetric Nash equilibrium? First, from (4.4), (4.11),(4.13) we see that

$$\frac{\partial\Omega^a}{\partial\pi^a} = (\beta\lambda(1-\tau) + \eta\tau) > 0;\ \frac{\partial\pi^a}{\partial t_2} = (\mu-1)\mu\left[\frac{\partial x^a_1}{\partial q_2} + \frac{\partial x^b_1}{\partial q_2}\right] \tag{4.15}$$

So, at symmetric Nash equilibrium (where $x_j^i = x$, $q_1 = q_2 = \mu(1+t)$) we see from (4.15) that

$$\frac{1}{\mu x}\frac{\partial \pi^a}{\partial q_2} = \frac{(\mu - 1)}{q_2}\left[\frac{q_2 \partial x_1^a}{x_1^a \partial q_2} + \frac{q_2 \partial x_1^b}{x_1^b \partial q_2}\right] = \frac{(\mu - 1)}{\mu(1+t)}(\sigma - \varepsilon) \tag{4.16}$$

So, the rent spillover is positive if and only if the two goods are substitutes. The intuition is clear; an increase in the t_2 raises the price of good 2 to all consumers, and so increases demand for good 1, which increases the profits of firms located in country a:

Finally, note that as in the base case,

$$\frac{1}{x}\frac{\partial \Omega^a}{\partial q_2} = -\beta\lambda + \eta\frac{t}{1+t}[\sigma - \varepsilon];$$

and from (4.11), $\partial q_2/\partial t_2 = \mu$: Inserting (4.14), (4.16) into (4.14), we have a formula for the total spillover;

$$\frac{1}{\mu x_2^a}\frac{\partial \Omega^a}{\partial t_2} = \underbrace{-\beta\lambda + \eta\frac{t}{1+t}[\sigma - \varepsilon]}_{\text{consumer price spillover}} + \underbrace{\frac{(\mu - 1)}{\mu(1+t)}(\sigma - \varepsilon)}_{\text{rent spillover}} \tag{4.17}$$

Using (4.17), the following simple rules for Pareto-improving tax reforms can be derived.

Proposition 4.2. Starting from the Nash equilibrium origin-based taxes, the following tax reforms are strictly Pareto-improving. (i) If the governments are Leviathans, goods are complements ($\sigma < \varepsilon$), a small increase (decrease) in both taxes if the two goods are substitutes (complements). (ii) If governments are welfaristic, and the two goods are complements, a small decrease in both taxes. (iii) If governments are welfaristic, and the two goods are substitutes, a small increase (decrease) in both taxes as $\sigma > (<)\underline{\sigma} = \varepsilon\eta/(\eta - \lambda) = \underline{\sigma}$:

Proof. See Appendix. $\square$

So, in both the Leviathan and welfaristic cases, the qualitative results on tax reform are not just close to, but identical to the base case with perfect competition. In particular, in the welfaristic case, the critical value of σ above which raising taxes becomes Pareto-improving, i.e.$\underline{\sigma}$ is the same as in the perfect competition case. This is because moving from perfect to imperfect competition introduces two new effects that exactly cancel out in equilibrium. First, the sign of the rent spillover is positive if goods are substitutes, which by inspection of (4.17), makes the overall spillover higher, at a given level of t. However, this is not the end of the story; if the rent spillover is positive, by inspection of (??) in the Appendix, t is lower, and so is the overall spillover from (4.17). In a more general model, these effects would not necessarily cancel out, but the logic at work would be the same.

4.3. Related Literature

To my knowledge, only three papers have analyzed commodity tax competition with imperfect competition: Keen and Lahiri (1993), (1998), and Trandel(1994). Trandel's model is partial equilibrium, and the profits generated by firms simply disappear to another part of the economy[28], so rent spillovers cannot operate in his model. The model used by Keen and Lahiri (1993), (1998), by contrast, is truly general equilibrium, and indeed is much closer to what we have here. First, in both their model and this one, the relative wage is fixed[29]. Second, in their model, goods produced in both countries are perfect substitutes, a possibility which is encompassed by this model as $\sigma \to \infty$. Third in their model, the firms are Cournot competitors[30].

The main focus of Keen and Lahiri (1993) is harmonization of destination-based taxes, and the main focus of Keen and Lahiri (1998) is the welfare consequences of a switch between destination and origin principles both when taxes are fixed, and when they are optimized. Consequently, both contributions are discussed in more detail in Sections 5 and 6.4 respectively.

However, one key result of Keen-Lahiri (1998) should be discussed at this point. When preferences and costs are identical across the two countries, and there is no reason for governments to raise revenue, they obtain the striking result

[28] Profits do not affect either tax revenue or consumer welfare in his model (see e.g. his equation (17) for consumer welfare).

[29] In Keen and Lahiri's model, the relative wage is fixed by assuming the existence of a numeraire traded good produced from labour with a constant returns to scale technology, and sold on a competitive market.

[30] The reason why we do not work with their model in this section is that when goods are not perfect substitutes (a central case for the approach of this paper), in their model, the characterization of the Cournot-Nash equilibrium between firms (and therefore the Nash equilibrium in taxes) becomes very complex.

(Proposition 6 in their paper) that Nash equilibrium in origin-based taxes is first-best efficient (i.e. equilibrium taxes are such that firms price at marginal cost), whereas Nash equilibrium in destination-based taxes is inefficient. The intuition for this result is simple; with imperfect competition, the first-best requires production subsidies for firms, which can be financed out of profit taxes. Such subsidies are origin-based by definition, and so cannot be implemented by destination-based taxes.

This result also emerges in our model when the appropriate assumptions are made that ensure consistency with the Keen and Lahiri model, but the result does not generalize to the case of differentiated products ($\sigma < \infty$). First, in Keen and Lahiri's model, the government has no revenue requirement, captured in our model by the condition that $\lambda = \eta$ in the Nash tax equilibrium. Under this assumption, it is shown in Appendix A4 that the equilibrium origin-based tax satisfies

$$t_o = \frac{(1-\mu)}{\mu} + \frac{1+t_o}{\sigma+\varepsilon} \tag{4.18}$$

Here, $(1-\mu)/\mu < 0$ is the optimal Pigouvian subsidy that would induce firms to price at marginal cost. When $\sigma \to \infty$, the Nash equilibrium tax tends to this optimal subsidy, and the Nash equilibrium is therefore first-best efficient.

However, when the products produced by the two countries are not perfect substitutes, then, generally this tax is above the optimal subsidy. The reason is that if $\sigma < \infty$, the government of country a can force residents of b to bear some of the burden of its tax on good 1.

5. Tax Harmonization

As remarked in the introduction, one form of tax co-ordination that has received special attention in the literature is tax harmonization. This literature has tried to identify conditions under which harmonizing tax reforms are potentially or actually Pareto-improving, starting at the non-cooperative Nash equilibrium taxes. In our set-up, we can study tax harmonization in the destination case, and in this case, the sufficient conditions for Pareto-improving tax harmonization can be derived particularly easily. In the origin case, however, due to complete specialization in production, each country only chooses one tax rate, and so at the symmetric Nash equilibrium, taxes are the same and consequently already fully harmonized. This is clearly a limitation of the model.

Following Lockwood(1997), we can define a harmonizing tax reform[31] from any arbitrary initial taxes $(t_1^a; t_2^a; t_1^b; t_2^b)$ as follows. First define

$$z_j = \omega_j t_j^a + (1 - \omega_j)t_j^b; \; 0 < \omega_j < 1$$

to be some weighted average of the two countries' tax rates on good $j = 1; 2$: Then a harmonizing tax reform is a reform where each country $i = a; b$ moves its tax on good j from the initial value t_j^i in the direction of this weighted average i.e.

$$dt_j^i = \mu_j^i (z_j - t_j^i); \; \mu_j^i > 0$$

Now consider harmonization of destination-based taxes in any of the three variants of the model studied above, starting at the Nash equilibrium. In the basic model, taxes on the two goods are the same within countries, due to the symmetry of country preferences over the two goods, and the absence of tax spillovers. As both countries have identical preferences, taxes are also the same between countries. So, taxes are fully harmonized already, and further harmonization is not feasible. Even if countries were not identical, so that taxes were not harmonized across countries, harmonizing reforms could not be Pareto-improving, as the Nash equilibrium in taxes is efficient (Proposition 1 also applies to the case of heterogenous countries).

When factors are not mobile, or where firms earn rent, the picture is very different. First, in either Nash equilibrium, by the symmetry of the model, both countries tax their imported good, and their exported good, at the same rate i.e.

$$t_2^a = t_1^b = t^*; \; t_1^a = t_2^b = t^{**}$$

Second, in general, $t^* \neq t^{**}$; as the effect of a tax on the exported good on domestic rents, or the domestic terms of trade, is generally different from effect of a tax on the imported good on domestic rents, or the domestic terms of trade. This point is discussed in more detail below. For the moment, we simply explore the implications of the fact that t^* and t^{**} may be different. In fact, we have the following;

Proposition 5.1. Assume that labor is immobile, or that there is imperfect competition, that initial taxes are Nash equilibrium destination-based taxes, and that the two goods are substitutes. If the imported good in each country is taxed

[31] Note that this definition of a harmonising tax reform is more general that that of Keen(1987), (1989), as it does not require producer prices to remain unchanged.

more than the exported good ($t^* > t^{**}$), then every harmonizing tax reform is Pareto-improving. If the imported good in each country is taxed less than the exported good ($t^* < t^{**}$), then no harmonizing tax reform is Pareto-improving (in fact, every such reform makes both countries worse off).

Proof. If $t^* > t^{**}$, then any harmonizing tax reform will decrease the tax on the imported good in each country and increase the tax on the exported good in each country. By Propositions 4,5 each of these two reforms separately is Pareto-improving, so taken together, they are also Pareto-improving. A similar argument applies in reverse if $t^* < t^{**}$. $\square$

This result, and its proof, are strikingly simple, and make it clear that the merits of harmonization are best studied in a setting where tax spillovers are made explicit.

Of course, it is important to know of the underlying conditions under which we might expect $t^* > t^{**}$ or $t^* < t^{**}$. Consider first the case of producer price spillovers. When the terms of trade is constant (i.e. in the basic model of Section 2), conditions on preferences are sufficient for uniform optimal taxes, and consequently both the imported and exported good are taxed at the same rate. With an endogenous terms of trade, each country has the incentive to increase the tax on its imported good to improve its terms of trade, as we saw in Section 3. So, we might expect that $t^* > t^{**}$ in this case.

To make this argument rigorous, however, it is convenient to specialize utility to

$$u^i = \frac{\sigma}{\sigma - 1}\left[0.5(x_1^i)^{\frac{\sigma-1}{\sigma}} + 0.5(x_1^i)^{\frac{\sigma-1}{\sigma}}\right] + l^i + \eta g^i \tag{5.1}$$

This formulation embodies the following assumptions[32]: ε, λ are both fixed at constant values, with $\lambda = 1$, $\varepsilon = \sigma$. Also, marginal benefit from the public good, $\eta \geq 1$, is fixed independently of g.

For these preferences, in Appendix A.2, the Nash equilibrium taxes (as proportions of the consumer prices) are explicitly calculated to be;

$$\frac{t^{**}}{1+t^{**}} = \frac{\eta - 1}{\eta\sigma} \tag{5.2}$$

$$\frac{t^{*}}{1+t^{*}} = \frac{\eta - 1 + \kappa_d}{\eta(\sigma + \kappa_d(1 - \sigma))} \tag{5.3}$$

[32] In terms of (2.1), we are assuming $u(X; l) = \frac{\sigma}{\sigma-1}X^{(\sigma-1)/\sigma} + l$.

where $\kappa_d = \sigma/(2\sigma - 1)$ is the elasticity of country a's terms of trade, $1/p$, with respect to the tax on country a′s exported good, and is positive from[33] assumption A3. So, we see that taxes on imports are determined not just by the usual deadweight loss considerations, but also by an incentive to manipulate the terms of trade, as measured by κ_d.

From (5.2),(5.3) we see that t^* is greater than t^{**} if $\sigma > \frac{\eta - 1}{\eta}$. But by A3, this certainly holds[34], so the tax on the imported good is higher, as claimed. It follows that at least for this example, tax harmonization will always be Pareto-improving.

This example is of course very special, as absent terms of trade effects, optimal taxation is uniform. One way to generalize the example would be to allow the two goods to have different own-price elasticities, as in the example of Lockwood(1997). Then, it is easy to show that if the own-price elasticity of the exported good is very low, and/or the own-price elasticity of the imported good is very high, imported goods may be taxed at a lower rate than exported goods ($t^* < t^{**}$) and consequently there will be no Pareto-improving harmonizing tax reforms.

A similar example can be constructed in the case of rent spillovers. The intuition is the following. Suppose there are no cross-price effects in demand, as in the utility function (5.1). Then an increase in the tax on country a′s imported good will have no effect on π^a, profits accruing to residents of a. On the other hand, an increase in the tax on country a′s exported good, t_1^a, will reduce demand for the good produced at home, and so will decrease π^a. So, ceteris paribus, it is optimal to set a lower tax on the exported good.

This argument can be made precise if we assume the utility function (5.1). It then is possible to calculate explicitly (see Appendix A.3) that the Nash equilibrium taxes are;

$$\frac{t^{**}}{1+t^{**}} = \frac{\eta - 1}{\eta}\frac{1}{\sigma} - \frac{(1 - \tau + \eta\tau))(\mu - 1)}{(1+t^{**})\mu\eta} \tag{5.4}$$

$$\frac{t^{*}}{1+t^{*}} = \frac{\eta - 1}{\eta}\frac{1}{\sigma} \tag{5.5}$$

[33] In fact, A3 is not needed to ensure $\kappa_d > 0$; this follows simply from the stability condition, derived in footnote 19 above, that $\sigma + \varepsilon > 1$, bearing in mind that for utility function (5.1), $\sigma = \varepsilon$.

[34] Even in the absence of assumption A3, it is possible to show that the second-order conditions to country a's tax design problem that σ is greater than $\frac{\eta - 1}{\eta}$ (see Lockwood(1993)), and so we still conclude that $t^* > t^{**}$.

From (5.5), and $\eta \geq 1$, $t^* > 0$. From (5.4), if $t^{**} > 0$; $t^{**} < t^*$. So, as required, $t^* > t^{**}$. Note also that as goods become perfect substitutes, $(\sigma \to 1)$; and when there is no revenue requirement $(\eta = 1)$, then the tax on the imported good in each country is zero, but the tax on the exported good is optimal Pigouvian subsidy i.e. $t^{**} = -(\mu - 1)/\mu$. This is consistent with Proposition 6 of Keen and Lahiri (1998) which asserts that even under these conditions, Nash equilibrium in destination-based taxes will not be first-best[35].

5.1. Related Literature

The only paper that deals with international tax reform in an imperfect competition environment is Keen and Lahiri(1993). Their Proposition 3 states that starting from Nash taxes, any harmonization of (destination-based) taxes is Pareto-improving. But this is exactly the same result that we have, at least in the case where preferences are given by (5.1) - for then, the fact that $t^* > t^{**}$ from (5.4),(5.5), plus Proposition 7, imply all harmonizing reforms are Pareto-improving. Moreover, the clear intuition offered here for the result - namely, that taxes on imports are too high, due to rent spillovers - also applies to the Keen and Lahiri model.

We now turn to the literature on tax harmonization in the presence of producer price spillovers. Two influential papers by Keen [(1987),(1989)] studied a model much more general to ours, with n goods, two countries which need not be symmetric, and a general production technology for each country. The main restriction was that countries had no revenue requirements, or equivalently no demand for public goods (which corresponds to $\eta = \lambda$ in our model). His main findings were that potential Pareto-improving tax reforms exist under quite general conditions, but conditions for actual Pareto-improving tax reforms are much more stringent[36]. Subsequently, Delipalla(1997), Lockwood(1997), Lahiri and Raimondos(1998), and Lopez-Garcia(1998) have analyzed the case where the government has a positive revenue requirement.

Both Keen's original contribution, and some of the subsequent work, can be understood in the framework of this paper. First, the relevant result of Keen's

[35] For a first-best outcome, we need the tax on the imported good also to be equal to the optimal Pigouvian subsidy.

[36] Specifically, some sufficient conditions are (i) two goods, and initial taxes are Nash equilibrium ones; (ii) n goods, initial taxes are Nash equilibrium ones, and either (a) no cross-price effects between taxed goods in consumption or production, or (b) the representative consumers have identical Slutsky matrices at the initial taxes.

is when there are two goods and initial taxes are Nash equilibrium ones. In our model, if there is no revenue requirement (´ = 1) then from (5.2),(5.3), we see that the tax on the exported good is zero, whereas the tax on the imported good is strictly positive; so from Proposition 7 we see that all harmonizing tax reforms are is Pareto-improving, consistently with Keen's results. [This is the case in our model even if the two-goods have different own-price elasticities (see Lockwood(1997)].

The papers by Delipalla(1997), Lahiri and Raimondos(1998), and Lopez-Garcia(1998) all work within the Keen model (n traded goods, m fixed factors of production, general production technologies). There are two problems with this strategy. The first is that the presence of fixed factors means that there is a non-distortionary source of tax revenue, and so it is hard to explain why the government would want to use commodity taxes at all. Second, the generality of this framework makes it had to get strong results in the case where governments have revenue requirements. Lahiri and Raimondos(1998) in fact assume that producer prices are exogenous, so there are no spillovers. In this case, at Nash equilibrium, taxes are efficiently set (cf. Proposition 2 above). Their paper focuses on tax reforms starting from arbitrary non-Nash initial taxes. Delipalla has endogenous producer prices, but her conditions for potentially and actually Pareto-improving tax reforms require that the reforms must also leave tax revenues in each country unchanged (conditional revenue neutrality). As the reforms are determined uniquely even without this condition, this additional condition means that the reform vector is "overdetermined" and will (generically) never exist. Lopez-Garcia(1998) constructs harmonizing tax reforms that will raise the weighted sum of the welfare of the home consumer and world tax revenue, while leaving the welfare of the foreign consumer fixed. However, such reforms are not necessarily Pareto-improving[37].

Lockwood(1997) takes a different approach, using a model similar to Keen's but with the production technology specialized to be Ricardian (one factor of production (labor) and constant returns to scale). So the model is a more general version of our model in Section 3 (n goods, countries not necessarily symmetric). There, a general result is proved: any tax reform that increases the value of both countries' import demands (at Nash producer prices) is (actually) Pareto-improving. From this can be deduced a number of specific propositions about Pareto-improving harmonizing tax reforms (such as Proposition 7 above). This

[37] Such a reform is potentially Pareto-improving if (i) conditional revenue neutrality holds, as then the world tax revenue does not change, or (ii) if the home or foreign governments could compensate the home consumer via a lump-sum subsidy.

general result is also be true in our case (as the model of Section 3 is a special case of that in Lockwood(1997)), as argued in Section 3.3 above.

6. Global Comparisons of Origin- and Destination-Based Taxes

6.1. A Benchmark Result: Uniform Taxation and Factor Mobility

Part of the literature in this area focuses on global comparisons of the outcome of tax competition under destination and origin principles, with a focus on whether tax rates are lower under the origin principle, as a simple "race to the bottom" argument would imply. Also, there is a closely related literature on when the destination and origin principles are equivalent at fixed tax rates (i.e. when real variables are left unchanged following a switch from destination to origin). In this section, we integrate these two literatures in our simple framework. The starting point is the following. The literature on equivalence results shows that a sufficient condition for equivalence is that[38] taxes within a country must be at a uniform ad valorem rate. Now, in our model (or in any model where there is more than one good) uniform taxation is very unlikely to prevail at the Nash equilibrium, even under conditions on preferences that imply uniform taxation is optimal in the closed economy. (The example in Section 5 explains why.)

So, the only way in which we can relate the equivalence results to tax competition is if we constrain the governments to choose uniform taxes i.e. $t_1^i = t_2^i$, $i = a; b$. In this case, we know from the equivalence literature that if the producer price is fully flexible, a switch between destination- and origin-based taxation will have no real effects under otherwise quite general conditions (Lockwood, de Meza and Myles(1994)). It follows that if governments anticipate the effects of changes in the taxes on the producer prices, as they do in our model, the allocation of real resources at Nash equilibrium will be the same whether the origin or destination principle is in place.

The logic is even clearer in our simple model. Suppose that governments are originally setting destination-based optimal taxes t_d and in equilibrium, the producer price p is unity. Now suppose that there is a switch to the origin-based

[38] Georgakopoulos and Hitiris (1991) have shown that this can be relaxed to the assumption that the ratios of taxes on any good in the two countries must be the same for all goods. However, even this weaker condition will not generally be satisfied in Nash equilibrium in taxes, even in our simple model, so the argument of the following paragraph still applies.

taxation, and the home country raises his tax to t_o. Then, the home country wage will immediately fall by $t_d = t_o\%$, completely offsetting the home country's tax rise. Consequently, taxes will be the same at both equilibria.

However, when all factors of production are mobile, we know that the equivalence result breaks down (Lockwood, de Meza and Myles(1994)). So, in both variants of our model with factor mobility, we will not generally have identical equilibria under the different principles, even if taxes across goods are constrained to be uniform (to see this in the basic model, see section 6.2 below).

This gives us a very useful benchmark result:

Proposition 6.1. Nash equilibrium taxes are the always the same under both destination and origin principles if and only if (i) governments are constrained to choose uniform taxes i.e. ($t_1^i = t_2^i = t^i$, $i = a, b$); (ii) labor is immobile.

We now turn to consider how taxes and equilibrium welfare levels compare under the two principles when taxes are not constrained to be uniform. Specifically, we study each of the three variants of the model when (destination) taxes are not constrained to be uniform across commodities. In each of the three cases, we compare Nash equilibrium taxes and welfare levels in destination and origin cases. Let Ω^d, Ω^o respectively denote destination and origin equilibrium welfare for either country.

6.2. The Basic Model

We begin by deriving explicit formulae for Nash tax rates under destination and origin principles in the basic model of Section 2. Maximizing country welfare (2.8) with respect to t_j^a gives the following first-order conditions defining the optimal destination-based taxes of country[39] a;

$$\frac{\partial \Omega^a}{\partial t_j^i} = -\beta \lambda^a x_j^a + \eta \left[x_j^a + t_1^a \frac{\partial x_1^a}{\partial q_j^a} + t_2^i \frac{\partial x_2^a}{\partial q_j^a} \right] = 0, \;\; j = 1, 2 \qquad (6.1)$$

At the symmetric Nash equilibrium, we must have $x_j^i = x$, and $t_1 = t_2 = t$. So, evaluating (6.1) at the symmetric Nash equilibrium, dividing all terms by x, and using the definitions of ε_{own}, ε_{cross} we get

$$-\beta\lambda + \eta\left[1 + \frac{t}{1+t}\varepsilon_{own} + \frac{t}{1+t}\varepsilon_{cross}\right] = 0 \qquad (6.2)$$

[39] In what follows, it is always sufficient to focus only on the behavior of country a due to symmetry of the model.

Using the fact that $\varepsilon_{own} + \varepsilon_{cross} = -\varepsilon$ from (2.1),(2.3), we get, after rearrangement of (6.2), the standard Ramsey tax formula

$$\frac{t_d}{1+t_d} = \left(\frac{\eta_d - \beta\lambda_d}{\eta_d}\right)\frac{1}{\varepsilon_d} \tag{6.3}$$

where the tax rate is inversely related to the elasticity of demand for the aggregate consumer good ε_d. The "d" subscripts indicate that these variables are evaluated at the equilibrium destination-based taxes. Note from A3, $\varepsilon_d > 1$; so the tax rate is non-negative and well-defined for all $\beta \geq 0$. If the government has a positive (zero) revenue requirement, then $\eta_d > \lambda_d$ ($\eta_d = \lambda_d$) in the welfaristic case, implying a positive or zero tax respectively.

Note also that the elasticity of substitution σ between varieties of good does not affect the formula directly. The reason for this is the following. When t_1^i increases, agents in country i substitute out of consumption and into leisure (at rate measured by ε), and also out of good 1 into good 2 (at rate measured by σ). However, as good 2 is taxed at the same rate as good 1, substitution between goods does not matter for the collection of tax revenue.

We now turn to origin-based taxes. Maximizing country welfare (2.11) with respect to t_1 gives the following first-order condition defining the optimal origin-based tax of country a;

$$\frac{\partial \Omega^a}{\partial t_1} = -\beta\lambda^a x_1^a + \eta^a\left[x_1^a + x_1^b + t_1\left(\frac{\partial x_1^a}{\partial q_1} + \frac{\partial x_1^b}{\partial q_1}\right)\right] = 0 \tag{6.4}$$

At the symmetric Nash equilibrium, $\lambda^i = \lambda$, $x_j^i = x$, $t_1 = t_2 = t$, so dividing though by x, after some simplification, (6.4) reduces to

$$-\beta\lambda + \eta\left[2 + \frac{t}{1+t}2\varepsilon_{own}\right] = -\beta\lambda + \eta\left[2 - \frac{t}{1+t}(\sigma + \varepsilon)\right] = 0 \tag{6.5}$$

Rearranging (6.5), we see that we get

$$\frac{t_o}{1+t_o} = \left(\frac{2\eta_o - \beta\lambda_o}{\eta_o}\right)\frac{1}{\sigma + \varepsilon_o} \tag{6.6}$$

The "o" subscripts indicate that these variables are evaluated at the equilibrium origin-based taxes.

Note two differences[40] between (6.3) and (6.6). First, in (6.6), the elasticity of substitution between goods, σ; now does affect the formula directly; from the point of view of tax design, demand is now more elastic, implying t_o lower, other things equal. This is because (for example) if country b raises t_2, agents can now not only substitute out of consumption into leisure, but also out of good 2 into good 1.

Second, the term η in the numerator in (6.6) is multiplied by two, implying t_o higher, other things equal. This is due to the fact that taxes are exported under the origin principle[41]. Specifically, as foreign consumers purchase the domestically produced good they bear part (in fact, in symmetric equilibrium, one half) of the tax burden, a burden that is ignored by the domestic government when choosing the tax.

It is not clear a priori, which of these differences will dominate, especially as the only exogenous parameter in these formulae is σ: We can make a more precise comparison if we assume ε; λ and η are constant. One utility function satisfying these conditions is

$$u^i = \frac{(X^i)^{1-1/\varepsilon}}{1-1/\varepsilon} + \lambda l^i + \eta g^i \tag{6.7}$$

Then, from (6.3) and (6.6) for this special case, we have

$$\frac{t_d}{1+t_d} = \left(\frac{\eta-\beta\lambda}{\eta}\right)\frac{1}{\varepsilon}; \quad \frac{t_o}{1+t_o} = \left(\frac{2\eta-\beta\lambda}{\eta}\right)\frac{1}{\sigma+\varepsilon} \tag{6.8}$$

So, from (6.8), we have the following;

Proposition 6.2. *Assume preferences are given by (6.7). Then if governments are Leviathans, $t_o < t_d$. If governments are welfaristic, then $t_o < t_d$ only if goods are sufficiently strong substitutes i.e. $\sigma - \varepsilon > \frac{\varepsilon\lambda}{\eta-\lambda} > 0$: Welfare is always higher in the destination case ($\Omega^d \geq \Omega^o$), and strictly so ($\Omega^d > \Omega^o$) unless $t_o = t_d$.*

Proof. From (6.8), we have $t_o < t_d$ iff $\sigma > \frac{\varepsilon\eta}{\eta-\beta\lambda}$: Setting $\beta = 0$ (Leviathan) or $\beta = 1$ (welfaristic), the result follows. The welfare result follows from the fact that there are no spillovers between the two countries in the destination case, so

[40] Note that even though Nash equilibrium taxes are uniform within countries, destination- and origin-based taxes are not equivalent because there is factor mobility, and so the relative price of the factor in the two countries cannot adjust to offset a switch from destination to origin (for more on this point, see Lockwood, de Meza, and Myles(1994)).

[41] For more discussion of tax exporting, see Krelove(1992).

destination taxes are second-best efficient. From the symmetry of the model, both countries have the same payoff at equilibrium, so both countries' welfare must be higher in the destination case. ¤

So, we see that the conventional wisdom that a move to origin-based taxation reduces tax rates is only true if the elasticity of substitution between the goods is sufficiently large. By assuming this elasticity infinite, many papers simply assume the conventional wisdom. Note also the link between Propositions 2 and 9; $t_o < t_d$ if and only if a small increase in both taxes, starting at the Nash equilibrium with origin-based taxes is Pareto-improving. Finally, note that as optimal taxes are uniform across goods in the Nash equilibrium, Proposition 9 continues to hold even if taxes are constrained to be uniform. On the other hand, the conventional wisdom that destination-based taxes are to be preferred on welfare grounds is confirmed.

7. Conclusions and Policy Recommendations

7.1. New Results

This paper has a general framework for analyzing tax competition under destination and origin principles, based on three possible commodity tax spillovers, the consumer price spillover, the producer price/terms of trade spillover, and rent spillovers. A model is presented which can be extended to accommodate all three spillovers. Using this model, many of the results in the existing literature can be derived, compared, and extended.

Key results are; (i) starting in destination-based Nash equilibrium in taxes, it is generally desirable to lower taxes on imports, and - if the two goods are substitutes- raise taxes on exports; (ii) the conventional wisdom that taxes are too low in origin-based Nash tax equilibrium (and should therefore be raised) is only true if goods are sufficiently strong substitutes; (iii) tax harmonization is desirable whenever a good is taxed more heavily by the importer than by the exporter. The innovation of this paper is partly to show that these conclusions are robust: i.e. they hold both in the case with an endogenous terms of trade (producer price externalities) and with imperfect competition (rent externalities).

7.2. Relaxing Some Assumptions

In some respects, the model used in this paper is quite special: two goods, two countries, a special production technology (one factor of production and constant returns to scale), and no costs of transporting goods for either individuals or firms. The assumption of two countries is however, common to all the literature in this area, except that dealing with the restricted origin principle (e.g. Lockwood, de Meza and Myles(1994)). The model could be straightforwardly generalized to n countries and n goods[42], while retaining the symmetric structure, by allowing each country to produce one good, and assuming the household in each country has a symmetric CES sub-utility function defined over the n goods with elasticity of substitution σ_n.

In this case, the consumer price spillover in the basic model is unchanged. To see this, let countries be indexed by $k; l; m = 1; ..n$; and note that (2.12) becomes:

$$\frac{\partial \Omega^l}{\partial t_k} = -\beta\lambda^l x_k^l + \eta^l t_l \sum_{m=1} \frac{\partial x_l^m}{\partial q_k}; \; k \neq l$$

But analogously to (2.2),(2.3), the cross price elasticity of demand in Nash equilibrium is $(\sigma - \varepsilon)/n$; so again, at the symmetric Nash equilibrium, the spillover is given by the formula (2.13). Moving to the extensions of the basic model, the qualitative features of the spillovers in both cases (factor mobility, imperfect competition) would be similar, because even with n countries, both countries and firms have monopoly power.

Note however, that generally[43], the Nash equilibrium level of the tax will vary with the number of countries and goods. For example,in the base case, the formula for Nash equilibrium origin-based taxes would change to

$$\frac{t_o}{1+t_o} = \left(\frac{n\eta_o - \beta\lambda_o}{\eta_o}\right)\frac{1}{\sigma_n + \varepsilon_o}$$

where the term $n\eta_o$ captures the fact that each country can "export" its tax burden to $n - 1$ other countries, rather than just one. So, other things equal, the larger the number of countries, the higher origin-based equilibrium taxes. On the other hand, it is plausible that goods become closer substitutes, there more goods there are (σ_n increasing in n), and this effect will reduce t_o:

Turning to transport costs, as remarked in Section 2, the finite elasticity of substitution between the goods can be interpreted as an indirect way of modelling

[42] Lockwood(1997) has an analysis of the n good version of the model in Section 3, without imposing any special structure on preferences.

[43] The exception is the base case with destination-based taxes, where the Nash equilibrium is unchanged as the number of countries varies, because each country solves its own independent optimal tax problem.

the case where goods are perfect substitutes, but where the imported good is more costly to buy. Finally, the analysis does rely quite heavily on the special Ricardian structure of production. For example, if we had several, rather than one, immobile factors of production, the producer price externality would be multidimensional. Again, decreasing returns to scale would generate pure rents, even without to imperfect competition, and so there would be rent spillovers. As argued in Section 5.1 above, it is di¢cult to get any results when moving to this level of generality.

7.3. Policy Implications

This paper has focussed on the theoretical contributions to the literature on destination and origin principles, but some policy implications do emerge from this study, especially given the robustness of our results. First, note that our model has no intermediate goods, so we do not distinguish between retail sales taxes and value-added taxes - our results apply equally to both. Also, as the model is static, a proportional labor income tax is equivalent to a uniform tax on the two goods, so our results have implications for income taxes as well[44].

However, in deriving such implications, caveats must be borne in mind, that some OECD countries do not operate a "pure" destination or origin regime, but rather a mixture of the two. This occurs for example within the EU, where cross-border shopping by private individuals is taxed on an origin basis[45], with other cross-border ‡ows of goods and services between EU countries are taxed on a destination basis (Keen and Smith(1996)). The picture is rather di¤erent in the US and Canada. There, state and provincial sales taxes are e¤ectively levied on private individuals according to an origin basis, with out-of-state purchasers paying the sales tax (if any) in the state of purchase, and to some extent that is also true of purchases by business …rms. This is the case even though the state where the purchaser is resident has the legal power to collect sales tax from the purchaser (Due(1983)), due to practical problems of enforcement. So, the US case can be described as de jure destination-based, but de facto origin-based.

Bearing in mind this caveat, some policy recommendations can be made. First, note that for EU countries, except for certain the narrowly de…ned commodities, the fraction of inter-EU trade that is taxed on an origin basis is tiny, and consequently, commodity taxation is e¤ectively destination-based. So, according to

[44] In our model, non-labour income (pro…t) should be taxed at 100% - see Section 4 above.

[45] The major exception is goods that need to be registered in the palce of residence, such as cars.

the analysis of this paper, the European Commission's emphasis on minimum tax rates is misplaced; rather, by Propositions 3 and 5, taxes should be cut on imported goods, and raised on those goods that are substitutes. This certainly seems a sensible recommendation for alcoholic drinks such as wine, which are typically taxed at a very low or zero rates in the exporting countries of the EU, and at high rates in the importing countries. By contrast, in the US, where taxation is effectively origin-based, there may be a case for raising taxes more generally (Propositions 2,4,6).

8. References

L.Bovenberg.(1994), “Destination and origin-based taxation under international capital mobility”, International Tax and Public Finance 1, 247-273

A. de Crombrugghe,and H.Tulkens(1990), “On Pareto-improving commodity tax changes under …scal competition”, Journal of Economics 41, 335-350

S. Delipalla (1996) “Commodity tax harmonization and public goods”, Journal of Public Economics 63, 447-466

J.F.Due (1983) “The retail sales tax: the US experience”, in Comparative Tax Studies (ed. S.Cnossen), North-Holland

A.F.Friedlander and A.L.Vandendorpe, (1968), “Excise taxes and the gains from trade”, Journal of Political Economy, 76, 1058-1068

H.Grossman(1980), “Border tax adjustments: do they distort trade?”, Journal of International Economics, 10,

A. Hau‡er(1996) “Tax coordination with di¤erent preferences for public goods: con‡ict or harmony of interest?” International Tax and Public Finance 3, 5-28

A. Hau‡er (1998) “Asymmetric commodity tax competition - comment on de Crombrugghe and Tulkens”, Journal of Public Economics 67, 135-144

A.Hau‡er and S.B.Nielsen (1997), “Dynamic e¤ects of an anticipated switch from destination- to origin-based commodity taxation”, Journal of Economics 66, 43-69

T.Georgakopoulos and T.Hitiris, (1991), “On the equivalence of the destination and the origin principles of taxation in the case of non-general product taxes”, Osaka Economic Papers, Vo. 39

T.Georgakopoulos and T.Hitiris, (1992), “On the superiority of the destination over the origin principle of taxation for intra-union trade”, Economic Journal, 102, 117-126

R.Gordon(1983), “An optimal tax approach to …scal federalism”, Quarterly Journal of Economics, 48, 566-586

H.Huizinga and S.B.Nielsen (1997), “Capital income and pro…t taxation with foreign ownership of …rms”, Journal of International Economics 42, 149-165

R.Kanbur and M.Keen (1993) “Jeux sans frontiers: tax competition and tax coordination when countries di¤er in size”, American Economic Review,XX, 877-892

M. Keen (1987) “Welfare e¤ects of commodity tax harmonization”, Journal of Public Economics 33, 107-114

M.Keen(1989) “Pareto-improving indirect tax harmonization”, European Economic Review 33, 1-12

M.Keen and S.Lahiri (1993) “Domestic tax reform and international oligopoly”, Journal of Public Economics 51, 55-74

M.Keen and S.Lahiri (1998), “The comparison between destination and origin principles under imperfect competition, Journal of Public Economics 45, 323-350

M.Keen, S.Lahiri, and P.Raimondos-Moller (1998) “When is Policy Harmonization Desirable?”, EPRU Working Paper 98-02, University of Copenhagen

M.Keen and S.Smith (1996), “The future of VAT in the European Union”, Economic Policy 23, 373-411

J.Kennan and R.Riezman (1998), “Do big countries win tariff wars?”, International Economic Review, 29, 81-85

R.Krelove(1992), “Efficient tax exporting”, Canadian Journal of Economics, 25, 145-55

S.Lahiri and P.Raimondos-Moller, (1998) “Public good provision and the welfare effects of indirect tax harmonization”, Journal of Public Economics 67, 253-267

B.Lockwood (1993), “Commodity tax competition under destination and origin principles”, Journal of Public Economics 52, 141-162

B.Lockwood(1997), “Can commodity tax harmonization be Pareto-improving when governments supply public goods?”, Journal of International Economics 1997,43, 387-408

B.Lockwood, D.de Meza and G.Myles(1994), “When are origin and destination regimes equivalent?”, International Tax and Public Finance, 1,

B.Lockwood, D.de Meza and G.Myles(1994a) “The equivalence between destination and non-reciprocal restricted origin tax regimes”, Scandinavian Journal of Economics, 96, 311-328

J.McMillan, (1986), Game Theory in International Economics, Harwood

M-A.Lopez-Garcia (1996) “The origin principle and the welfare gains from indirect tax harmonization”, International Tax and Public Finance 3, 83-93

Lopez-Garcia(1997), “On welfare and revenue effects of indirect tax harmonization”, unpublished paper, Universidad Autonoma de Barcelona

J.Mintz and H.Tulkens (1986) “Commodity tax competition between member states of a federation: equilibrium and efficiency”, Journal of Public Economics 29, 133-172

S.B.Nielsen (1998) “A simple model of commodity taxation and cross-border shopping”, unpublished paper, EPRU, Copenhagen Business School

H.Shibata (1967), "The theory of economic unions", in C.S.Shoup (ed.) Fiscal Harmonization in Common Markets, Columbia University Press

G. Trandel(1994) "Interstate commodity tax di¤erentials and the distribution of residents", Journal of Public Economics 53, 435-457

A. Venables(1982), "Optimal tari¤s for trade in monopolistically competitive commodities", Journal of International Economics 11, 225-241

J.Whalley (1979), "Uniform domestic tax rates, trade distortions, and economic integration", Journal of Public Economics 11, 213-221

J.Wilson(1986), "A theory of interregional tax competition", Journal of Urban Economics 39, 296-315

G.Zodrow and P.Miezowski(1986), "Pigou, Tiebout, property taxation and the underprovision of local Public Goods", Journal of Urban Economics, 19, 356-370

A. Appendix

A.1. Proofs of Propositions

Proof of Proposition 4. Part (i) follows from the fact that if governments are Leviathans, the spillover is $\eta\frac{t}{1+t}[\sigma - \varepsilon] + \theta$; which is positive as $\sigma > \varepsilon$ by the fact that goods are assumed substitutes.

To prove part (ii), first set $\beta = 1$. Now note that the first-order condition for the choice of t_1 by country a is

$$\frac{\partial \Omega^a}{\partial t_1} = -\lambda^a x_1^a + \eta^a \left[x_1^a + x_1^b + t_1 \left(\frac{\partial x_1^a}{\partial q_1} + \frac{\partial x_1^b}{\partial q_1} \right) \right] + \frac{\partial \Omega^a}{\partial p}\frac{\partial p}{\partial t_1} = 0 \qquad \text{(A.1)}$$

i.e. as in (6.4), except that the country takes into account the effect of its tax instrument on the terms of trade. Evaluating (A.1)at the symmetric Nash equilibrium as before, using the fact that at this equilibrium $\partial p/\partial t_1 = -\partial p/\partial t_2$, $x_j^i = x$, $\lambda^i = \lambda$, $\eta^i = \eta$, $t_i = t$, and dividing through by x, we get

$$-\lambda + \eta \left[2 - \frac{t}{1+t}(\sigma + \varepsilon) \right] - \theta = 0; \; \theta = \frac{1}{x_2^a}\frac{\partial \Omega^a}{\partial p}\frac{\partial p}{\partial t_2}:$$

Solving, we get

$$\frac{t}{1+t} = \left(\frac{2\eta - \lambda - \theta}{\eta} \right) \frac{1}{\sigma + \varepsilon} \qquad \text{(A.2)}$$

Substituting (A.2) into (3.17), we see that the spillover can be written

$$\begin{aligned} \frac{1}{x}\frac{\partial \Omega^a}{\partial t_2} &= -\lambda + \eta \left(\frac{2\eta - \lambda - \theta}{\eta} \right) \frac{1}{\sigma + \varepsilon}[\sigma - \varepsilon] + \theta \\ &= \frac{2}{\sigma + \varepsilon}[(\sigma - \varepsilon)\eta - \sigma\lambda + \theta] \end{aligned}$$

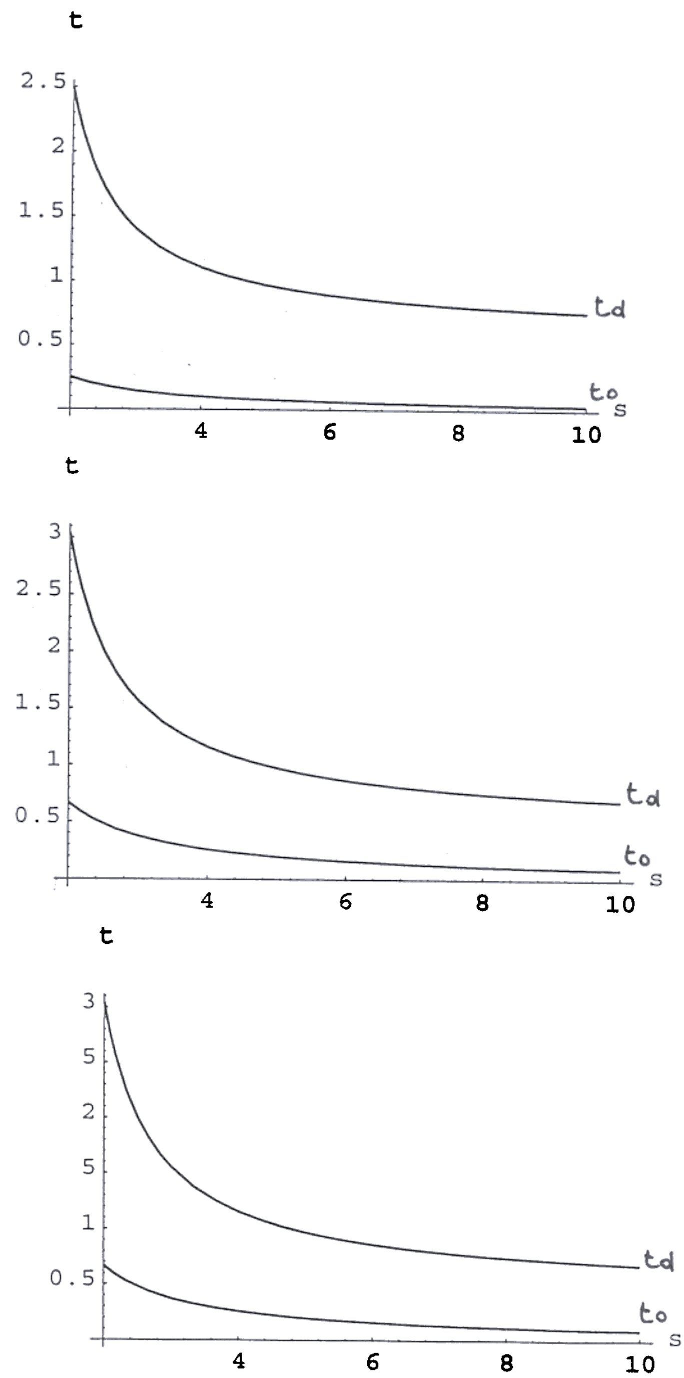
So, the spillover is positive iff $\sigma > (\varepsilon\eta - \theta)/(\eta - \lambda) = \underline{\sigma}$ and so the result follows. □

Proof of Proposition 6. In the Leviathan case, the overall spillover is proportional to $\sigma - \varepsilon$, and so the result follows immediately. To prove part (ii), note that the first-order condition for the choice of t_1 by country a is

$$\frac{\partial \Omega^a}{\partial t_1} = -\lambda^a x_1^a + \eta^a \left[(x_1^a + x_1^b) + t_1 \left(\frac{\partial x_1^a}{\partial q_1} + \frac{\partial x_1^b}{\partial q_1} \right) \right] + (\beta\lambda^a(1-\tau) + \eta^a\tau)\frac{\partial \pi^a}{\partial q_1} = 0 \qquad \text{(A.3)}$$

Figure 1

Destination and Origin Effective Taxes with Producer Price Spillovers.



Values of h': .0, .5, 2.0.

Figure 2(a)

Desti d Or ffec T w h R pill rs h b

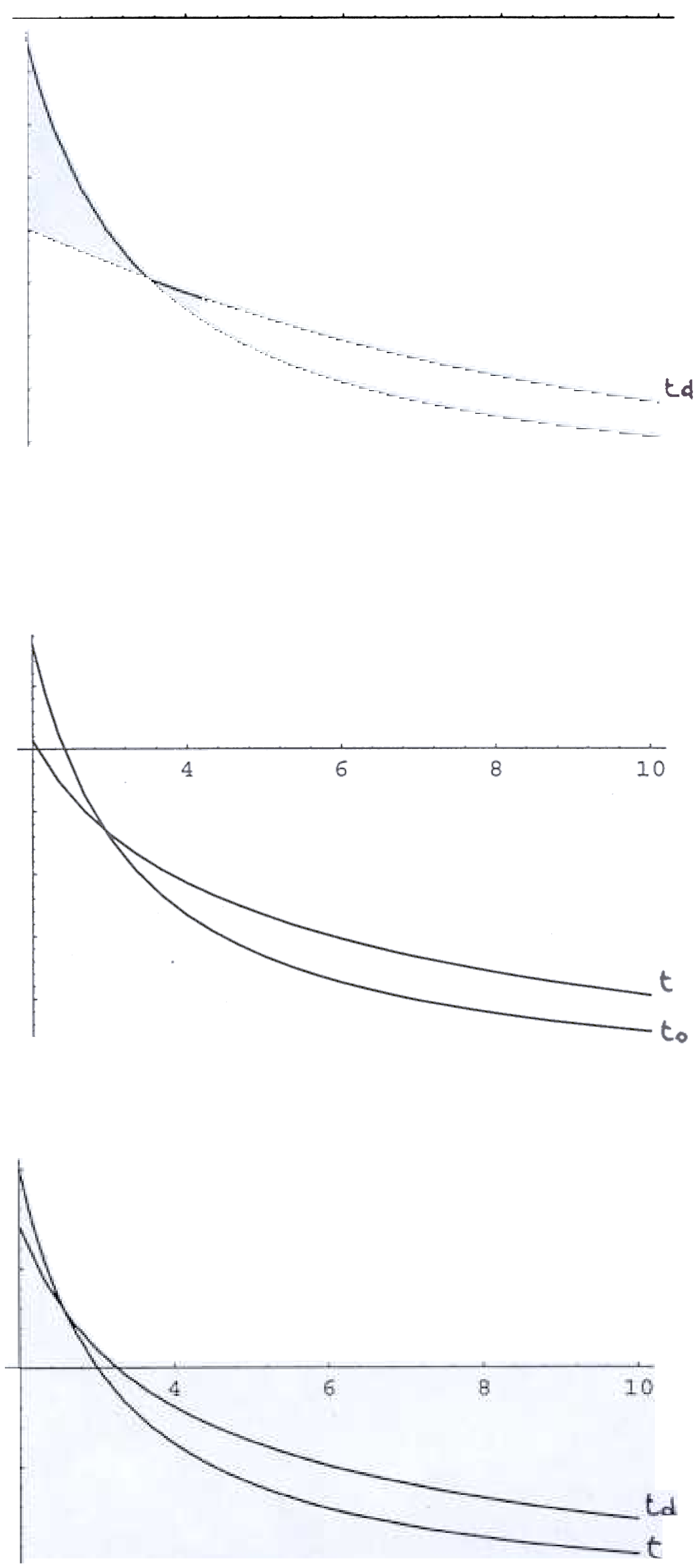
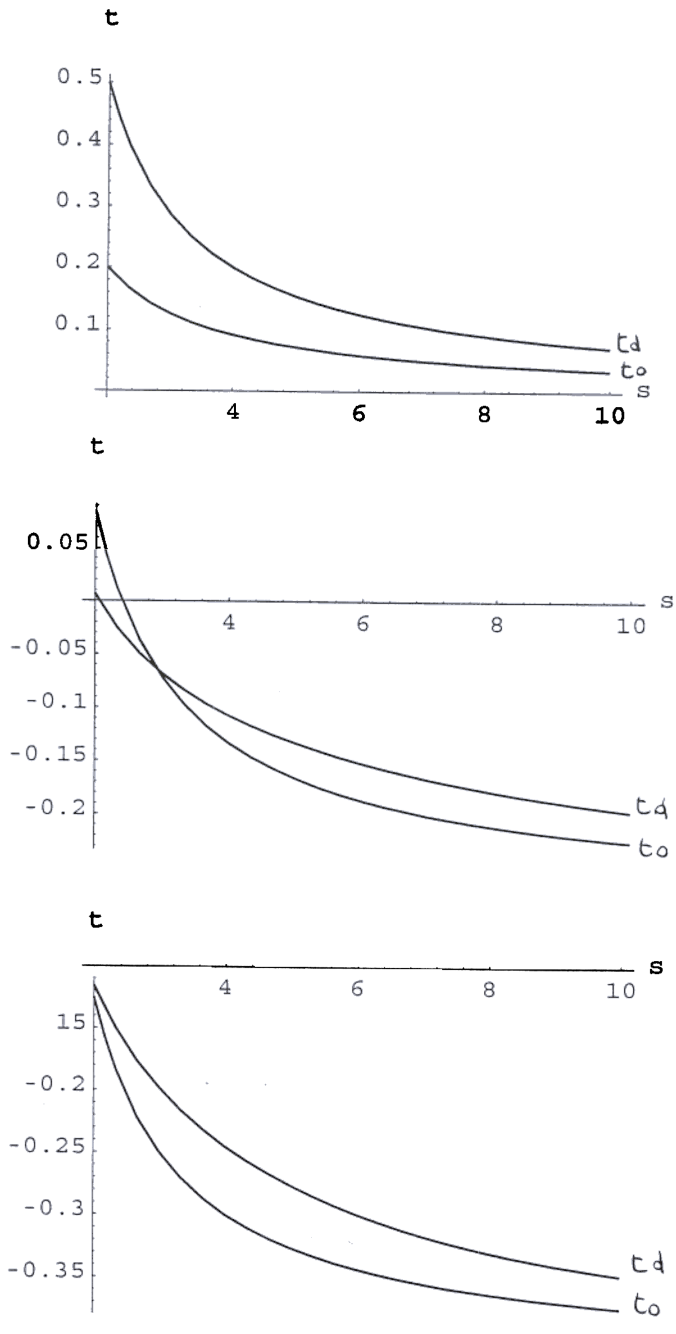


Figure 2(b)

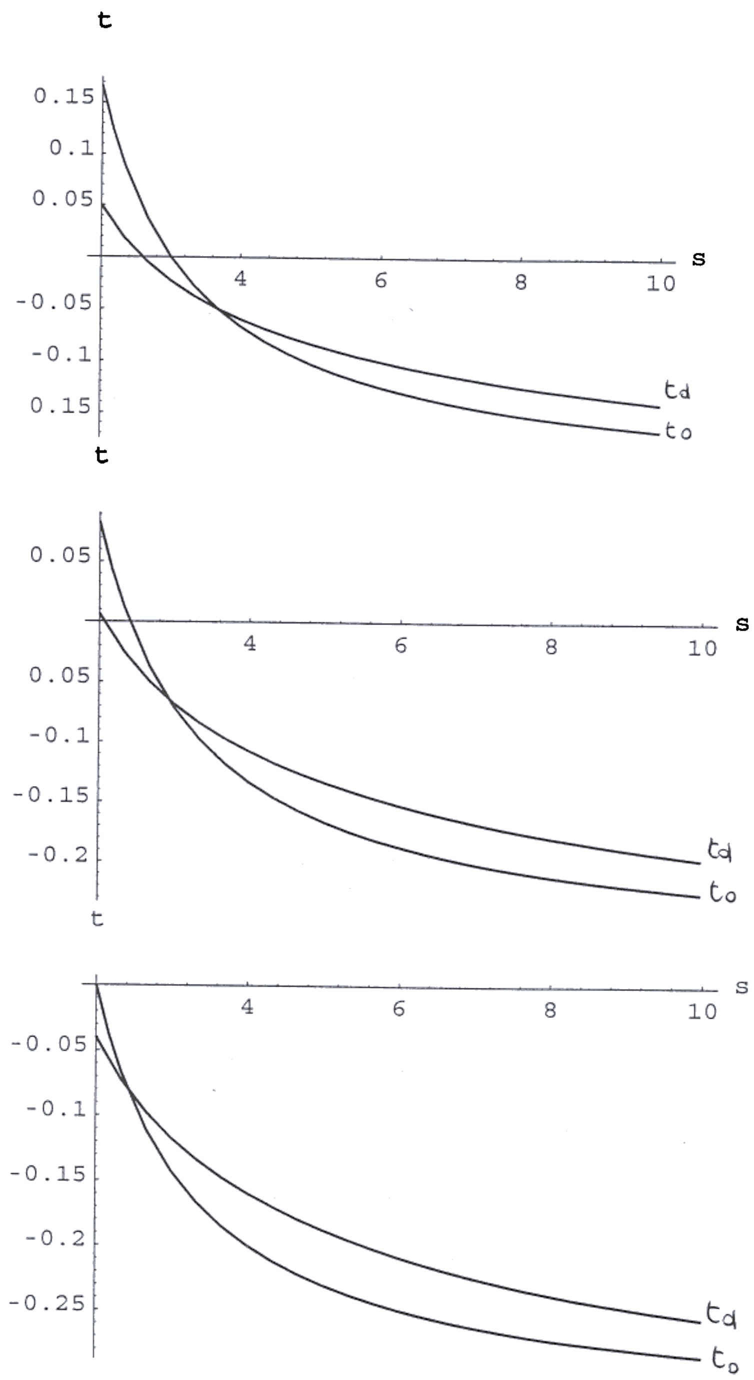
Destination and Origin Effective Taxes with Rent Spillovers (μ variable).



Values of μ: .0, .5, 2.0.

Figure 2(c)

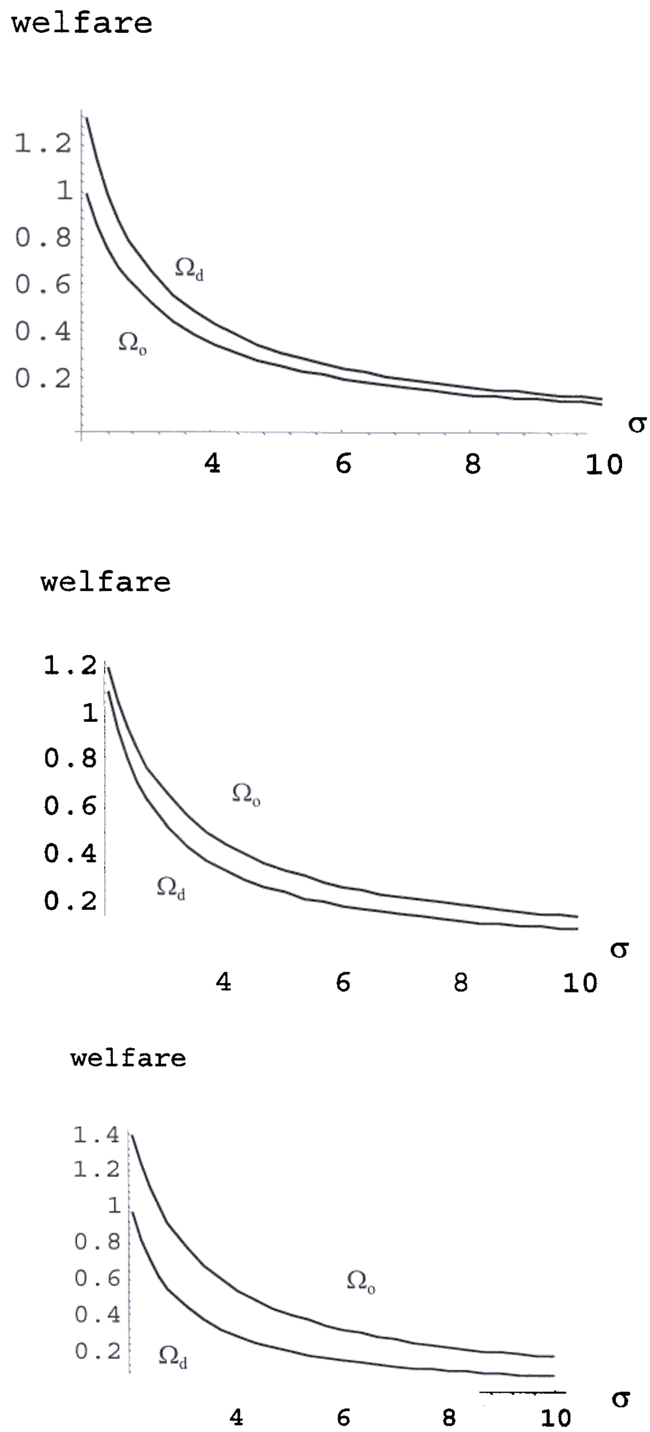
Destination and Origin Effective Taxes with Rent Spillovers (τ variable).



Values of τ: 0.0, 0.5, 1.0.

Figure 3

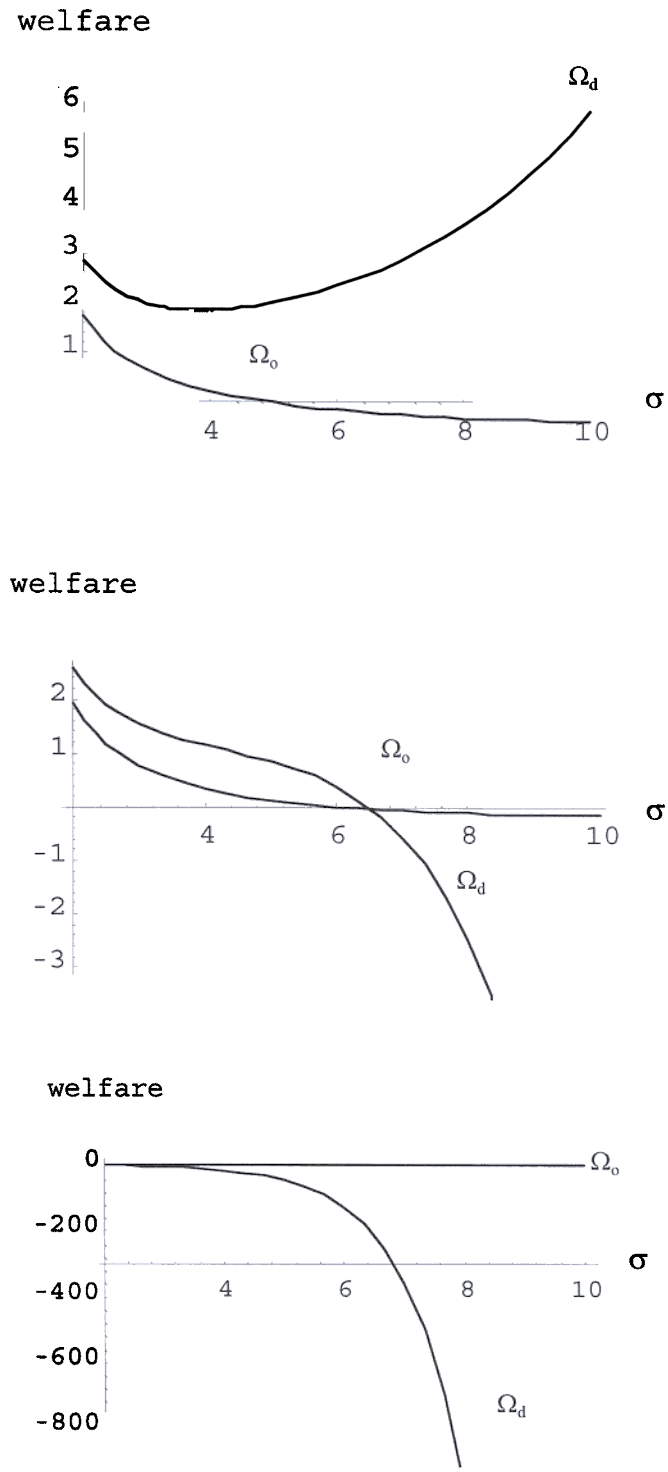
Destination and Origin Welfare Levels with Producer Price Spillovers.



Values of h′: 1.0, 1.5, 2.0.

Figure 4 (a)

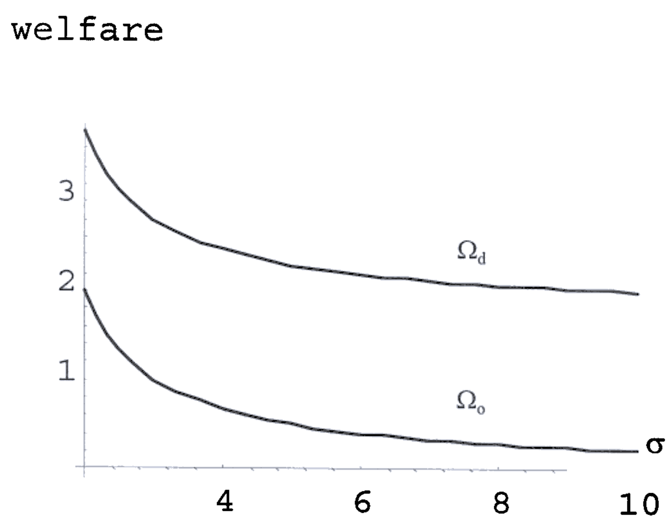
Destination and Origin Welfare Levels with Rent Spillovers (h′ variable).

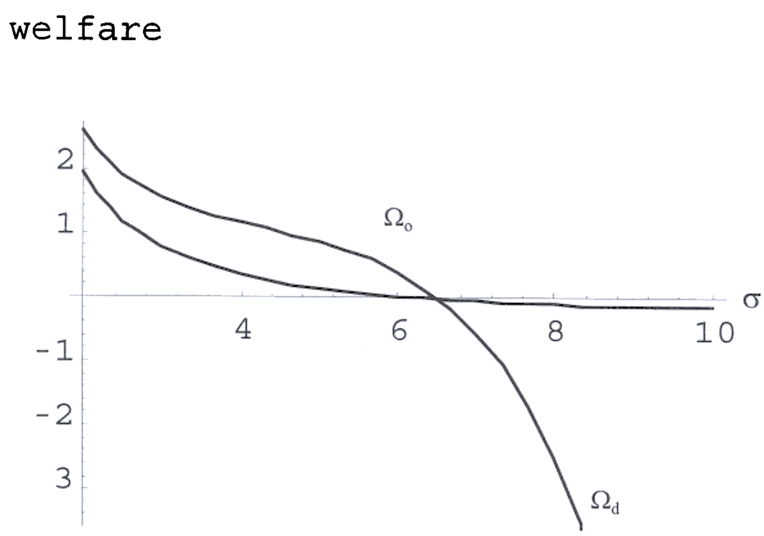


Values of h′: .0, .5, 2.0.

<u>Figure 4 (b)</u>

Destination and Origin Welfare Levels with Rent Spillovers (μ variable).

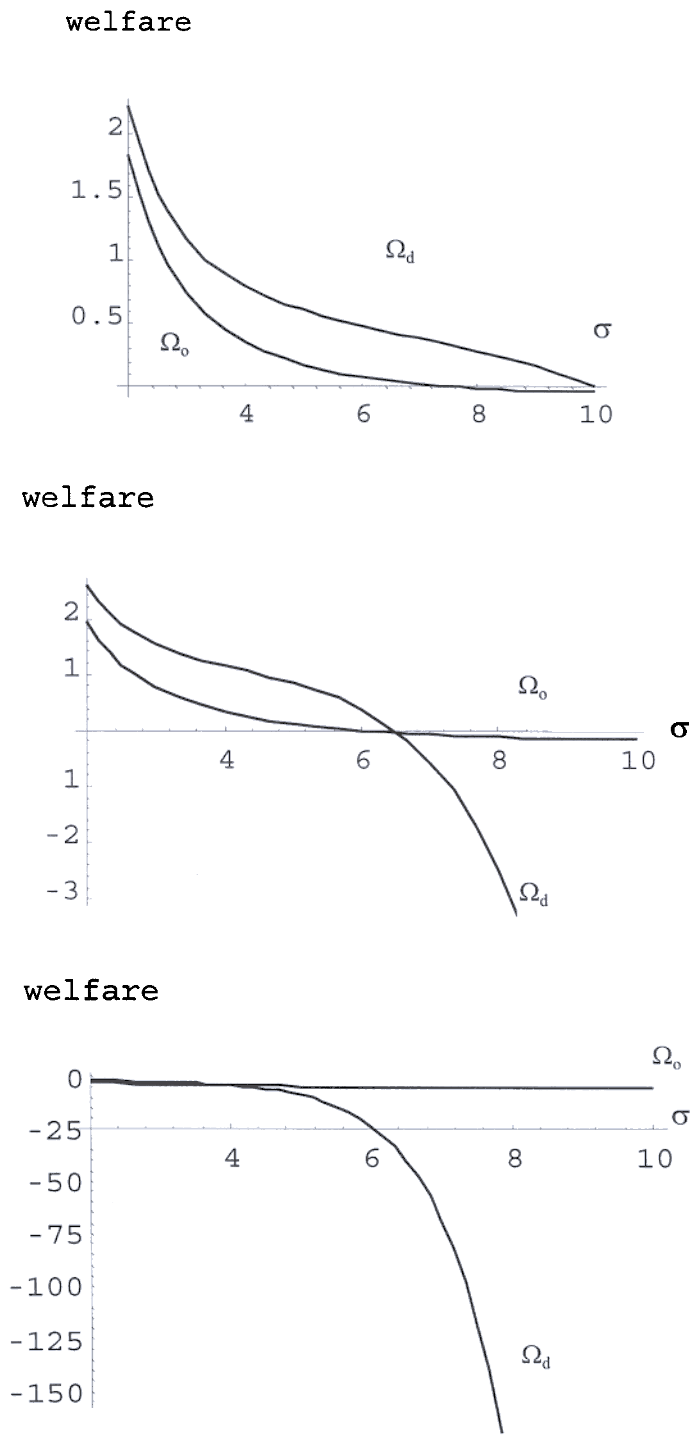




Values of μ: 1.0, 1.5.

Figure 4 (c)

Destination and Origin Welfare Levels with Rent Spillovers (τ variable).



Values of τ: 0.0, 0.5, .0.

Table 1 - The Main Results[1]

Key Assumptions	Types of Spillover	Tax reform results (D)	Tax reform results (O)	Tax harmonisation results (D)	Comparison of destination and origin tax rates and welfare levels	Equivalence results with uniform taxation
perfect competition factor mobility	Consumer price(O)	no welfare-improving tax reforms	increase in both taxes is Pareto-improving *only* if goods are sufficiently strong substitutes	no welfare-improving tax harmonisation	destination tax rate greater than origin tax rate *only* if goods are sufficiently strong substitutes	D and O tax equilibria *not* equivalent
perfect competition factor immobility	Consumer price(O), producer price(O,D)	decrease (increase) in taxes on imported (exported) goods is Pareto-improving	as above	harmonisation is Pareto-improving iff tax rate on imported goods is higher than tax rate on exported goods	Origin effective tax rate lower, welfare levels ambiguous[2]	D and O tax equilibria equivalent
imperfect competition	Consumer price(O),	as above	as above	as above	Effective tax rates and welfare levels ambiguous[3]	D and O tax equilibria *not* equivalent

[1] Assuming that governments are welfaristic, and that the two goods are substitutes
[2] Simulation results only
[3] Simulation results only

factor mobility	rent(O,D)					