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On the optimal tax policy mix when consumers and firms are imperfectly mobile

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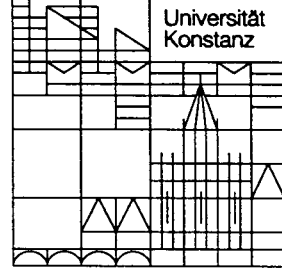
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**Sonderforschungsbereich 178
„Internationalisierung der Wirtschaft“**

Diskussionsbeiträge

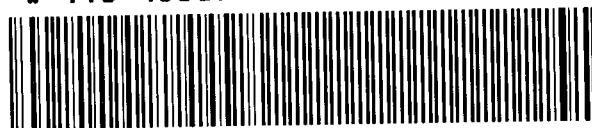
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when Consumers and Firms are
Imperfectly Mobile**

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**On the Optimal Tax Policy Mix when
Consumers and Firms are Imperfectly Mobile**

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Abstract

An optimal taxation approach is employed to discuss the interaction between factor and commodity taxes for a small open economy when both profit-earning firms and domestic consumers are imperfectly mobile internationally. In this framework, we demonstrate two main results: first, a destination-based commodity tax dominates an origin-based VAT from an efficiency perspective since the first is an independent instrument in the presence of non-wage income, whereas the latter can be duplicated by an appropriate combination of wage and (cash-flow) profit taxation. Second, with mobility costs for firms the optimal profit tax is positive even if the location of firms imposes no social costs on the small country. Simulation results show how the optimal mix of wage, profit and consumption taxes depends on key model parameters.

Zusammenfassung

Anhand eines Optimalsteueransatzes wird das Zusammenwirken von Faktor- und Gütersteuern in einer kleinen offenen Volkswirtschaft untersucht, wenn Standortverlagerungen von international mobilen Firmen und heimische Direktimporte durch Konsumenten Transaktionskosten verursachen. In diesem ökonomischen Modellrahmen erweist sich eine bestimmungslandbasierte Mehrwertsteuer einer ursprungslandbasierten aus Effizienzgründen überlegen, da sie ein eigenständiges Besteuerungsinstrument darstellt, wenn neben den Löhnen weitere Einkommen erzielt werden. Dagegen kann eine Mehrwertsteuer nach dem Ursprungslandprinzip durch eine geeignete Kombination von Lohnsteuern und Gewinnsteuern (cash flow Steuer) ersetzt werden. Als zweites Ergebnis der Analyse ergibt sich bei unvollkommener Firmenmobilität ein positiver Gewinnsteuersatz, auch wenn die Firmenansiedlung im kleinen Land keine sozialen Grenzkosten verursacht. Die Abhängigkeit des optimalen Besteuerungsmix von zentralen Modellparametern wird mit Hilfe von Simulationen veranschaulicht.

JEL classification: H21, H25, H73, R30

1 Introduction

The past decade has seen a remarkable acceleration of the process of European integration revolving around the realization of the so-called “four liberties” (the free flow of goods, services and capital as well as the free migration of workers). The resulting, increased international mobility of commodity and factor tax bases significantly changes the framework for national tax policy (cf., e.g., Sinn 1994). In the policy debate, concern has so far been mainly with the future system of value-added taxation in Europe on the one hand, and the taxation of capital income and corporate profits on the other.

Since 1993, EU citizens are allowed to purchase commodities in any member country at the going consumer prices, which include the commodity taxes (VAT and excises) of the country of purchase. Cross-border shopping of final consumers is no longer subject to any border tax adjustment mechanism and follows the rules of an origin-based tax system, thereby favouring shopping in low tax countries. On the other hand, member states have decided to maintain the destination principle for commodity trade in the business sector. This is true for the prevailing transitional VAT regime (a variant of the deferred payment scheme), but also for the Commission’s proposal of a final European VAT with transnational tax credits. To limit the problems posed by cross-border shopping, a minimum standard VAT rate of 15 % has been instituted in the European Union, and similar minimum rate requirements hold for various excise taxes.

Also since 1993, but in effect already since 1990, business capital can move freely between EU member countries and locate in any place which promises an attractive rate of return. The mobility of internationally operating firms has been further enhanced by several directives which eliminate various forms of tax discrimination against EU multinationals. While no explicit measures of tax harmonization in the field of capital income and corporate profit taxation have been taken so far, such steps have been strongly recommended by the Ruding Committee instituted by the European Commission (Ruding Report, 1992). Meanwhile many national governments have unilaterally responded to the increased mobility of internationally operating firms. In Germany, for example, the corporate income tax rate has been reduced to 45 % in the “Standortsicherungsgesetz” and the discussion about a second round of a business tax reform, including a partial abolition of the Gewerbesteuer (business tax) has only been postponed as a matter of fiscal pressure.

In most of the literature, the issues raised by the abolition of border controls on the one hand and by increased capital and firm mobility on the other have been discussed in isolation. As a solution to the problem of cross-border shopping several authors have proposed to replace the current commodity tax scheme with a “true” origin-based VAT within the EU, taxing all trade by either consumers or the business sector in the exporting country (Sinn 1990, Krause-Junk 1990).¹ While much of this debate has been

¹It has also been shown that an EU-wide origin principle can be designed in a way which avoids

carried out in a framework with commodity trade only, recent contributions have begun to analyze the interactions between commodity and factor flows. In a setting with perfect international capital mobility, a uniform origin-based VAT, like a cash-flow tax on corporate income, retains its allocational efficiency by exempting all investment from tax and thus remains an attractive reform option. This argument has – to our knowledge – first been made by Krause-Junk (1992) and has later been extended by Bovenberg (1994) and Genser/Haufler/Sørensen (1995). However, there is a critical difference between capital mobility and the mobility of firms. As is shown in Richter (1994), the allocational neutrality of a cash-flow tax – or an origin-based commodity tax – no longer holds if profit-making firms can move between countries.

Based on these results, two recent papers have discussed the choice between the destination principle and the origin principle in a framework with perfect international mobility of firms (Genser and Haufler 1996, Richter 1996). In general, these analyses find that a destination-based commodity tax dominates an origin-based tax, although the two may also be equivalent in certain cases. Another result derived from these optimal taxation analyses is that internationally mobile firms should only be taxed to the extent that they cause positive marginal “congestion costs” in the jurisdiction in which they locate.

The present paper extends this work by considering *imperfect* mobility of firms. In a model where location matters, mobility costs for firms can arise for a variety of reasons: they may reflect additional transport costs for shipping goods to a central marketplace in the country, or they may result from increased set-up or development costs as firms have to settle in inferior locations. Alternatively, and more in a regional economics tradition, increased costs for firms can arise from fixed factors such as land, whose price is driven up as the number of firms operating in the country increases. Costly mobility of firms is combined with imperfect mobility of consumers, who can cross-border shop in the foreign country but incur convex transaction costs in doing so (e.g. Kanbur and Keen 1993). Hence, as in Richter (1996), there is a symmetry between consumers and firms, but the symmetry is here of a different kind. Richter considers households and firms which face no mobility costs but cause positive congestion costs for the jurisdiction in which they locate. In contrast, the present analysis assumes that congestion costs are zero but mobility costs are positive.

The remainder of this paper is organized as follows. Section 2 presents the basic model, which describes the optimization problems of households and firms and introduces four possible tax instruments: destination- and origin-based commodity taxes, as well as a wage and a profit tax. In section 3, second-best tax rules are derived and interpreted. The main results are that (i) a destination-based commodity tax continues to dominate an origin-based tax, even if firm mobility is imperfect, (ii) the destination-based VAT rate

consistency problems when trade with non-EU countries remains taxed under the destination principle (Lockwood, de Meza and Myles 1995, Genser 1996).

can never be negative in the optimum, and (iii) the optimal profit tax is always positive in the presence of mobility costs. Section 4 illustrates the optimal pattern of tax rates by changing the values of key model parameters. Section 5 concludes.

2 The model

We consider a small country (the ‘home country’) with identical individuals that can be treated as a single, representative household. The household supplies an endogenous amount of internationally immobile labour (L) and consumes an aggregate private good (C). Its utility function has the usual properties and is given by

$$u = u(C, -L). \quad (1)$$

The world price of the single output good is normalized to unity. In principle, the small country can tax both the consumption and the production of the aggregate good. In the first case, the tax corresponds to a destination-based commodity tax (t_d) whereas it is an origin-based commodity tax (t_o) in the second case. Also, we do not impose any restrictions on the sign that each tax rate may have. The domestic producer price p and the domestic consumer price q are given by

$$p = 1 - t_o, \quad (2)$$

$$q = 1 + t_d. \quad (3)$$

Production in the small country takes place in n identical firms, where n is taken to be a continuous variable. All firms are owned by foreigners, a simplifying assumption to which we will return below. Each firm chooses a labour input l and employs a fixed factor, which can alternatively be thought of as a public intermediate input (Richter 1994, 1996), or as entrepreneurial services (cf. Huizinga and Nielsen 1996). The production function at the firm level, $x(l)$, exhibits decreasing returns to scale in the labour input only and constant returns to scale in both factors together, hence giving rise to pure profits before tax (π).

In addition to the two commodity tax instruments, the governments also disposes of a tax on wages (t_w) and of a cash-flow tax on the firm’s profits (t_p). For algebraic simplicity, both of these taxes are modelled as unit taxes. The wage tax creates a wedge between the gross wage w and the net wage ω

$$\omega = w - t_w. \quad (4)$$

Foreign-owned firms can realize a fixed profit level π^* in the (large) world market. We assume that an interior solution exists, i.e., in the tax equilibrium it is profitable for a strictly positive number of firms to produce in the small home country.

If international firm mobility were perfect, then net profits earned in the small country would have to equal the international profit level. Furthermore, defining gross profits as the

difference between the revenues from selling output and the labour costs incurred, the only deduction from the gross profit level would be cash-flow taxes. There are, however, several reasons why a rising number of firms that locate in the small country will lead to additional costs that increase the wedge between gross and net profits. One possible scenario is that firms locate around a central marketplace (for example a harbour from which exports are shipped) and early entrants will be able to settle close to this market while later entrants have to locate in more distant places and incur additional transportation costs. A similar argument can be made using set-up or development costs which increase for new entrants that are forced to settle in inferior locations.²

Alternatively, and closer to the regional economics tradition, it can be argued that the fixed factor underlying our analysis consists not exclusively of free public inputs or entrepreneurial services. Rather, it partly represents the return to a private factor in limited supply (e.g. land) and an increasing number of firms producing in the small country drives up the land rent to be paid in equilibrium. To exclude the income effects that arise for land owners, this interpretation of mobility costs requires the further assumption – a common one in the local public finance literature – that land is entirely owned by foreigners (“absentee landowners”; cf. Wildasin 1986 and Wellisch 1995).

Any of these scenarios can be called on to motivate an additional mobility (or location) cost element $\rho(n)$ that is a rising function of the number of firms operating in the small country. If internationally mobile firms produce in the large world market, then they are guaranteed the profit level π^* . International arbitrage by firms ensures that net profits received in the small country – after the deduction of both profit taxes and location costs – are equal to this exogenous profit level. Hence the gross profit level that must be earned in the small country is determined by

$$\pi - t_p - \rho(n) = \pi^*, \quad \rho'(n) > 0. \quad (5)$$

The arbitrage condition (5) generalizes the case of perfect firm mobility [$\rho(n) = 0$] that we have discussed in an earlier paper (Genser and Haufler 1996). In this case a reduction in the domestic profit tax t_p leads to an inflow of foreign firms until the level of gross profits has fallen by the full amount of the tax. If, instead, mobility costs are positive, then the inflow of foreign firms induced by a reduction in the domestic profit tax rate will be limited by the additional costs that new entrants face. Hence a given reduction in t_p will not be fully matched in the new equilibrium by a corresponding reduction in the level

²An analytically similar approach is followed by Hagen, Osmundsen and Schjelderup (1995), who model firms which parametrically differ in their opportunity costs of relocating and hence exhibit varying degrees of international mobility. The authors give the example of the shipping industry where producers of bulk carriers and tankers make use of standard technology and thus face low extra costs of foreign investment. At the other end of the scale, firms trying to enter the freight industry of a foreign country face specific national regulations and information requirements, which impose high mobility costs.

of gross profits.³

From (2)–(3), producer and consumer prices in the small country are directly determined by the world price of unity and the tax rates chosen by the government. In contrast, both the gross wage w and the gross profit level π in the small country are endogenous. Together with the producer price p , they determine the level of employment in each firm, $l(w, p, \pi)$, from the gross profit definition $px(l) - wl = 0$. The gross profit requirement acts like a factor price in a setting with internationally mobile firms so that labour demand depends, as usual, on the price of output and all factor prices. Furthermore, we can express the gross wage as $w(p, \pi)$, using the firm's profit maximization condition $p(\partial x / \partial l(w, p, \pi)) = w$.⁴ Hence the gross profit identity can be written as

$$p x[l(w(p, \pi), p, \pi)] - w(p, \pi) l[w(p, \pi), p, \pi] - \pi = 0.$$

Labour demand is homogeneous of degree zero in (w, p, π) and since we will need this property in the following it is important to clearly separate the direct effects of (tax-induced) changes in p and π from the indirect effects that operate through changes in the gross wage. Differentiating the profit definition with respect to p and π and using the property that the wage rate equals the marginal value product of labour in the firm's optimum gives

$$\frac{\partial w}{\partial \pi} = \frac{-1}{l} < 0, \quad \frac{\partial w}{\partial p} = \frac{x(l)}{l} > 0. \quad (6)$$

The interpretation of these derivatives is straightforward: a higher gross profit requirement will reduce the gross wage that firms are paying in equilibrium for any given output price p , whereas a higher output price will allow a higher gross wage for any given level of gross profits. This completes the description of the production side of our model.

Turning to consumption, we model imperfect mobility of consumers in a way that is similar to the treatment of firms. Total consumption of the homogeneous private good (C) consists of domestic (c^H) and foreign (c^F) purchases:

$$C = c^H + c^F. \quad (7)$$

If the home country levies a consumption tax $t_d > 0$, then its residents can shop abroad and purchase goods at the world price of unity, but these purchases are subject to convex transaction costs (e.g. Kanbur and Keen, 1993). We emphasize that our analysis also allows for the symmetric case where the home country offers a consumption subsidy $t_d < 0$. In this case it attracts foreign consumers ($c^F < 0$) and hence, from (7), the total amount of goods

³A similar argument would apply in the *absence* of mobility costs, if the home country were large in the world economy. In this case, the profit level π^* in the rest of the world becomes an endogenous variable and rises in response to a reduction in t_p . Hence, as in the case discussed here, gross profits in the home country will not fall by the full amount of the tax in the new international equilibrium.

⁴The relationship $w(\pi)$ is analogous to the “factor price frontier” in models where the inputs are labour and capital (e.g. Bucovetsky and Wilson 1991).

purchased in the home country (c^H) exceeds the total consumption of the representative individual (C). The relationship between the level of cross-border shopping (in either direction) and the consumer transaction costs incurred is shown in Figure 1.

Figure 1 about here

The properties of the consumer transaction cost function $\tau(c^F)$ are summarized as follows:

$$\tau(c^F) > 0 \text{ if } c^F \neq 0, \quad \text{sign}(\tau') = \text{sign}(c^F), \quad \tau(0) = \tau'_c(0) = 0, \quad \tau'' > 0.$$

Consumer arbitrage equalizes the marginal transaction costs of foreign purchases with the difference in consumer prices between home and foreign goods. From (3) this implies $\tau'(c^F) = q - 1$ in the consumer optimum, irrespective of the direction of cross-border shopping. Inverting determines the volume of cross-border shopping as a function of the domestic consumer price

$$c^F(q) = (\tau')^{-1}, \quad c^F(1) = 0.$$

Differentiating with respect to q gives

$$\frac{\partial c^F}{\partial q} = \frac{1}{\tau''} > 0, \tag{8}$$

which holds for either positive or negative values of c^F . Consumer transaction costs represent a loss of real resources and enter the budget constraint for the representative individual in the home country if c^F is positive. By assumption, domestic residents do not earn profit income since all firms are foreign-owned. However, we do allow for an additional source of income to domestic residents, for example from a fixed level of foreign assets which earn interest income in the world market. Since the rate of return to these assets is also fixed, non-wage income is lump sum and denoted by $Z \geq 0$. We assume that there is no independent instrument to tax this source of income. This assumption can be motivated by the absence of *worldwide* cooperation agreements between tax authorities, which implies that any residence-based tax on worldwide income can easily be evaded by simply not declaring foreign-source income (cf. Razin and Sadka 1991).

The consumer budget constraint depends on the direction of consumer purchases, or the *trade regime*. If domestic residents shop abroad ($c^F > 0$), then the budget constraint reads $q c^H + c^F + \tau(c^F) = \omega L + Z$, which can be rearranged using (7). If instead $c^F \leq 0$, then all domestic income must be spent at home.⁵ Hence we get

$$q C = \omega L + Y, \tag{9}$$

⁵By Walras' law, the budget constraints for the consumer and the government of the home country simultaneously ensure balanced trade or - more precisely, in the present context - a balanced current account.

where

$$Y = Z + [(q - 1) c^F - \tau] \text{ if } c^F > 0, \quad Y = Z \text{ if } c^F \leq 0.$$

Therefore, for $c^F > 0$, exogenous income includes the aggregate tax savings that home residents can make by shopping abroad. Maximizing (1) subject to (9) yields the individual's (regime-specific) indirect utility function $v(q, \omega, Y)$. By Roy's identity, and setting the marginal utility of private income equal to one for notational simplicity, the derivatives of the indirect utility function are given by

$$\begin{aligned} \frac{\partial v}{\partial \omega} &= L(q, \omega, Y), \\ \frac{\partial v}{\partial q} &= -c^H(q, \omega, Y) \text{ if } c^F > 0, \quad \frac{\partial v}{\partial q} = -C(q, \omega, Y) \text{ if } c^F \leq 0. \end{aligned} \quad (10)$$

Production and consumption decisions together determine the last endogenous variable in this model, the number of firms operating in the small country. Since firms are identical by assumption, the labour market clearing condition gives

$$n(p, q, \pi, \omega, Y) = \frac{L(q, \omega, Y)}{l[w(p, \pi), p, \pi]}. \quad (11)$$

The government of the small country maximizes the indirect utility of the representative consumer, subject to a given revenue requirement $R_0 > 0$. The problem is thus

$$\max v(q, \omega, Y) \quad \text{s.t.} \quad R_0 = t_d c^H + t_w L + t_o n x + t_p n,$$

where $n x$ is total output produced in the small open economy and t_p , modelled as a unit tax, acts like a tax on firms operating in the home country. Note that the formulation of the government budget constraint allows for negative tax rates on any of the possible tax bases. For example, if the destination-based tax rate $t_d < 0$, then the government has to pay a consumption subsidy not only to domestic consumers, but also to foreign cross-border shoppers. Hence the relevant tax base is c^H , which gives the total amount of goods purchased in the home country and exceeds total domestic consumption (C) whenever $t_d < 0$ [eq. (7)]. Using (11) we can set up the Lagrangian

$$\mathcal{L} = v(q, \omega, Y) + \lambda \left\{ t_d c^H(q, \omega, Y) + \left[t_w + \frac{t_o x}{l}(p, \pi) + \frac{t_p}{l}(p, \pi) \right] L(q, \omega, Y) - R_0 \right\}. \quad (12)$$

The complexity of this problem derives from the fact that, through the firms' arbitrage condition (5), the gross profit level that must be earned in the home country depends on the number of firms in the market. Hence all tax instruments considered affect π through their effects on either domestic labour supply or the employment level of firms. Differentiating (5) and (11) with respect to the different tax instruments gives

$$\frac{\partial \pi}{\partial t_p} = 1 - \frac{\rho'}{(1 + \rho'\beta)} \frac{1}{l} \beta, \quad \frac{\partial \pi}{\partial t_w} = \frac{-\rho'}{(1 + \rho'\beta)} \frac{1}{l} \frac{\partial L}{\partial \omega},$$

$$\frac{\partial \pi}{\partial t_d} = \frac{\rho'}{(1 + \rho'\beta)} \frac{1}{l} \frac{\partial L}{\partial q}, \quad \frac{\partial \pi}{\partial t_o} = \frac{\rho'}{(1 + \rho'\beta)} \frac{1}{l} \left(n \frac{dl}{dp} - \frac{\partial L}{\partial \omega} \frac{\partial w}{\partial p} \right), \quad (13)$$

where

$$\beta = n \frac{dl}{d\pi} - \frac{\partial L}{\partial \omega} \frac{\partial w}{\partial \pi}$$

and

$$\frac{dl}{d\pi} \equiv \frac{\partial l}{\partial w} \frac{\partial w}{\partial \pi} + \frac{\partial l}{\partial \pi} > 0, \quad \frac{dl}{dp} \equiv \frac{\partial l}{\partial w} \frac{\partial w}{\partial p} + \frac{\partial l}{\partial p} < 0 \quad (14)$$

summarize the direct and the indirect effects (via the gross wage w) of changes in p and π on the firm's labour demand. To interpret the derivatives in (13) let us assume for concreteness that the labour supply curve is upward sloping ($\partial L/\partial \omega > 0$, $\partial L/\partial q < 0$).⁶ First, it is evident that an increase in the profit tax requires a higher level of gross profits to be earned in the small country. In contrast, both the wage tax and the consumption tax reduce labour supply and thus the number of firms operating in the small country. With imperfect firm mobility, the reduced mobility costs then allow a reduction in π in the firm's arbitrage equilibrium. Finally, the production tax also reduces the number of firms in equilibrium since it reduces aggregate labour supply while simultaneously raising the level of firm employment (by lowering the producer price and thus the gross wage).

With these effects in mind, we can now turn to the first-order conditions for the four tax instruments $t_i \in \{t_d, t_w, t_p, t_o\}$ available to the home country government. Using (2)–(4), (6) and (10)–(11) these are given by⁷

$$\frac{\partial \mathcal{L}}{\partial t_d} = -c^H + \lambda \left(c^H + t_d \frac{\partial c^H}{\partial q} + \alpha \frac{\partial L}{\partial q} \right) + \frac{\partial \pi}{\partial t_d} \gamma = 0 \quad \text{if } c^F > 0,$$

$$\frac{\partial \mathcal{L}}{\partial t_d} = -C + \lambda \left(c^H + t_d \frac{\partial c^H}{\partial q} + \alpha \frac{\partial L}{\partial q} \right) + \frac{\partial \pi}{\partial t_d} \gamma = 0 \quad \text{if } c^F \leq 0, \quad (15)$$

$$\frac{\partial \mathcal{L}}{\partial t_w} = -L + \lambda \left(L - t_d \frac{\partial c^H}{\partial \omega} - \alpha \frac{\partial L}{\partial \omega} \right) + \frac{\partial \pi}{\partial t_w} \gamma = 0, \quad (16)$$

$$\frac{\partial \mathcal{L}}{\partial t_p} = -\frac{L}{l} + \frac{\lambda}{l} \left(L - t_d \frac{\partial c^H}{\partial \omega} - \alpha \frac{\partial L}{\partial \omega} \right) + \left(\frac{\partial \pi}{\partial t_p} - 1 \right) \gamma + n \left[t_o \left(\frac{\partial x}{\partial l} - \frac{x}{l} \right) - \frac{t_p}{l} \right] \frac{dl}{d\pi} = 0, \quad (17)$$

⁶Note that this assumption is made purely to facilitate the interpretation and is not needed for any of the results derived in the analysis.

⁷The equation system (15)–(18) is obtained through straightforward differentiation, where all terms involving the derivatives $\partial \pi/\partial t_i$ are collected separately. Note further that $\partial \pi/\partial t_p$ is decomposed in equation (17) using the first equation in (13). The effects of the various taxes on the average labour productivity $x(l)/l[w(p, \pi), p, \pi]$ are obtained as

$$\frac{\partial(x/l)}{\partial t_j} = \frac{1}{l} \left(\frac{\partial x}{\partial l} - \frac{x}{l} \right) \frac{\partial \pi}{\partial t_j} \frac{dl}{d\pi} \quad \forall t_j \in \{t_d, t_w, t_p\}, \quad \frac{\partial(x/l)}{\partial t_o} = \frac{1}{l} \left(\frac{\partial x}{\partial l} - \frac{x}{l} \right) \left(\frac{\partial \pi}{\partial t_o} \frac{dl}{d\pi} - \frac{dl}{dp} \right).$$

The derivatives $\partial(1/l)/\partial t_i$ are obtained analogously. Finally, recall from (6) that $\partial w/\partial p = x/l$ and $\partial w/\partial \pi = -1/l$.

$$\frac{\partial \mathcal{L}}{\partial t_o} = -\frac{Lx}{l} + \frac{\lambda x}{l} \left(L - t_d \frac{\partial c^H}{\partial \omega} - \alpha \frac{\partial L}{\partial \omega} \right) + \frac{\partial \pi}{\partial t_o} \gamma - n \left[t_o \left(\frac{\partial x}{\partial l} - \frac{x}{l} \right) - \frac{t_p}{l} \right] \frac{dl}{dp} = 0, \quad (18)$$

where the effects of the different tax rates on the gross profit level are given in (13),

$$\alpha = t_w + \frac{t_o x}{l} + \frac{t_p}{l} \quad (19)$$

can be interpreted as the effective tax rate on labour, $dl/d\pi$ and dl/dp are given in (14) and

$$\gamma = -\frac{L}{l} + \lambda \left\{ -t_d \frac{\partial c^H}{\partial \omega} \frac{1}{l} - \alpha \frac{\partial L}{\partial \omega} \frac{1}{l} + n \left[t_o \left(\frac{\partial x}{\partial l} - \frac{x}{l} \right) - \frac{t_p}{l} \right] \frac{dl}{d\pi} \right\} \quad (20)$$

is the common multiplier for the derivatives $\partial \pi / \partial t_i$.

Two observations should be pointed out in this set of equations. First, note that the first-order condition for the consumption tax t_d [eq. (15)] depends on the direction of consumer trade. However, the derivative $\partial c^H / \partial q$ captures the substitution effect from cross-border shopping in *both* regimes since a rise in q will either increase the purchases of domestic residents abroad, or reduce cross-border shopping by foreigners in the home country [cf. eq. (8)]. Second, closer inspection of equations (17)–(18) reveals that these first-order conditions can be further simplified if they are combined with the optimality condition for the wage tax (16). This last property of the present model will be analysed further in the following section.

3 The optimal tax structure

In a first step we express the first-order condition for the profit tax and the production tax [eqs. (17)–(18)] using the optimality condition for the wage tax [eq. (16)]. This yields

$$\frac{\partial \mathcal{L}}{\partial t_p} = \frac{1}{l} \frac{\partial \mathcal{L}}{\partial t_w} - n \frac{dl}{d\pi} \left[\frac{\rho'}{(1 + \rho'\beta)} \frac{\gamma}{l} + \frac{t_p}{l} - t_o \left(\frac{\partial x}{\partial l} - \frac{x}{l} \right) \right] = 0, \quad (21)$$

$$\frac{\partial \mathcal{L}}{\partial t_o} = \frac{x}{l} \frac{\partial \mathcal{L}}{\partial t_w} + n \frac{dl}{dp} \left[\frac{\rho'}{(1 + \rho'\beta)} \frac{\gamma}{l} + \frac{t_p}{l} - t_o \left(\frac{\partial x}{\partial l} - \frac{x}{l} \right) \right] = 0. \quad (22)$$

In a second step we add (21), multiplied by $(dl/dp)/(dl/d\pi)$, to (22) without requiring, for now, that the profit tax rate be optimized. This replaces the squared bracket in (22) by the derivative $\partial \mathcal{L} / \partial t_p$. Further we use the homogeneity property of the labour demand function. If indirect effects via the induced change in wages are taken into account then proportional increases in both the price of output and the required gross profit level will leave the firms' labour demand unaffected. Recalling the definition of $dl/d\pi$ and dl/dp in (14) this is expressed by

$$\pi \frac{dl}{d\pi} + p \frac{dl}{dp} = 0.$$

Noting further that $px - \pi = wl$ from the definition of gross profits we can finally write the first-order condition for the production tax as

$$\frac{\partial \mathcal{L}}{\partial t_o} = \frac{w}{p} \frac{\partial \mathcal{L}}{\partial t_w} + \frac{\pi}{p} \frac{\partial \mathcal{L}}{\partial t_p} = 0. \quad (23)$$

Equation (23) shows that the production tax serves as an imperfect substitute for both the wage tax and the profit tax. If either t_w or t_p is exogenously fixed *below* its optimal level then $\partial \mathcal{L} / \partial t_w > 0$ or $\partial \mathcal{L} / \partial t_p = 0$ and this will tend to increase the optimal production tax rate t_o .⁸ If, however, both of these taxes can be optimally chosen, then $\partial \mathcal{L} / \partial t_w = \partial \mathcal{L} / \partial t_p = 0$ and equation (23) is always fulfilled. In the absence of constraints on the taxation of wages and profits, equation (23) is thus redundant and the production tax does not constitute an independent tax instrument.

Result 1: *If both wages and profits can be optimally taxed, then an origin-based commodity tax is not needed as an additional tax instrument and its tax rate can be set equal to zero without welfare loss.*

Result 1 should be immediately intuitive from the equality $px = wl + \pi$, which implies that the production tax is equivalent to a tax that falls on wages and profits at the same rate. Since it will generally not be optimal to tax wages and profits at equal rates, the origin-based commodity tax is thus dominated by independently optimized wage and profit taxes. In the special case where firms are perfectly mobile internationally (Genser and Haufler 1996), the effective tax on firms' profits will be zero in the optimum so that only the labour tax instrument is used.⁹ With imperfect firm mobility, a production tax will be able to effectively tax profits, but it is still dominated by an optimal combination of the direct taxes t_w and t_c . Given Result 1, we can thus exclude the production tax in the following without restricting the government's set of independent tax instruments.

We turn next to the optimal rate of profit taxation. A convenient starting point for this analysis is the modified first-order condition (21). If wages can be optimally taxed then $\partial \mathcal{L} / \partial t_w = 0$ and the expression in the squared bracket must be zero for optimality. Furthermore, the last term in this bracket disappears for $t_o = 0$. Let us first consider the special case of perfect firm mobility [$\rho(n) = \rho' = 0$]. In this case the first term in the bracket is also zero and equation (21) can only be fulfilled for $t_p = 0$. Hence our analysis reproduces the result that profits remain entirely untaxed if firms face zero extra costs of locating in the small country.

⁸We assume throughout the analysis that the second-order conditions are fulfilled for each tax instrument, i.e., $\partial^2 \mathcal{L} / \partial (t_i)^2 < 0 \forall t_i \in \{t_d, t_w, t_p, t_o\}$. Hence whenever $\partial \mathcal{L} / \partial t_i > 0$ then the tax rate t_i must rise in the optimum.

⁹This result is a variant of the production efficiency theorem. With perfect firm mobility, any profit or production tax will be borne exclusively by labour, but creates an additional distortion by reducing the number of firms in the small country below its efficient level. Hence it is more efficient to tax labour directly and avoid the additional production distortion.

In the presence of mobility costs ($\rho' > 0$), the first term in the square bracket of (21) is non-zero and depends on the sign of γ . This sign is not immediately obvious from (20) since the slope of the labour supply curve is generally ambiguous and negative tax rates are not excluded in the present analysis. However, γ can be signed from the first-order condition (17). If the terms from the derivative $\partial\pi/\partial t_p$ [eq. (13)] are collected, this equation can be condensed to

$$\frac{\partial\mathcal{L}}{\partial t_p} = \lambda n + \gamma \frac{\partial\pi}{\partial t_p} = 0. \quad (24)$$

Since $\lambda > 0$ is the shadow price of the government budget constraint and $\partial\pi/\partial t_p > 0$ from (13) this equation can only be fulfilled for $\gamma < 0$. Hence the first term in the square bracket of (21) is negative. Thus the second term must be positive to fulfill the equation, implying a positive profit tax rate t_p .

Result 2: *The optimal profit tax rate t_p is positive when there are positive mobility costs which are rising in the number of firms ($\rho' > 0$). In the special case of zero mobility costs the optimal profit tax is zero.*

Result 2 is easily understood by noting that our setting of imperfectly mobile firms lies in between the two benchmark cases of firms that are either immobile or perfectly mobile internationally. In the first case, the profit tax is a lump-sum instrument and – in the absence of further constraints – profits will be fully taxed away in the optimum. In the perfect mobility case, profits cannot effectively be taxed by the government of a small country and the optimal profit tax rate is zero. In an intermediate setting with positive, but finite, mobility costs, the base of the profit tax is less than perfectly elastic and it will thus be optimal for the government to obtain some fraction of the required tax revenue from this base. This is essentially a standard application of the inverse-elasticity rule in optimal taxation. Note also that, in contrast to taxes that affect margins of substitution in consumption, there is no ambiguity about the positive sign of the tax t_p , since there are no potentially counteracting cross-price effects. Hence the introduction of mobility costs can provide an optimal tax argument for the survival of corporate profit taxation in small open economies.

The final question is whether the remaining tax rates t_w and t_d can also be expected to be positive. Both of these taxes reduce the net real wage and thus distort the consumer's labour-leisure choice. The fundamental trade-off between the wage tax and the consumption tax is that the latter is able to tax the lump-sum income Z along with wage income, but at the same time causes an additional distortion through cross-border shopping.

The appendix shows that if t_d and t_w are both chosen optimally, the Slutsky decomposition and the homogeneity properties of compensated commodity demand and labour supply functions can be used to derive the following regime-specific relationships

$$\left[Z - c^F - \tau(c^F) \right] \varphi = q t_d \frac{\partial c^F}{\partial q} \quad \text{if } c^F > 0,$$

$$Z\varphi - qc^F = qt_d \frac{\partial c^F}{\partial q} \quad \text{if } c^F \leq 0, \quad (25)$$

where it is shown in the appendix [eqs. (A.7)–(A.8)] that $\varphi > 0$.

Equations (25) isolate the differences between the consumption tax and the wage tax in the two different trade regimes. In both equations, the left-hand side gives the difference in the base of the two taxes while the right-hand side shows the additional distortion through cross-border shopping caused by the destination tax.

It is easy to check that a strictly positive level of Z is incompatible with either a negative or a zero rate of t_d , i.e. with a solution in the second trade regime $c^F \leq 0$. The left-hand side of the second equation in (25) is unambiguously positive for $c^F \leq 0$ whereas the right-hand side has the same sign as t_d since $\partial c^F / \partial q > 0$ from (8). Hence $t_d \leq 0$ cannot be optimal in this case. In contrast, $Z > 0$ is compatible with a solution in the first trade regime $c^F > 0$. To see this we start from $t_d = 0$ (and thus $c^F = 0$ and $\tau(0) = 0$ from the properties of the consumer transaction cost function) and note that in this case the left-hand side of the first equation in (25) is strictly positive, whereas the right-hand side is zero. As t_d is increased, the left-hand side of the equation becomes smaller while the right-hand side increases; hence, from continuity, there must be a positive tax rate t_d for which the equation is fulfilled.

Similar reasoning applies in the case $Z = 0$. In this case, neither a strictly positive nor a strictly negative tax rate t_d are compatible with (25), whereas a consumption tax rate of zero (which implies the borderline case $c^F = 0$) satisfies the second equation.

Result 3: *For $Z \geq 0$, the destination-based commodity tax will never be negative in the optimum. It is zero if and only if there is no non-wage income.*

Intuitively, since the consumption tax is the only instrument that is able to effectively tax the lump-sum income Z this instrument will always be used to some extent. The use of the consumption tax as an imperfect substitute for a tax on lump-sum income is also stated in Richter (1996, Proposition 3). In the present setting with cross-border shopping the optimal level of t_d is reached when the additional distortion caused by this activity just compensates for the benefit of being able to levy a tax on a partly immobile base. It is then also obvious that if non-wage income is zero then the consumption tax is unambiguously more distortive than a wage tax for any given amount of revenue collected; hence this instrument will not be used in the optimum.

In general, however, non-wage income will be positive, implying an independent role for a positive consumption tax t_d in the present model. As we have seen above, the same is not true for the production tax t_o . Taken together, Results 1 and 3 thus establish that a destination-based commodity tax dominates an origin-based tax in a second-best setting where optimal factor taxation is simultaneously taken into account.

Finally, note that while we are able to exclude the possibility of a negative consumption tax from optimal tax considerations, a similar argument cannot be made for the wage tax. The reason is that t_w does not appear in equation (25); hence the optimal choice of t_d has no general implications for the sign of the wage tax. Of course, in the special case of zero non-wage income and zero firm mobility costs both t_p and t_d will be zero and the wage tax must be positive to meet the government revenue constraint. In general, however, situations where a wage subsidy is optimal cannot be excluded by means of theoretical analysis alone.

4 Some numerical results

To gain a deeper understanding for the optimal tax structure discussed in the preceding section and its dependence on core model parameters, we have simulated our model using the GAMS software developed at the World Bank (Brooke, Kendrick and Meeraus 1992). For this purpose we have specified a CES utility function for the representative individual of the form

$$u = \left(s_1^{1/\sigma} C^{(\sigma-1)/\sigma} + s_2^{1/\sigma} (T - L)^{(\sigma-1)/\sigma} \right)^{\sigma/(\sigma-1)},$$

where σ is the elasticity of substitution and T denotes an exogenous time endowment so that $(T - L)$ is the consumption of leisure. The exogenous weights obey the adding-up restriction $s_1^{1/\sigma} + s_2^{1/\sigma} = 1$ and we have chosen the ratio of the weights to be $s_1/s_2 = 4$. This makes commodity consumption four times as important as leisure in the individual's utility function and corresponds roughly to the weights calibrated by Ballard, Fullerton, Shoven and Whalley (1985, p. 130) for a large-scale tax reform model based on U.S. data. The production function at the firm level has been specified as $x = l^{0.8}$. Finally we have assumed that the firm's mobility cost function, $\rho(n)$, and the marginal transportation cost function for consumers, $\tau'(c^F)$, are linearly increasing in n and c^F , respectively:

$$\begin{aligned} \rho(n) &= \theta_f n, \\ \tau'(c^F) &= \theta_c c^F. \end{aligned}$$

In the following we report simulation results for different values of key model parameters. The production tax is excluded as an independent tax instrument and the remaining tax rates are expressed in ad valorem form. Thus $t_w^* = t_w/w$, $t_p^* = t_p/\pi^*$ and $t_d^* = t_d/1 = t_d$. The results are summarized in two tables: Table 1 gives the effects of different mobility cost parameters θ_f and θ_c on the optimal mix of tax rates whereas Table 2 considers the role of the elasticity of substitution in consumption σ and the amount of lump-sum income Z .

The results presented in Table 1 are based on a substitution elasticity $\sigma = 1$ (Cobb-Douglas preferences). The level of exogenous income is fixed at $Z = 3$. This implies a ratio of non-wage to wage income in the range of 1 : 3 under the specifications made, a figure

Table 1: Optimal Tax Rates for Different Mobility Cost Parameters

	$\theta_c = 0.1$	$\theta_c = 0.5$	$\theta_c = 2.0$
$\theta_f = 0.000$	$t_d^* = 2.0\%$ $t_w^* = 21.1\%$ $t_p^* = 0.0\%$	$t_d^* = 8.3\%$ $t_w^* = 14.8\%$ $t_p^* = 0.0\%$	$t_d^* = 22.1\%$ $t_w^* = 0.9\%$ $t_p^* = 0.0\%$
$\theta_f = 0.001$	$t_d^* = 1.9\%$ $t_w^* = 20.1\%$ $t_p^* = 11.2\%$	$t_d^* = 7.9\%$ $t_w^* = 13.9\%$ $t_p^* = 11.2\%$	$t_d^* = 21.1\%$ $t_w^* = 0.4\%$ $t_p^* = 11.3\%$
$\theta_f = 0.005$	$t_d^* = 1.9\%$ $t_w^* = 19.4\%$ $t_p^* = 36.3\%$	$t_d^* = 7.7\%$ $t_w^* = 13.2\%$ $t_p^* = 36.4\%$	$t_d^* = 20.3\%$ $t_w^* = -0.1\%$ $t_p^* = 36.6\%$

$$T = 20, \pi^* = 0.15, R_0 = 3, Z = 3, \sigma = 1.$$

which is roughly representative of the composition of national income in many OECD countries.

The results are easily interpreted with the help of our theoretical analysis above. If there are no mobility costs for firms, as is the case in the first row of Table 1, then the optimal profit tax will be zero (cf. Result 2). However, it can be seen from the second and third row in the table that even comparatively small location costs for firms can generate significant rates of profit taxation in the optimum. Also we have previously discussed that the consumption tax distorts the decision between domestic and foreign purchases, in addition to the distortion of the labour-leisure choice that it shares with the wage tax. The simulation results show that, for the given level of Z , the wage tax is the dominant tax instrument when consumer mobility costs are very low and cross-border shopping is potentially large. In contrast, the consumption tax is the dominant instrument when cross-border shopping is limited by very high transaction costs.

If low mobility costs for firms and consumers are combined, so that the tax rates on consumption and profits are both relatively high, then the wage tax may actually turn negative. This is shown in the lower right corner of Table 1 and confirms that the sign of this tax rate is indeed not unambiguous. However, the numerical analysis also suggests that a wage subsidy will be optimal only for a very limited range of parameter combinations.

Table 2 summarizes the optimal tax structures for varying substitution elasticities σ and different levels of lump-sum income Z , fixing the mobility cost parameters at the intermediate levels $\theta_f = 0.001$ and $\theta_c = 0.5$. At the same time the values $\sigma = 1$ and $Z = 3$ – which underlay the simulations in Table 1 – are chosen as intermediate cases so

Table 2: Optimal Tax Rates for Different Substitution Elasticities
and Lump-Sum Income Levels

	$\sigma = 0.25$	$\sigma = 1$	$\sigma = 2.0$
$Z = 0 (R_0 = 2)$	$t_d^* = 0.0\%$ $t_w^* = 12.2\%$ $t_p^* = 12.2\%$	$t_d^* = 0.0\%$ $t_w^* = 13.0\%$ $t_p^* = 11.7\%$	$t_d^* = 0.0\%$ $t_w^* = 14.3\%$ $t_p^* = 11.0\%$
$Z = 3 (R_0 = 3)$	$t_d^* = 12.4\%$ $t_w^* = 6.9\%$ $t_p^* = 12.2\%$	$t_d^* = 7.9\%$ $t_w^* = 13.9\%$ $t_p^* = 11.2\%$	$t_d^* = 5.3\%$ $t_w^* = 17.9\%$ $t_p^* = 10.8\%$
$Z = 6 (R_0 = 4)$	$t_d^* = 33.9\%$ $t_w^* = -11.0\%$ $t_p^* = 12.2\%$	$t_d^* = 19.4\%$ $t_w^* = 9.3\%$ $t_p^* = 10.8\%$	$t_d^* = 8.7\%$ $t_w^* = 22.4\%$ $t_p^* = 10.5\%$

$$T = 20, \pi^* = 0.15, \theta_f = 0.001, \theta_c = 0.5.$$

that the entries in the central cells of Tables 1 and 2 are identical. Finally, to maintain comparability between cases where exogenous income levels differ, we have simultaneously varied the exogenous revenue requirement R_0 , thus maintaining a roughly constant ratio of tax revenues to national income.

The results show that the exogenous parameter variations carried out in this table have very little influence on the optimal profit tax rate t_p^* , but are clearly critical for the chosen mix of wage and consumption taxation. As expected from Result 3 of our theoretical discussion, the role of consumption taxes increases when the share of exogenous income rises. It is also seen that a higher elasticity of substitution reduces the role of consumption taxes and increases the role of wage taxation. Again this can be explained from the fact that the base of the consumption tax is more elastic than the base of the wage tax, since it is reduced by both the increased consumption of leisure and the purchases in the foreign country. For any given level of non-wage income, an increase in the substitution elasticity thus shifts the balance between the two instruments in favour of the wage tax.

Finally, note that there is again one special case where the optimal tax rate on wages is negative. This occurs in the lower left corner of Table 2 where the exogenous income component is high and the substitution elasticity is low. The combination of these factors makes it optimal to put a high indirect tax on all sources of income and partly relieve labour from the tax burden by offering a wage subsidy.

Summarizing the results of our numerical analysis, two points deserve emphasis: first the optimal level of profit taxation depends primarily on the mobility costs faced by

international firms and proves to be very robust with respect to variations in all other model parameters. Second, except for a few rather special parameter combinations, all tax rates are positive. Therefore even the simple framework employed in this analysis is able to motivate a tax system where profits, wages and consumption are all taxed at positive rates.

5 Conclusions

The results of the present paper can be summarized in two main points. First, in a model that allows for the optimal taxation of goods, wages and profits, the economic effects of an origin-based commodity tax can be duplicated by an appropriate variation of factor taxes. In contrast, a destination-based commodity tax is an independent instrument whenever there are non-wage components of national income, which cannot effectively be taxed by independent instruments. An example of the latter is foreign-earned interest income where a residence-based income tax – even if nominally in place – can be easily evaded by simple non-declaration. Therefore, the maintainance of a destination-based VAT in Europe is supported from an optimal taxation perspective, despite the fact that this tax not only affects the labour-leisure choice but creates additional distortions through cross-border shopping.

The second main result of the paper is that a small open economy will impose a positive tax on firm profits if firm mobility is imperfect. Most previous models have assumed perfect firm mobility, warranting a profit tax only to the extent that the location of a firm in a given jurisdiction causes positive marginal costs of providing public inputs (Richter 1994, 1996). Given the empirical evidence for surprisingly low levels of foreign direct investment – at least relative to theoretical ‘benchmark’ results –, mobility costs can thus provide one economic motivation for the persistence of corporate profit taxation in all OECD countries.

The results of our simple model should not be overemphasized, however. First, our analysis has neglected all distributional considerations, both within the small country considered and between the member states of the European Union. Keen and Smith (1996) relax the second assumption and show that an efficient tax system from an international perspective also has to take into account cross-country differences in the marginal costs of public funds.

A second limitation of the present analysis is that we have assumed the existence of a tax instrument that can be precisely targeted at firms’ profits. Instead, existing corporate income taxes are a less targeted instrument, taxing returns on net assets along with pure profits. Hence a more realistic model would have to include capital as a second, internationally mobile, factor of production. If capital returns and pure profits can only be taxed by one single instrument then it will not generally be possible to duplicate the effects of a production tax by a combination of wage and corporate income taxation. However,

when both the corporate income tax and the production tax serve as indirect instruments to tax pure profits, then one of these taxes is likely to be negative in the optimum (cf. Haufler 1996). Hence it is by no means clear that this model extension (re-) establishes an efficiency argument for a positive origin-based commodity tax.

Appendix : Derivation of Equation (25)

Exploiting the similarity between the derivatives $\partial\pi/\partial t_d$ and $\partial\pi/\partial t_w$ in (13), we can rewrite the first-order conditions for the consumption tax and the wage tax [eqs. (15)–(16)] as

$$\frac{\partial\mathcal{L}}{\partial t_d} = -c^H + \lambda \left(c^H + t_d \frac{\partial c^H}{\partial q} + \varepsilon \frac{\partial L}{\partial q} \right) = 0 \quad \text{if } c^F > 0,$$

$$\frac{\partial\mathcal{L}}{\partial t_d} = -C + \lambda \left(c^H + t_d \frac{\partial c^H}{\partial q} + \varepsilon \frac{\partial L}{\partial q} \right) = 0 \quad \text{if } c^F \leq 0, \quad (\text{A.1})$$

$$\frac{\partial\mathcal{L}}{\partial t_w} = -L + \lambda \left(L - t_d \frac{\partial c^H}{\partial \omega} - \varepsilon \frac{\partial L}{\partial \omega} \right) = 0, \quad (\text{A.2})$$

where

$$\varepsilon \equiv \alpha + \frac{\rho'}{(1 + \rho'\beta)} \frac{1}{l} \frac{\gamma}{\lambda} \quad (\text{A.3})$$

can be interpreted as an adjusted effective tax rate on labour and α and γ are given in (19)–(20). Uncompensated commodity demand and labour supply functions are decomposed using the Slutsky equations. Denoting a compensated derivative by a tilde and nominal income by y gives

$$\frac{\partial L}{\partial q} = \frac{\partial \tilde{L}}{\partial q} - c^H \frac{\partial L}{\partial y}, \quad \frac{\partial c^H}{\partial q} = \frac{\partial \tilde{c}^H}{\partial q} - c^H \frac{\partial c^H}{\partial y} \quad \text{if } c^F > 0,$$

$$\frac{\partial L}{\partial q} = \frac{\partial \tilde{L}}{\partial q} - C \frac{\partial L}{\partial y}, \quad \frac{\partial c^H}{\partial q} = \frac{\partial \tilde{c}^H}{\partial q} - C \frac{\partial c^H}{\partial y} \quad \text{if } c^F \leq 0,$$

$$\frac{\partial L}{\partial \omega} = \frac{\partial \tilde{L}}{\partial \omega} + L \frac{\partial L}{\partial y}, \quad \frac{\partial c^H}{\partial \omega} = \frac{\partial \tilde{c}^H}{\partial \omega} + L \frac{\partial c^H}{\partial y}. \quad (\text{A.4})$$

Substituting the Slutsky equations (A.4) into (A.1) and (A.2) and dividing by λ gives

$$c^H \varphi = -t_d \frac{\partial \tilde{c}^H}{\partial q} - \varepsilon \frac{\partial \tilde{L}}{\partial q} \quad \text{if } c^F > 0, \quad C \varphi - c^F = -t_d \frac{\partial \tilde{c}^H}{\partial q} - \varepsilon \frac{\partial \tilde{L}}{\partial q} \quad \text{if } c^F \leq 0, \quad (\text{A.5})$$

$$L \varphi = t_d \frac{\partial \tilde{c}^H}{\partial \omega} + \varepsilon \frac{\partial \tilde{L}}{\partial \omega}, \quad (\text{A.6})$$

where

$$\varphi = \frac{\lambda - 1}{\lambda} - t_d \frac{\partial c^H}{\partial y} - \varepsilon \frac{\partial L}{\partial y}. \quad (\text{A.7})$$

To show, for the regime $c^F > 0$, that φ must be positive, we multiply both sides of the first equation in (A.5) by t_d and both sides of (A.6) by ε . Summing over the two resulting equations gives, in matrix form

$$\varphi (t_d c^H + \varepsilon L) = \begin{bmatrix} t_d & \varepsilon \end{bmatrix} \begin{bmatrix} \frac{-\partial \tilde{c}^H}{\partial q} & \frac{-\partial \tilde{L}}{\partial q} \\ \frac{\partial \tilde{c}^H}{\partial \omega} & \frac{\partial \tilde{L}}{\partial \omega} \end{bmatrix} \begin{bmatrix} t_d \\ \varepsilon \end{bmatrix}. \quad (\text{A.8})$$

The substitution matrix on the right-hand side of (A.8) is positive semi-definite; hence the right-hand side must be positive, irrespective of the sign of individual tax rates. The bracketed term on the left-hand side of (A.8) strictly equals the tax revenue collected in the home country when mobility costs are absent ($\tau'' = 0$), as can be seen from the Lagrangian (12) and eq. (19) in the main text. Hence this term must be positive for a positive revenue requirement in the home country and thus signs $\varphi > 0$. This restates a standard property of the Ramsey optimal commodity tax model (e.g. Myles, 1995, p. 104) in the present context. For the second trade regime $c^F \leq 0$, it is easily checked that φ must also be positive.

Next we use $c^H(q, \omega, Y) = C(q, \omega, Y) - c^F(q)$ from (7). This gives for both regimes

$$\frac{\partial \tilde{c}^H}{\partial q} = \frac{\partial \tilde{C}}{\partial q} - \frac{\partial c^F}{\partial q}, \quad \frac{\partial \tilde{c}^H}{\partial \omega} = \frac{\partial \tilde{C}}{\partial \omega}. \quad (\text{A.9})$$

Multiplying equation (A.5) by q and equation (A.6) by ω , using (A.9) and subtracting the two resulting equations gives

$$\begin{aligned} (q c^H - \omega L) \varphi &= - \left(t_d \left[q \frac{\partial \tilde{C}}{\partial q} + \omega \frac{\partial \tilde{C}}{\partial \omega} - q \frac{\partial c^F}{\partial q} \right] + \varepsilon \left[q \frac{\partial \tilde{L}}{\partial q} + \omega \frac{\partial \tilde{L}}{\partial \omega} \right] \right) \quad \text{if } c^F > 0, \\ (q C - \omega \tilde{L}) \varphi - q c^F &= - \left(t_d \left[q \frac{\partial \tilde{C}}{\partial q} + \omega \frac{\partial \tilde{C}}{\partial \omega} - q \frac{\partial c^F}{\partial q} \right] + \varepsilon \left[q \frac{\partial \tilde{L}}{\partial q} + \omega \frac{\partial \tilde{L}}{\partial \omega} \right] \right) \quad \text{if } c^F \leq 0. \end{aligned}$$

But from the homogeneity properties of the compensated commodity demand and labour supply functions this reduces to

$$\begin{aligned} (q c^H - \omega L) \varphi &= t_d q \frac{\partial c^F}{\partial q} \quad \text{if } c^F > 0, \\ (q C - \omega L) \varphi - q c^F &= t_d q \frac{\partial c^F}{\partial q} \quad \text{if } c^F \leq 0, \end{aligned} \quad (\text{A.10})$$

The last step is to use the consumer budget constraint (9) to transform (A.10) into equation set (25) in the main text. \square

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Figure 1: Consumer transaction costs

