1. Introduction

A central result in the theory of optimal taxation is that both source-based taxes on capital income and origin-based taxes on commodities are inefficient instruments with which to raise revenue in a small open economy. The first formal statement of this proposition is due to Diamond and Mirrlees (1971): source- and origin-based taxes cannot be part of an optimal system of linear taxation since they prevent the attainment of productive efficiency by inserting a wedge between domestic and foreign producer prices. Subsequent literature strengthens the conclusion of Diamond and Mirrlees by showing that taxes on internationally immobile factors always dominate source- and origin-based taxes in economies with identical individuals (Gordon 1986, Bucovetstky and Wilson 1991, Haufler 1996 inter alia). The intuition is simple: if world prices are unaffected by national policies, the burden of source- or origin-based taxes falls completely on immobile factors. Hence, it is more efficient to tax these factors directly.

In the light of such clearcut theoretical conclusions the experience of many countries appears quite puzzling especially in the field of capital taxation. For example, despite the downward trend in statutory tax rates for corporate income, the effective tax rates for both inward and outward direct investment remain high in several small open economies (Chennels and Griffith 1997).

In the literature there are several explanations which rationalize existing tax policies but none of them provide a satisfactory answer. Following Feldstein and Horioka (1980), many question the assumption of perfect capital mobility. This suggests that even a small open economy may enjoy some monopoly power that could be exploited through source-based taxation. However, Gordon and Bovenberg (1996) show that capital immobility gives countries an incentive to *subsidize* foreign capital and is therefore not sufficient to explain source-based taxation.

Gordon (1992) argues that small countries may find it optimal to tax capital income if they act as Stackelberg followers of a dominant capital exporter that operates a credit system for taxing foreign source income. This argument may well fit both the fact that United States was the dominant capital exporter during much of the postwar period and the roughly simultaneous implementation of corporate tax reforms among the major industrialized countries in the Eighties. On the downside, Chennels and Griffith (1997) point out that Gordon's analysis does not explain why a capital-exporting country should operate a credit system instead of a deduction system.

Finally, Huizinga and Nielsen (1997) maintain that a source based tax is an indirect means of taxing profits that accrue both to foreign and to domestic investors when a tax on pure profits is not feasible. Yet, their results are based on the restrictive assumption that investors cannot avoid the tax by selling their shares. If this assumption is dropped, domestic shares must always pay the profit rate that could be earned on the world equity market. Consequently, any direct or indirect tax on profits is shifted entirely onto immobile domestic factors.

This paper investigates whether the pursuit of redistributive objectives can provide an alternative rationale for source-based taxes on capital income and origin-based taxes on commodities.

The use of redistributive source-based capital taxation has been advocated by Haufler (1997) and Lopez et al. (1996). Both papers argue that a source-based tax can be an efficient tool to redistribute income from capital owners to workers when residence-based capital taxation cannot be implemented. However, this conclusion rests on the assumption that national economies are large with respect to the rest of the world, so that capital taxation is not shifted completely onto immobile labour. The government can then exploit differences in capital endowments to redistribute income between individuals. Such a strategy is ruled out in a small open economy where capital owners can always invest abroad to earn the exogenous world interest rate.

This paper takes an alternative view and looks at source- and origin-based taxes as substitutes for labour taxation rather than as substitutes for residence-based taxes on capital and destination-based taxes on commodities. The analysis combines the theory of optimal taxation in small open economies with the conventional model of redistributive income taxation between skilled and unskilled wage earners. I assume that the government can directly observe neither the individual wage nor the labour supply, but only labour income. I then investigate whether a small open economy would resort to source-based taxation once an optimal, linear or non-linear, labour income tax has been implemented.

The analysis delivers the following main conclusions. In the presence of linear income taxation, source-based taxes can increase the government's ability to redistribute income only if wage differentials are endogenous. With a fixed wage ratio, a source-based tax affects only the wage level and adds nothing to the linear income tax. With completely endogenous wages a source-based tax results in a differential burden on the two types of labour: the government can then exploit the differential incidence to improve on the allocation obtained with the linear income tax. Welfare can be further increased with differential origin-based commodity taxation. When an optimal non-linear tax is implemented, a different marginal tax rate can be set for each type of labour. Hence, source- and origin-based taxes cannot improve on the distribution of net wages. However there may be, an alternative rationale for source- and origin-based taxes: by changing the distribution of gross wages, source- and origin-based taxation can relax the self-selection constraint that binds the nonlinear tax.

I am aware of two papers that offer related analyses. The first is Gerber and Hewitt (1987).

This paper is based on the framework with skilled and unskilled labour but considers a different set of tax instruments. On the one hand, Gerber and Hewitt assume that the government can observe individual skills and levy linear taxes at different rates on the two types of labour, on the other, they assume that institutional constraints hinder the provision of any positive transfer to workers. The main result is that countries have an incentive to *subsidize* investment in order to transfer income to the unskilled indirectly by raising the wage level. In the present paper differential linear taxation on the two types of labour is ruled out endogenously on the basis of asymmetric information between agents and the government. Consequently, the analysis reveals the role played by the differential incidence and shows that even strictly positive source-based *taxes* are Pareto efficient.

The second related paper is Huber (1999), which analyses the problem investigated here but considers exclusively source-based linear taxes on capital income and non-linear labour income taxes. The present paper extends Huber's analysis to linear labour income taxation and studies the role of differential origin-based commodity taxation. As noted earlier, it turns out that source-based capital taxation is Pareto efficient both with linear and with non-linear income taxes. Further, rather surprisingly, the structure of origin-based commodity taxation does not depend on whether the labour income tax is linear or non-linear.

The paper is organised as follows. Section 2 sets up the model. Section 3 discusses the desirability of source- and origin-based taxes given optimal linear taxes on labour. Section 3.1 analyses the benchmark case with differential linear labour taxation. Section 3.2 studies the optimal source-based taxation when the government levies a linear tax on labour income. Section 3.3 extends the analysis to origin-based taxes. Section 4 discusses the optimality of source- and origin-based taxes under optimal non-linear taxation of labour income. Finally, section 5 considers further extensions of the analysis and section 6 concludes.

2. The model

The economy is represented as a standard general equilibrium model with perfect competition. Two traded goods are produced using capital and two different types of labour.

Consumers have identical tastes and own the same quantity of capital. They are endowed with just one of the two types of labour required in production. Hence they can be divided into two homogeneous categories according to the type of labour they offer. The indirect utility function for consumers of type i is

$$V\left(\pi^1, \pi^2, \omega^i, I\right) \tag{2.1}$$

where π^j is the consumer price of good j, ω^i is the consumer wage for labour of type i, and I is lump-sum income, i.e.

$$I = (1 + \rho)\,\overline{K} + b \tag{2.2}$$

where ρ is the consumer interest rate, $\overline{K}$ is the capital endowment and b is a lump-sum tax or subsidy. The population is normalised to 1 and n denotes the fraction of consumers of type 1.

As regards production, I assume constant returns to scale and rule out joint production. In order to maintain mathematical tractability and to avoid complications that are of secondary importance, I also assume that each type of labour is a sector-specific input, so that the same superscript denotes both a productive sector and the type of consumer supplying labour in that sector (hence $i = 1, 2$). Further, I adopt the non-restrictive convention that the producer wage is higher in sector 1 and refer to labour of type 1 as *skilled* labour.

The government implements a social welfare functional,

$$W\left(nV\left(\pi^1, \pi^2, \omega^1, I\right), (1-n)\, V\left(\pi^1, \pi^2, \omega^2, I\right)\right), \tag{2.3}$$

through the uniform lump-sum transfer b and through taxes on both commodities and income from productive factors.

Labour is internationally immobile. A tax on labour income inserts a wedge between consumer and producer wages. Using Latin letters to denote producer prices:

$$\omega^i = w^i \left(1 - t_L\right) \tag{2.4}$$

where t_L is the ad-valorem tax on labour income.

Capital is perfectly mobile across countries. Capital income is taxed in the country where it originates according to the *source* principle. A source-based tax, t_S, creates a wedge between the rental rate of capital paid by domestic producers, r, and the world interest rate, r^*:

$$r = r^* + t_S. \tag{2.5}$$

Traded goods are taxed where they are produced according to the *origin* principle. An origin-based tax, t_O^i, imposes a wedge between the world price for good i, p^{i*}, and the producer price:

$$p^i = p^{i*} - t_O^i. \tag{2.6}$$

The model can easily accommodate *destination*-based commodity taxes, which are paid where a good is actually sold. A destination-based tax, t_D^j, raises the consumer price above the world price:

$$\pi^i = p^{i*} + t_D^i. \tag{2.7}$$

By contrast, the static framework does not allow to analyse taxes on capital income levied in the country where the recipient is located according to the *residence* principle. A residence-based tax, t_R, results in a wedge between the world interest rate and the return on capital received by domestic consumers:

$$\rho = r^* - t_R. \tag{2.8}$$

Given that consumers supply capital inelastically, a residence-based tax on capital income is equivalent to lump-sum taxation. In section 5 I show that the model can readily be extended to generate an elastic savings supply and that all the results hold when both optimal residence-based capital taxes and destination-based commodity taxes are levied.

A final remark is needed to justify the absence of personalised lump-sum taxes. It is usually argued that such taxes are infeasible since the government can directly observe neither the individual wage nor the labour supply, but only labour income. However, when all the workers of a specific type work in just one sector, optimal lump-sum taxes can be implemented without knowing the individual type of worker by taxing skills at the firm level with differentiated wage-bill taxes. Hence, in order to sustain the infeasibility of differential lump-sum taxation in the present model, I must introduce the additional assumptions that the government cannot observe the sector in which each individual works and that it cannot levy differentiated taxes on labour at the firm level. These assumptions are clearly unrealistic but they are not restrictive since all the results of the paper carry over to the more general case in which each sector uses both types of labour, as illustrated in section 5. An additional remark may further clarify the informational structure of the model. The optimal tax formulas derived in the paper assume knowledge of wage levels and elasticities, but only require *anonymous* information on the wage distribution at the *firm level.* Such information is not sufficient, however, to implement optimal lump-sum taxation since personalised lump-sum taxes can be levied only on the basis of the wage distribution at the *individual level.*

3. Optimal linear taxation of labour

From (2.5) it is apparent that an increase in source-based taxes translates into an identical increase in the producer interest rate, while leaving the consumer interest rate unaffected. As a result, source-based taxes cannot redistribute income by exploiting differences in consumers' saving behaviour as, for example in Haufler (1997) and Lopez et al. (1996). Nonetheless, the change in the producer interest rate modifies the demand for labour and induces a variation in equilibrium wage levels. Given constant returns to scale and no-joint production, the final effect on wages can be retrieved from the equilibrium conditions in production. The zero profit conditions for the two sectors are

$$c^1(w^1, r) = p^1 \tag{3.1}$$

$$c^2\left(w^2, r\right) = p^2 \tag{3.2}$$

where c^i represents the unit cost function. In the absence of commodity taxes, producer prices, p^i, are equal to the given world price levels, so that equilibrium wages are functions of the producer interest rate only. Implicit differentiation and application of Shephard's lemma entail that

$$\frac{\partial w^i}{\partial r} = -\frac{c_r^i}{c_{w^i}^i} = -\frac{K^i}{L^i} \equiv -\gamma^i \tag{3.3}$$

where K^i and L^i denote, respectively, the demand for capital and the demand for labour in sector i. In other words, the burden of source-based taxation is shifted completely onto the two immobile factors as an increase in the producer interest rate reduces wages in both sectors. Furthermore, in each sector the wage reduction equals the capital-labour ratio, γ^i. As a result, source-based taxes do not necessarily lead to a proportional fall in the wage level but they may well modify the distribution of income between agents endowed with different types of labour.

The issue analysed in the rest of this section is whether the government can exploit the *differential incidence* of a source-based tax to improve on the income distribution achieved with linear taxes on labour income. I tackle the question in two steps. In the next subsection I investigate whether the introduction of a source-based tax is welfare-improving given optimal differential taxation of labour and optimal residence-based capital income taxes. This is rather an artificial problem. If the government can directly observe the type of labour supplied by each individual, the first best allocation can be implemented through personalised lump-sum transfers. Nevertheless, the analysis of differential linear taxation of labour provides a useful benchmark for interpreting the optimal tax formulas derived in subsection (3.2) under the assumption that the government can observe directly neither wages nor the labour supply. Finally, in subsection (3.3) I analyse the optimality of differential origin-based commodity taxation.

3.1. Differential labour taxation

When each type of labour can be taxed at a different rate the optimal taxation problem faced by the government is

$$\max_{t_L^1, t_L^2, t_S, b} \quad W\left(nV\left(\omega^1, b\right), (1-n)\, V\left(\omega^2, b\right)\right) \tag{3.4}$$

subject to

$$R + b - t_L^1 n w^1 l^1 - t_L^2 (1-n)\, w^2 l^2 - t_S \left(n\gamma^1 l^1 + (1-n)\, \gamma^2 l^2\right) \leq 0 \tag{3.5}$$

where R is an exogenous budget requirement, l^i is the individual supply of labour of type i. Using subscripts to denote partial derivatives, the first order conditions for b, t_L^1 and t_L^2 and t_S are respectively

$$\begin{aligned} &n\left\{\left(\alpha^1 - 1\right) + \left[t_L^1 w^1 l_b^1 + t_S \gamma^1 l_b^1\right]\right\} + \\ &(1-n)\left\{\left(\alpha^2 - 1\right) + \left[t_L^2 w^2 l_b^2 + t_S \gamma^2 l_b^2\right]\right\} = 0 \end{aligned} \tag{3.6}$$

$$w^1 n\left\{\left(1-\alpha^1\right) l^1 - \left[t_L^1 w^1 l_w^1 + t_S \gamma^1 l_w^1\right]\right\} = 0 \tag{3.7}$$

$$w^2 (1-n)\left\{\left(1-\alpha^2\right) l^2 - \left[t_L^2 w^2 l_w^2 + t_S \gamma^2 l_w^2\right]\right\} = 0 \tag{3.8}$$

$$\begin{aligned} &\left(1-t_L^1\right) \gamma^1 n\left\{\left(1-\alpha^1\right) l^1 - \left[t_L^1 w^1 l_w^1 + t_S \gamma^1 l_w^1\right]\right\} + \\ &\left(1-t_L^2\right) \gamma^2 (1-n)\left\{\left(1-\alpha^2\right) l^2 - \left[t_L^2 w^2 l_w^2 + t_S \gamma^2 l_w^2\right]\right\} + \\ &t_S\left(\gamma_r^1 n l^1 + \gamma_r^2 (1-n)\, l^2\right) = 0 \end{aligned} \tag{3.9}$$

where α^i is the social marginal valuation of income accruing to consumers of type i measured in terms of government revenue.[1]

Expression (3.9) shows that a marginal increase in the source-based tax produces three different effects on welfare.

First, it reduces the net wage of skilled workers by an amount equal to $\left(1-t_L^1\right)\gamma^1$. The expression inside the curly brackets gives the social evaluation of this reduction. The first term represents the direct effects on both the government budget constraint (l^1) and the consumer's utility $(-\alpha^1 l^1)$. The second term identifies the indirect effects on the government of changes in the labour supply.

Second, it reduces the net wage of the unskilled by an amount equal to $\left(1-t_L^2\right)\gamma^2$. As for wage 1, the expression inside the curly brackets represents the direct and indirect effects on social welfare.

Third, it raises the producer interest rate and brings about a variation in the domestic capital stock equal to $\gamma_r^1 n l^1 + \gamma_r^2 (1-n) l^2$. By taking the derivative of (3.3) one obtains

$$\gamma_r^i \equiv -\frac{\partial^2 w^i}{\partial (r)^2} = \frac{c_{rr}^i c_w^i - c_r^i c_{wr}^i}{\left(c_w^i\right)^2} - \frac{c_{rw}^i c_w^i - c_r^i c_{ww}^i}{\left(c_w^i\right)^2}\gamma^i \tag{3.10}$$

which shows that γ_r^i is always non-positive since c_{rr}^i and c_{ww}^i are non-positive whilst c_{rw}^i and c_{wr}^i are non-negative numbers. Hence by increasing its source-based tax the country experiences a capital outflow that decreases both revenue and welfare.

[1] If λ denotes the the multiplier associated to the government budget constraint (i.e. the social marginal value of revenue) α^i is defined as follows:

$$\alpha^i \equiv \frac{\partial W}{\partial V^i}\frac{\partial V^i}{\partial b}\Big/\lambda.$$

Notice that condition (3.6) implies that the multiplier is different from zero.

It is apparent that the first two effects of the source-based tax are proportional to the effects produced by the two taxes on labour represented by the left hand sides of (3.7) and (3.8). When t_L^1 and t_L^2 are set to their optimal values, these effects vanish. The impact of the source-based tax on social welfare reduces to the revenue loss due to the capital outflow. In fact, substituting (3.7) and (3.8) into (3.9) gives

$$t_S \left(\gamma_r^1 n l^1 + \gamma_r^2 (1-n) l^2 \right) = 0. \tag{3.11}$$

Equation (3.11) implies that the optimal source-based tax is equal to zero when $\gamma_r^i \neq 0$. There is just one particular case where this condition is not met: when a Leontief technology is adopted in both sectors. In this case (3.7), (3.8) and (3.9) are linearly dependent and the optimal source-based taxation is indeterminate. Summarizing,

Proposition 3.1. *The optimal source-based tax is zero when each type of labour can be taxed at a different rate.*

This result is not just a corollary of Diamond and Mirrlees' theorem on production efficiency as commodity taxes are not set at their optimal level. The proposition is an extension of the result obtained by Bucovetsky and Wilson (1991) in a framework with identical individuals. In the next section I show that the optimal source-based tax is not zero if the government is constrained to use a uniform tax on labour.

In order to interpret the formulas that are presented in the following, it is expedient to elaborate the first order conditions (3.6)-(3.9). Let β^i be the *net* social marginal valuation of income accruing to consumers of type i measured in terms of government revenue, i.e.:

$$\beta^i \equiv \alpha^i + \left(t_L^i w^i + t_S \gamma^i\right) l_b^i.$$

It is *net* as it takes into account the taxes paid on a unit transfer to individual i due to the income effects on the labour supply. Using Proposition 3.1, the Slutsky relationship and standard algebraic manipulations,[2] the first order conditions (3.6)-(3.9) give:

$$n\beta^1 + (1-n)\,\beta^2 = 1 \tag{3.12}$$

$$\frac{t_L^1}{1-t_L^1} = \frac{\left(1-\beta^1\right)}{\varepsilon_{lw}^{c1}} \tag{3.13}$$

$$\frac{t_L^2}{1-t_L^2} = \frac{\left(1-\beta^2\right)}{\varepsilon_{lw}^{c2}} \tag{3.14}$$

where ε_{lw}^{ci} is the elasticity of the compensated labour supply with respect to the wage. Condition (3.12) states that the lump-sum transfer equates the average net social marginal utility of income to 1. It implies that the two terms $\left(1-\beta^i\right)$ are either opposite in sign or both equal to 0. The optimal tax rates on labour satisfy a standard inverse elasticity rule adjusted for distributional considerations. When the government is indifferent with regard to the distribution of income, that is $\alpha^1 = \alpha^2 = 1$ in competitive equilibrium with uniform lump-sum taxation, there is no reason to resort to distortionary taxation. By contrast, if the government wishes to change the distribution of income that arises in the competitive equilibrium, it levies a tax on the wage of workers with the lower net social marginal valuation of income and pays a subsidy to workers

[2] See, for example, Atkinson and Stiglitz (1981) pp. 386-388.

with the higher net social marginal valuation of income. The tax and subsidy rates decrease with the elasticity of the labour supply on which they are levied or granted.

3.2. Uniform labour taxation

As previously remarked, problem (3.4) does not take account of the informational constraints faced by the government in a consistent manner. Personalised lump-sum transfers are deemed to be infeasible even if the government can directly observe the type of labour supplied by each individual. In the rest of this paper I resolve this inconsistency by assuming that the government cannot directly observe either the individual wage or the labour supply, but only labour income.[3] Hence, differential labour taxation is infeasible and the government is left with two alternatives: uniform linear taxation or non linear taxation of labour income. Uniform linear taxation is considered first, while the analysis of non-linear income taxation is postponed to section 4.

When labour income is taxed at a uniform rate the optimal tax problem becomes

$$\underset{t_L,t_S,b}{Max} \quad W\left(nV\left(\omega^1,b\right),(1-n)\,V\left(\omega^2,b\right)\right) \tag{3.15}$$

subject to

$$R+b-t_L\left(nw^1l^1+(1-n)\,w^2l^2\right)-t_S\left(\gamma^1nl^1+\gamma^2\,(1-n)\,l^2\right)\leq 0 \tag{3.16}$$

The first order conditions for b, t_L and t_S read respectively

[3] As remarked in section 2, in order to sustain the unfeasiblility of differential linear taxation when labour is sector specific, one must further assume both that the government cannot observe the sector where each individual works and that it cannot levy taxes on labour at the firm level.

$$
\begin{aligned}
& n\left\{\left(\alpha^1-1\right)+\left[t_L w^1 l_b^1+t_S \gamma^1 l_b^1\right]\right\}+ \\
& (1-n)\left\{\left(\alpha^2-1\right)+\left[t_L w^2 l_b^2+t_S \gamma^2 l_b^2\right]\right\}=0
\end{aligned} \tag{3.17}
$$

$$
\begin{aligned}
& w^1 n\left\{\left(1-\alpha^1\right) l^1-\left[t_L w^1 l_w^1+t_S \gamma^1 l_w^1\right]\right\}+ \\
& w^2(1-n)\left\{\left(1-\alpha^2\right) l^2-\left[t_L w^2 l_w^2+t_S \gamma^2 l_w^2\right]\right\}=0
\end{aligned} \tag{3.18}
$$

$$
\begin{aligned}
& \left(1-t_L\right) \gamma^1 n\left\{\left(1-\alpha^1\right) l^1-\left[t_L w^1 l_w^1+t_S \gamma^1 l_w^1\right]\right\}+ \\
& \left(1-t_L\right) \gamma^2(1-n)\left\{\left(1-\alpha^2\right) l^2-\left[t_L w^2 l_w^2+t_S \gamma^2 l_w^2\right]\right\}+ \\
& t_S\left(\gamma_r^1 n l^1+\gamma_r^2(1-n) l^2\right)=0
\end{aligned} \tag{3.19}
$$

The first two effects of the source-based tax, produced by the change in the two net wages, do not vanish although the labour tax has been set to its optimal level according to (3.18). In fact, by substituting (3.18) into (3.19) and rearranging, one obtains

$$
\frac{\varepsilon_{wr}^2-\varepsilon_{wr}^1}{r} \omega^2(1-n)\left\{\left(\alpha^2-1\right) l^2+\left[t_L w^2 l_w^2+t_S \gamma^2 l_w^2\right]\right\}+
$$

$$
t_S\left(\gamma_r^1 n l^1+\gamma_r^2(1-n) l^2\right)=0. \tag{3.20}
$$

where ε_{wr}^i represent both the elasticity of wage i with respect to the producer interest rate and the ratio between total interest and wages paid in sector i.

The first term in equation (3.20) describes the effect on social welfare of the income redistribution brought about by a marginal increase in the source-based tax. In order to interpret this expression it is expedient to decompose the final change in equilibrium wages using the elasticities ε_{wr}^{i}:

$$\frac{\partial w^1}{\partial r}\Big/ w^1 = \frac{\varepsilon_{wr}^1}{r} \tag{3.21}$$

$$\frac{\partial w^2}{\partial r}\Big/ w^2 = \frac{\varepsilon_{wr}^1}{r} + \frac{\varepsilon_{wr}^2 - \varepsilon_{wr}^1}{r}. \tag{3.22}$$

The source-based tax reduces both wages by a percentage equal to ε_{wr}^1 / r. Then it brings about an additional variation in the wage of the unskilled that is equal to $\left(\left|\varepsilon_{wr}^1\right| - \left|\varepsilon_{wr}^2\right|\right) / r$ as a percentage of the initial level. This additional change may represent an increase if $\left|\varepsilon_{wr}^1\right| < \left|\varepsilon_{wr}^2\right|$ or a further decrease if $\left|\varepsilon_{wr}^1\right| < \left|\varepsilon_{wr}^2\right|$. The proportional reduction in both wages does not affect social welfare as the labour tax is at its optimal level. Hence the first term in (3.20) contains exclusively the additional increase (decrease) in the wage of the unskilled that is measured by the multiplicative factor outside the curly brackets. The expression inside the curly brackets gives the social evaluation of such a change as explained when discussing (3.9).

As in (3.9), the second term in (3.20) represents the revenue loss due to capital outflow.

Expression (3.20) shows that source-based taxation is a substitute for differential labour taxation. In fact, there are just two circumstances in which the (3.20) implies that the optimal source-based tax is zero. The first is when the source-based tax produces the same proportional reduction in both wages (i.e. $\varepsilon_{wr}^2 = \varepsilon_{wr}^1$). In this case the source-based tax is Pareto dominated by the uniform labour tax as the latter reduces wages but does not affect the return on the domestic capital stock. The second is when differential labour taxation is not socially desirable. In fact, the tax rates that solve problem (3.4) are also a solution of problem (3.15) if the optimal rate on skilled labour is equal to the optimal rate on unskilled labour. In such case each single term in (3.18) is equal to zero and (3.20) reduces to (3.11). Further, a solution of problem (3.15) solves the first order conditions of problem (3.4) when the expression in curly brackets in (3.20) is equal to zero. However, the analysis presented at the end of the last section has shown that uniform labour taxation cannot be a solution of the optimal taxation problem, except where the government, in the absence of distributional objectives, finances its expenditure with a poll-tax.

Summarizing,

Proposition 3.2. *When $\alpha^1 \neq \alpha^2$ in competitive equilibrium with uniform lump-sum taxation and the government can implement an optimal linear tax on labour income, the optimal source-based tax is different from zero if and only if $\varepsilon^2_{wr} \neq \varepsilon^1_{wr}$.*

It is useful to compare the results presented up to this point with the conclusions reached by Gerber and Hewitt (1987). They argue that for a small open economy it may be expedient to grant a source-based capital *subsidy* but never desirable to resort to source-based taxes. These results are based on two crucial assumptions. The first is that the government cannot directly transfer income to workers either through subsidies to labour or through a uniform lump-sum grant even though it can levy taxes at different rates on skilled and unskilled labour. The second is that the wages of skilled workers are proportional to the wages of the unskilled.

The first assumption is needed to avoid the outcome of Proposition 3.1: if the government can levy positive as well negative differential taxes on labour there is no reason to resort to source-based capital taxes or subsidies. The second assumption, is responsible for the inefficiency of a source-based capital tax. When wages are proportional to each other, $\varepsilon^2_{wr} = \varepsilon^1_{wr}$: a source-based tax does not redistribute labour income but uniformly reduces the wage level. The same outcome can be achieved with labour taxes, while avoiding the revenue loss due to capital flight. By contrast, a source-based capital subsidy turns out to be efficient because it is the only instrument that allows income to be transferred from the skilled to the unskilled.

The government can grant a source-based subsidy on capital and finance it with a tax on skilled labour. The source-based subsidy raises both wages but only the unskilled enjoy a higher income as the labour tax more than compensates for the increase in the wage of the skilled.

By allowing for differential incidence the model analysed in this paper provides a rationale for source-based subsidies to capital that does not depend on ad hoc restrictions on labour income taxation. Furthermore, expression (3.20) suggests that even a *positive* source-based tax can be efficient, depending on the elasticities ε_{wr}^{i} and the social evaluation of an increase in the wage of the unskilled. For example, when a marginal increase in the net wage of the unskilled is socially desirable (i.e. the expression in curly brackets in (3.20) is positive), the optimal source-based tax is positive when the burden is shifted onto the wage of the skilled more than proportionally (i.e. $\left|\varepsilon_{wr}^{1}\right| > \left|\varepsilon_{wr}^{2}\right|$). This conclusion can be strengthened by solving condition (3.18) for t_L and substituting into (3.19). Tedious but straightforward manipulations yield:

$$t_S = \frac{\left(\varepsilon_{wr}^{2} - \varepsilon_{wr}^{1}\right)(1-n)\,\omega^2 l^2 \left[\varepsilon_{lw}^{c2}\left(1-\beta^1\right) - \varepsilon_{lw}^{c1}\left(1-\beta^2\right)\right] n w^1 l^1}{\Delta} \tag{3.23}$$

where Δ denotes an expression which is always positive[4]. As explained in the previous section condition (3.17) implies that the two terms $\left(1-\beta^i\right)$ are opposite in sign when the government has redistributional objectives. Hence the expression in the square bracket in (3.23) is positive when the government wants to redistribute income towards the unskilled, that is when $\beta^2 > \beta^1$, while it is negative when the government aims to transfer income from the unskilled to the

[4] It is

$$\Delta \equiv \left(\frac{\varepsilon_{wr}^{2}}{r} - \frac{\varepsilon_{wr}^{1}}{r}\right)^2 n l^1 w^1 \varepsilon_{lw}^{1}(1-n)\, l^2 w^2 \varepsilon_{lw}^{2}$$
$$-\left(n w^1 l^1 \varepsilon_{lw}^{1} + (1-n)\, w^2 l^2 \varepsilon_{lw}^{2}\right)\left(\gamma_r^1 n l^1 + \gamma_r^2 (1-n)\, l^2\right).$$

skilled, that is when $\beta^2 < \beta^1$. This leads immediately to the following result:

Proposition 3.3. *Under an optimal linear tax on labour income,*

$$\operatorname{sgn}(t_S) = \operatorname{sgn}\left(\left(\varepsilon^2_{wr} - \varepsilon^1_{wr}\right) \times \left(\beta^2 - \beta^1\right)\right). \tag{3.24}$$

We can conclude that the government of a small open economy levies a *positive* source-based tax on capital income if a higher proportion of the tax burden is shifted onto the class of workers with the lower net social marginal utility of income.

3.3. Optimal origin-based taxes

The conclusions drawn for source-based taxation can be easily applied to *uniform* origin-based taxation. If world prices are given, origin-based taxes are shifted completely onto the immobile factors and a uniform *ad valorem* origin-based commodity tax can exactly replicate a source-based tax on capital income[5].

The preceding analysis does not answer the question whether the government should levy *differential* origin-based commodity taxes. Such taxation provides an additional tool for redis-

[5] To see this point, assume that t_L^* and t_S^* are optimal tax rates. Taxes $t'_L \equiv \left(1 - t_L^*\right)\left(1 + \frac{t_S^*}{r^*}\right) - 1$, $t'_S = 0$ and a uniform origin-based *ad valorem* tax $\tau'_O \equiv \frac{t_S^*}{r^*} \Big/ \left(1 + \frac{t_S^*}{r^*}\right)$ are consistent with the original consumer equilibrium prices and satisfy the zero profit conditions

$$c^1\left(\frac{\omega^1}{(1-t_L^*)}, r^* - t_S^*\right) = p^{*1} \Leftrightarrow c^1\left(\frac{\omega^1}{(1-t_L^*)\left(1+\frac{t_S^*}{r^*}\right)}, r^*\right) = \frac{p^{*1}}{\left(1+\frac{t_S^*}{r^*}\right)} = p^{*1}\left(1 - \tau'_O\right)$$
$$c^2\left(\frac{\omega^2}{(1-t_L^*)}, r^* - t_S^*\right) = p^{*2} \Leftrightarrow c^2\left(\frac{\omega^2}{(1-t_L^*)\left(1+\frac{t_S^*}{r^*}\right)}, r^*\right) = \frac{p^{*2}}{\left(1+\frac{t_S^*}{r^*}\right)} = p^{*2}\left(1 - \tau'_O\right)$$

tribution. The no-profit conditions

$$c^1(w^1, r^*) = p^{1*} - t_O^1 \tag{3.25}$$

$$c^2\left(w^2, r^*\right) = p^{2*} - t_O^2 \tag{3.26}$$

show that gross wages can be independently manipulated through t_O^1 and t_O^2. However, it is not apparent whether it is desirable to resort to this additional instrument since uniform origin-based commodity taxation and a linear labour income tax are sufficient to control the distribution of the two net wages.

The question can be resolved by analyzing the government maximisation problem

$$\underset{t_L, t_S, t_O, b}{Max} \quad W\left(nV\left(\omega^1, b\right), (1-n)\, V\left(\omega^2, b\right)\right) \tag{3.27}$$

subject to

$$R + b - t_L\left(nw^1l^1 + (1-n)\, w^2l^2\right) - t_O^1\theta^1 nl^1 - t_O^2\theta^2 (1-n)\, l^2 \leq 0 \tag{3.28}$$

where

$$\theta^i \equiv \frac{\partial w^i}{\partial p^i} = \frac{1}{c_{w^i}^i} = \frac{X^i}{L^i} \tag{3.29}$$

and X^i is domestic production of the good i. As for source-based taxes, origin-based taxes do not enter directly into social welfare as they do not affect commodity consumer prices.

The first order conditions for t_L, t_O^1 and t_O^2 read respectively

$$
\begin{aligned}
& w^1 n \left\{ \left(1-\alpha^1\right) l^1 - \left[t_L w^1 l_w^1 + t_O^1 \theta^1 l_w^1 \right] \right\} + \\
& w^2 \left(1-n\right) \left\{ \left(1-\alpha^2\right) l^2 - \left[t_L w^2 l_w^2 + t_O^2 \theta^2 l_w^2 \right] \right\} = 0
\end{aligned} \tag{3.30}
$$

$$
-\left(1-t_L\right) \theta^1 \left\{ \left(\alpha^1 - 1\right) l^1 + \left[t_L w^1 l_w^1 + t_O^1 \theta^1 l_w^1 \right] \right\} - t_O^1 \theta_p^1 l^1 = 0. \tag{3.31}
$$

$$
-\left(1-t_L\right) \theta^2 \left\{ \left(\alpha^2 - 1\right) l^2 + \left[t_L w^2 l_w^2 + t_O \theta^2 l_w^2 \right] \right\} - t_O^2 \theta_p^2 l^2 = 0. \tag{3.32}
$$

Conditions (3.31) and (3.32) state that the optimal commodity tax rates must balance the marginal variation in welfare due to income redistribution with the variation in revenues due to the change in domestic production. An increase in the origin-based tax in sector i, leads both to a decrease in the net wage of labour of type i, equal to $\left(1-t_L\right)\theta^2$, and to a decrease in per-capita production in the same sector, equal to $-\theta_p^i l^i$, as the derivative of (3.29) with respect to p^i,

$$
\theta_p^i = -\frac{c_{ww}^i}{\left(c_w^i\right)^2}\theta
$$

is always positive since $c_{ww}^i < 0$.

The comparison of condition (3.20) with conditions (3.31) and (3.32) suggests that the main difference between uniform and differential origin-based commodity taxation lies in their incidence on wages. Given that the two types of labour are sector specific, differential commodity taxation always allows one wage to be reduced with respect to the other, while the same objective can be achieved with uniform taxation only if $\varepsilon_{wr}^1 \neq \varepsilon_{wr}^2$. As a result, optimal origin-based commodity taxes are always different from zero when the expressions in curly brackets in (3.31) and (3.32) do not vanish, that is, when the net social marginal utility of income is different for skilled and unskilled workers. Summarising,

Proposition 3.4. *When $\alpha^1 \neq \alpha^2$ in competitive equilibrium with uniform lump-sum taxation and the government can implement an optimal linear tax on labour income, optimal origin-based commodity taxes are different from zero.*

A closer look at expressions (3.31) and (3.32) clarifies the rationale of differential origin-based commodity taxation. By substituting condition (3.30) into (3.31) and rearranging one obtains

$$(1-t_L)\,\theta^1 \frac{w^2\,(1-n)}{w^1 n}\left\{\left(\alpha^2-1\right)l^2+\left[t_L w^2 l_w^2+t_O\theta^2 l_w^2\right]\right\}-t_O^1\theta_p^1 l^1=0. \qquad (3.33)$$

This expression shows that with an optimal linear income tax the redistribution of income brought about by the tax on good 1 has an effect on welfare that is proportional to the effect due to the redistribution of income produced by the tax on good 2. Why should the government resort to both taxes? The reason is that by mixing the two tax instruments the government reduces the revenue losses brought about by the redistribution of income. In order to achieve a unit increase in the net wage of the unskilled, the government has two options. The first, described by condition (3.32), is to reduce (increase) the tax (subsidy) on good 2 by an amount equal to $\left[(1-t_L)\,\theta^2\right]^{-1}$. As previously explained, this causes a revenue loss equal to $\left|\left[(1-t_L)\,\theta^2\right]^{-1} t_O^2\theta_p^2 l^2\right|$. The second, represented by condition (3.33), is to increase (reduce) the tax (subsidy) on good 1 by an amount equal to $\left[(1-t_L)\,\theta^1\right]^{-1}\left(w^1 n/\,w^2\,(1-n)\right)$. This in turn, reduces revenue by $\left|\left[(1-t_L)\,\theta^1\right]^{-1}\left(w^1 n/\,w^2\,(1-n)\right)t_O^1\theta_p^1 l^1\right|$. The desired increase in wage 2 is achieved efficiently when the marginal costs of the two tax instruments are equalised, that is, by substituting (3.32) into (3.33), when the following condition is satisfied

$$\frac{t_O^2 \theta_p^2 l^2}{(1-t_L)\,\theta^2} = -\frac{t_O^1 \theta_p^1 l^1}{(1-t_L)\,\theta^1} \frac{w^1 n}{w^2\,(1-n)}. \tag{3.34}$$

Using the fact that

$$p^i \theta^i = w^i + r\gamma^i \tag{3.35}$$

and rearranging, condition (3.34) can be rewritten as,

$$\frac{\tau_O^1}{\tau_O^2} = -\frac{(1-n)\,w^2 l^2}{n w^1 l^1} \frac{\eta_{lw}^2}{\eta_{lw}^1} \frac{\left(1+\left|\varepsilon_{wr}^2\right|\right)}{\left(1+\left|\varepsilon_{wr}^1\right|\right)} \tag{3.36}$$

where τ_O^i denotes the ad -valorem tax rate on good i and η_{lw}^i the elasticity of labour demand with respect to the wage. The striking feature of this expression is that the optimal ratio between the two commodity tax rates does not depend on the value judgements embedded in the social welfare functional. This is because the two taxes can achieve the same results in terms of income redistribution when coupled with a linear income tax. Another important implication of condition (3.36) is that the optimal tax rates have opposite signs. Hence, uniform ad -valorem commodity taxation cannot be a solution of the optimal taxation problem, apart from the trivial case where a government with no distributional objectives finances its expenditure exclusively through a uniform lump-sum tax. As to the level of the tax rates, condition (3.36) provides an inverse elasticity rule: the tax (subsidy) rate on good i decreases with total labour income, the elasticity of labour demand and the elasticity of the wage with respect to the interest rate in sector i.

4. Optimal non-linear taxation of labour income

In the preceding sections source- and origin-based taxes are presented as an indirect means of taxing labour at different rates when the labour tax is linear. However, the informational constraints do not bind the taxation on labour income to be linear: the government does not need to know individual wages and the labour supply in order to implement a nonlinear tax on labour income. Are source- and origin-based taxes still desirable when an optimal nonlinear income tax is levied?

The analysis developed up to this point suggests a negative answer. With a nonlinear income tax a different marginal tax rate can be set for each type of labour. Hence, source- and origin-based taxes cannot improve the distribution of net wages. However, I show in the following that an alternative rationale for source- and origin-based taxation does exist: by changing the distribution of gross wages, source- and origin-based taxes can relax the self-selection constraints that bind the non-linear tax.

The optimal taxation problem can be set up, as in Stiglitz (1986), in the following way. Let

$$U\left(x^{1i}, x^{2i}, s^{i}, l^{i}\right) \tag{4.1}$$

be the direct utility function for consumers of type i where x^{ji} is the demand for commodity j. A partially indirect utility function can be defined as follows,

$$V\left(l^{i}, m^{i}\right) \equiv \max_{x^1, x^2} \left\{ U\left(x^{1}, x^{2}, l\right) \middle| \, p^{1*}x^{1} + p^{2*}x^{2} \leq m^{i} \right\} \tag{4.2}$$

where m^i represents after-tax labour income. Given that the labour supply is not observable, it is expedient to rewrite utility function (4.2) in terms of before-tax labour income $Y^i = w^i l^i$:

$$V^i\left(Y^i, m^i\right) \equiv V\left(\frac{Y^i}{w^i}, m^i\right) = V\left(l^i, m^i\right). \tag{4.3}$$

The tax paid by consumers of type i on labour income is given by $Y^i - m^i$. The assumption that $w^1 > w^2$ in both the pre-tax and the post-tax situation guarantees the fulfilment of the single crossing condition. Consequently, at most one of the two self-selection constraints is binding in the optimum. If we consider the case where the self-selection constraint is binding for skilled workers, the optimal source-based and income tax are given by the solution to the problem

$$\max_{Y^1, Y^2, m^1, m^2, t_S} \quad W\left(nV^1\left(Y^1, m^1\right), (1-n)\,V^2\left(Y^2, m^2\right)\right) \tag{4.4}$$

subject to the revenue and self-selection constraints

$$R - n\left(Y^1 - m^1\right) - (1-n)\left(Y^2 - m^2\right) - t_S\left(\gamma^1 n\frac{Y^1}{w^1} + \gamma^2\,(1-n)\,\frac{Y^2}{w^2}\right) \leq 0 \tag{4.5}$$

$$V\left(\frac{Y^2}{w^1}, m^2\right) - V^1\left(Y^1, m^1\right) \leq 0. \tag{4.6}$$

The first of the two constraints requires that revenue should be sufficient to finance the exogenous budget requirement R, while the second requires that skilled workers should not strictly prefer the allocation assigned to the unskilled. The first order conditions for Y^1, Y^2 and t_S read respectively

$$\frac{\alpha_1}{V_m^1} n V_l^1 \frac{1}{w^1} - \left[-n - t_S\gamma^1 n\frac{1}{w^1}\right] + \mu V_l^1\frac{1}{w^1} = 0 \tag{4.7}$$

$$\frac{\alpha_2}{V_m^2}(1-n)V_l^2\frac{1}{w^2}-\left[-(1-n)-t_S\gamma^2(1-n)\frac{1}{w^2}\right]-\mu\left[V_l\left(\frac{Y^2}{w^1},m^2\right)\frac{1}{w^1}\right]=0 \tag{4.8}$$

$$\begin{aligned}&\left\{\tfrac{\alpha_1}{V_m^1}nV_l^1\tfrac{1}{w^1}-\left[-n-t_S\gamma^1 n\tfrac{1}{w^1}\right]\right\}\gamma^1 l^1+\\&\left\{\tfrac{\alpha_2}{V_m^2}(1-n)V_l^2\tfrac{1}{w^2}-\left[-(1-n)-t_S\gamma^2(1-n)\tfrac{1}{w^2}\right]\right\}\gamma^2 l^2+\\&t_S\left(\gamma_r^1 nl^1+\gamma_r^2(1-n)l^2\right)-\mu\left[V_l\left(\tfrac{Y^2}{w^1},m^2\right)\tfrac{Y^2}{(w^1)^2}-V_l^1\tfrac{Y^1}{(w^1)^2}\right]\gamma^1=0\end{aligned} \tag{4.9}$$

where μ is a non-negative scalar.[6] By substituting (4.7) and (4.8) into the (4.9) and rearranging, one obtains

$$\mu\left[V_l\left(\frac{Y^2}{w^1},m^2\right)\frac{Y^2}{(w^1)^2}\right]\frac{\varepsilon_{wr}^1-\varepsilon_{wr}^2}{r}w^1+t_S\left(\gamma_r^1 nl^1+\gamma_r^2(1-n)l^2\right)=0. \tag{4.10}$$

As for the linear case, (4.10) shows that the source-based tax is equal to zero only in two instances. The first is when $\varepsilon_{wr}^1=\varepsilon_{wr}^2$, that is the two types of labour bear the same tax burden. The second is when $\mu=0$, that is when the social optimum lies close to the competitive allocation so that the redistribution desired by the government is not bound by either of the two self-selection constraints. Consequently, the optimal allocation, represented by $\alpha^1=\alpha^2=1$, can be implemented through lump-sum taxes.

Proposition 4.1. *Under an optimal non-linear tax on labour income, the optimal source-based tax is different from zero if and only both $\varepsilon_{wr}^2\neq\varepsilon_{wr}^1$ and $\alpha^1\neq\alpha^2$ in competitive equilibrium with incentive- compatible lump-sum taxation.*

[6] The scalar μ is the ratio between the multiplier associated with the self-selection constraint and the multiplier associated with the budget constraint. Both multipliers are non negative (Stiglitz 1986).

Despite their similarity, the results stated in propositions (3.2) and (4.1) have rather different interpretations. In contrast with (3.20), the effects of a marginal increase in the source-based tax on consumers' net income does not enter into (4.10) since the government can achieve the optimal distribution of labour income that is consistent with the self-selection constraint through the nonlinear labour tax. What is left is the effect of the source-based tax on the self-selection constraint itself. If $\left|\varepsilon_{wr}^{1}\right| > \left|\varepsilon_{wr}^{2}\right|$, an increase in the source-based tax reduces the equilibrium gross wage of the skilled, so that they find it more costly to mimic the behaviour of the unskilled (as shown by the negative term inside the square brackets). Consequently, the self-selection constraint is relaxed and social welfare can be improved (recollect that μ is non negative). By the same token, when $\left|\varepsilon_{wr}^{1}\right| < \left|\varepsilon_{wr}^{2}\right|$, a reduction in the source-based tax relaxes the self-selection constraint and increases welfare.

As for the linear case, equation (4.10) shows that in equilibrium any positive effect on welfare, due to the relaxation of the self-selection constraint, must be counterbalanced by the revenue loss due to the variation in capital invested in the country. This condition makes it possible to determine the sign of the optimal tax rate. When $\left|\varepsilon_{wr}^{1}\right| > \left|\varepsilon_{wr}^{2}\right|$, the government levies a source-based tax. The tax rate is raised up to the point where the welfare gain due to relaxation of the self-selection constraint is exactly offset by the revenue loss due to capital outflow. When $\left|\varepsilon_{wr}^{2}\right| < \left|\varepsilon_{wr}^{1}\right|$, the government grants a subsidy. The subsidy rate is raised up to the point where the welfare gain due to relaxation of the self-selection constraint is exactly offset by the revenue loss due to capital inflow.

The case analysed in this section, in which the self-selection constraint is binding for the skilled, is usually regarded in the literature as the "normal" case. Yet, the possibility of the self-selection constraint being binding for the unskilled cannot be ruled out. Obviously, the foregoing analysis applies to this second case as well: by swapping the indices 1 and 2, one can conclude that a source-based tax is levied when $\left|\varepsilon_{wr}^{2}\right| < \left|\varepsilon_{wr}^{1}\right|$ and a subsidy granted when $\left|\varepsilon_{wr}^{2}\right| > \left|\varepsilon_{wr}^{1}\right|$. These results can be summarised using the fact that the self-selection is always binding for the group with the lower social marginal utility of income.

Proposition 4.2. *Under an optimal non-linear tax on labour income*[7],

$$\operatorname{sgn}(t_S) = \operatorname{sgn}\left(\left(\varepsilon_{wr}^{2} - \varepsilon_{wr}^{1}\right) \times \left(\alpha^{2} - \alpha^{1}\right)\right). \tag{4.11}$$

As explained in the preceding section, all the arguments developed for source-based taxation on capital income apply to uniform origin-based commodity taxation. However, it is worth investigating how the non-linear taxation of labour affects the structure of optimal differential commodity taxes. Differential origin-based commodity taxation can be introduced in problem 4.4 in the way described in section 3.3. The first-order conditions for Y^1, Y^2, t_O^1 and t_O^2 are respectively

$$\frac{\alpha_1}{V_m^1} n V_l^1 \frac{1}{w^1} - \left[-n - n t_O^1 \theta^1 \frac{1}{w^1}\right] + \mu V_l^1 \frac{1}{w^1} = 0 \tag{4.12}$$

$$\frac{\alpha_2}{V_m^2}(1-n) V_l^2 \frac{1}{w^2} - \left[-(1-n) - (1-n) t_O^2 \theta^2 \frac{1}{w^2}\right] - \mu \left[V_l\left(\frac{Y^2}{w^1}, m^2\right)\frac{1}{w^1}\right] = 0 \tag{4.13}$$

$$\begin{aligned} &\left\{\tfrac{\alpha_1}{V_m^1} n V_l^1 \tfrac{1}{w^1} - \left[-n - t_O^1 \theta^1 n \tfrac{1}{w^1}\right]\right\}\theta^1 l^1 - t_O^1 \theta_p^1 n l^1 \\ &-\mu\left[V_l\left(\tfrac{Y^2}{w^1}, m^2\right)\tfrac{Y^2}{(w^1)^2}\theta^1 - V_l^1 \tfrac{Y^1}{(w^1)^2}\theta^1\right] = 0 \end{aligned} \tag{4.14}$$

[7] *This result is equivalent to proposition 1 in Huber (1999).*

$$\left\{\frac{\alpha_2}{V_m^2}(1-n)V_l^2\frac{1}{w^2}-\left[-(1-n)-t_O^2\theta^2(1-n)\frac{1}{w^2}\right]\right\}\theta^2 l^2-t_O^2\theta_p^2(1-n)l^2-=0 \tag{4.15}$$

By substituting (4.12) into (4.14) and (4.13) into (4.15) and rearranging one gets

$$\mu\left[V_l\left(\frac{Y^2}{w^1},m^2\right)\frac{1}{w^1}\right]+t_O^1\frac{\theta_p^1}{\theta^1}n\frac{w^1}{w^2}\frac{l^1}{l^2}=0 \tag{4.16}$$

$$\mu\left[V_l\left(\frac{Y^2}{w^1},m^2\right)\frac{1}{w^1}\right]-t_O^2\frac{\theta_p^2}{\theta^2}(1-n)=0. \tag{4.17}$$

These two conditions can be easily interpreted in the light of the arguments presented earlier. As for source-based capital taxation, the redistribution of income brought about by the two origin-based commodity taxes does not affect welfare if an optimal non-linear income tax is levied. Differential commodity taxation affects welfare through the changes in the self-selection constraint and government revenue. The two taxes have opposite effects on the self-selection constraint as an increase in the tax on commodity 1 always reduces the gross wage of skilled workers while the opposite is true for the tax on commodity 2. This has two implications. First, differential commodity taxation is optimal whenever the self-selection constraint is binding. Second, since the same reduction in the skilled wage can be achieved either through an increase in the tax rate on commodity 1 or through a reduction in the tax rate on commodity 2, in order to determine the optimal tax rate ratio, the effects on government revenue alone must be considered. This can be easily seen by substituting condition (4.16) into (4.16). Surprisingly, this substitution yields directly condition (3.34). Hence, we can state the following result:

Proposition 4.3. *Condition (3.36) represents the structure of optimal origin-based commodity taxation under both a linear and a non-linear income tax.*

5. Further extensions

As noted in section 2, the framework of the present paper has two main shortcomings. First, residence-based taxes cannot be properly analysed as the domestic supply of capital is fixed. Second, since labour is sector specific, ad-hoc assumptions must be introduced in order to rule out the possibility of implementing the first-best solution by levying differential taxes at the firm level.

The first drawback can be overcome by extending the model to a two-period framework as in Bucovetstky and Wilson (1991) and Razin and Sadka (1991). In the first period no production or trade takes place. Consumers only choose how much to consume out of the same inherited lump-sum income. In the second period the economy is represented by the model analysed in this paper, except for the elastic saving supply, which stems from the choice made in the first period.

The arguments used to establish the optimality of source- and origin-based taxes in the static model[8] are still valid in the two-period framework with residence-based capital taxation. Source- and origin based taxes affect welfare exclusively through their impact on wages. They are not a substitute for residence-based taxation, as in Haufler (1997) and Lopez et al. (1996), since they do not influence the consumer interest rate. Consequently, the government resorts to them only if they can improve on the distribution of wages that can be implemented with the tax on labour income. For the source-based capital tax this is possible only if $\varepsilon_{wr}^1 \neq \varepsilon_{wr}^2$. Further, origin-based commodity taxes have opposite effects on the wage distribution. This implies that the optimal tax rate ratio is still defined by (3.36). As to the sign, the source-based capital tax

[8] The formal analysis of the two period model is contained in a previous version of this paper, Arachi (1999).

can be positive or negative depending on the elasticities of wages with respect to the interest rate and on the social evaluation of labour income redistribution. However, since the latter depends on the residence-based capital tax, it is difficult to identify the precise conditions that yield a positive source-based capital tax. These remarks apply to destination-based commodity taxes as well. Destination-based taxes leave the wage distribution unaffected since they do not impinge on producer commodity prices. Hence, they only affect the choice of source- and origin-based taxes indirectly by altering the social evaluation of labour income redistribution.

The second limitation of the paper can be overcome by showing that the analysis developed in the preceding sections extends to the more general case where each sector employs both types of labour.

Condition (3.9) can be rewritten as follows

$$\begin{aligned}
&-\left(1-t_L^1\right)\tfrac{\partial w^1}{\partial r}\left\{\left(1-\alpha^1\right)nl^1-\left[t_L^1 w^1 n l_w^1+t_S\tfrac{\partial K^1}{\partial w^1}\right]\right\}- \\
&\left(1-t_L^2\right)\tfrac{\partial w^2}{\partial r}\left\{\left(1-\alpha^2\right)(1-n)\,l^2-\left[t_L^2 w^2(1-n)\,l_w^2+t_S\tfrac{\partial K^2}{\partial w^2}\right]\right\}+ \\
&t_S\left(\tfrac{\partial K^1}{\partial r}+\tfrac{\partial K^2}{\partial r}\right)=0.
\end{aligned} \tag{5.1}$$

This condition must hold in the optimum even in the case where both types of labour enter into the production of each commodity. The differences between the general and the specific factor model lie in the derivatives of wages and domestic capital stock. In the general case, equation (3.3) must be replaced by[9]

$$\frac{\partial w^i}{\partial r}=\frac{K^j L_i^j-K^i L_j^j}{L_i^i L_j^j-L_j^i L_i^j}. \tag{5.2}$$

[9]When both sector employ the same proportions of skilled and unskilled, i.e. $L_i^i L_j^j - L_j^i L_i^j$, it is not possible to obtain the derivative of wages with respect to the interest rate from the no-profit conditions.

where L_j^i denotes the amount of labour of type i employed in sector j, while the function $\gamma^i L^i$, that yields the equilibrium capital stock in sector i, must be replaced by

$$K^i = c_r^i \frac{c_{w^j}^j L^i - c_{w^i}^j L^j}{c_{w^j}^j c_{w^i}^i - c_{w^i}^j c_{w^j}^i}. \tag{5.3}$$

The same argument applies to the remaining first-order conditions of problems (3.4), (3.15) and (4.4). Consequently, the optimal source-based capital income tax must still satisfy, in the more general framework, the crucial conditions (3.11), (3.20), and (4.10). A corollary of this conclusion is that the results stated in propositions (3.1), (3.2) and (4.1) do not depend on whether production requires just one or both types of labour. Further, the sign of the optimal source-based tax rate on capital can be determined on the basis of (3.24) and (4.11), provided the domestic capital stock is a decreasing function of the interest rate.[10] Expression (5.2) implies that a positive source-based tax may actually increase one of the two wages. For example, the wage of the unskilled rises when the industry that employs the higher share of unskilled labour uses more skilled labour than capital (i.e. $L_i^2 / L_j^2 > L_i^1 / L_j^1$ and $K^j / K^i > L_j^1 / L_i^1$). In this case the optimality of a source-based tax can be established without knowing wage elasticities, as the difference $\varepsilon_{wr}^1 - \varepsilon_{wr}^2$ cannot be equal to zero.

The results obtained for origin-based commodity taxation hold in the general framework as well. However, the analysis becomes much more intricate as each tax affects both wages. The

[10] With a linear labour income tax this guarantees a positive Δ in (3.23).

first order conditions (3.31) and (3.32) must be replaced by two equations similar to (3.31), i.e.

$$
\begin{aligned}
&(1-t_L)\,\tfrac{\partial w^1}{\partial p^i}\left\{\left(1-\alpha^1\right)nl^1-\left[t_L^1 w^1 n l_w^1+t_O^1\tfrac{\partial X^1}{\partial w^1}+t_O^2\tfrac{\partial X^2}{\partial w^1}\right]\right\}+\\
&(1-t_L)\,\tfrac{\partial w^2}{\partial p^i}\left\{\left(1-\alpha^2\right)(1-n)\,l^2-\left[t_L^2 w^2 (1-n)\,l_w^2+t_O^1\tfrac{\partial X^1}{\partial w^2}+t_O^2\tfrac{\partial X^2}{\partial w^2}\right]\right\}+\\
&t_O^1\tfrac{\partial X^1}{\partial p^i}+t_O^2\tfrac{\partial X^2}{\partial p^i}=0
\end{aligned}
\tag{5.4}
$$

where

$$\frac{dw^i}{dp^i}=\frac{c^j_{w^j}}{c^i_{w^i}c^j_{w^j}-c^j_{w^i}c^i_{w^j}} \tag{5.5}$$

$$\frac{dw^i}{dp^j}=-\frac{c^i_{w^j}}{c^i_{w^i}c^j_{w^j}-c^j_{w^i}c^i_{w^j}} \tag{5.6}$$

and

$$X^i=\frac{c^j_{w^i}L^j-c^j_{w^j}L^i}{c^i_{w^j}c^j_{w^i}-c^j_{w^j}c^i_{w^i}}. \tag{5.7}$$

It can be easily verified that the substitution of the first-order condition for the tax on labour income into (5.4) yields two equations similar to (3.20). These equations will contain two terms. The first is given by the product of one of the two curly bracket in (5.4) and the difference between the elasticities of the two wages with respect to the price of the taxed commodity. The second term is the effect of a change in the commodity price on government revenue. The difference between wage elasticities is never equal to zero since the right hand sides of (5.5) and (5.6) show that a price change has opposite effects on the two wages. Hence Proposition 3.4 can be restated in the general framework: the government resorts to differential origin-based commodity taxation whenever the expressions in square brackets in (5.4) are different from zero under an optimal linear labour tax.

By further substituting one of the two necessary conditions for optimal commodity taxes into the other, one obtains an equation that defines the optimal ratio between the two tax rates. This equation shares the two main characteristics of (3.36). First, the optimal tax ratio does not depend on the shape of the social welfare functional as the expression in square brackets in (5.4) has been eliminated through the substitution. Second, the two tax rates have opposite signs, as they bring about opposite changes in wage distribution.

Following the same steps, one can also generalise the conclusions reached under an optimal non-linear income tax.

6. Concluding remarks

The analysis developed in the paper shows that source- and origin-based taxes are constrained-efficient instruments in a small open economy when consumers differ in skills and the government cannot implement the optimal differential linear taxation of labour since it cannot directly observe individuals' characteristics. The rationale for such taxes is quite different from the one provided by the existing literature, which studies large open economies where source-based taxation is seen as a substitute for residence-based taxation.

In a small open economy source- and origin-based taxes are shifted completely onto immobile labour. Where a linear tax is levied on labour income, source- and origin-based taxes can act as substitutes for differential taxation of labour if the various types of labour bear a different tax burden. By contrast, if a non-linear tax is levied on labour income, source- and origin-based taxes cannot directly improve income distribution as the two types of labour are taxed at two different marginal rates. However, they may still improve social welfare as they relax the self-selection constraint that binds the non-linear tax by changing the distribution of gross wages.

This paper provides a basis for understanding tax policies in small open economies. Further research is needed to investigate whether actual tax-setting behaviour is consistent with the results obtained. To this purpose, both a theoretical and an empirical analysis of source- and origin-based tax incidence are of crucial importance.

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