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Efficient tax competition under formula apportionment without the sales factor

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Abstract

Within a tax competition framework, this note points out that the tax principle of Formula Apportionment may render corporate income taxation of multinational enterprises efficient even if a sales apportionment factor is not available. This is shown for constant returns to scale production functions with substitution elasticity greater than or equal to one. In the special case of a Cobb-Douglas production function, efficiency is attained either if the formula uses only payroll or if the formula weights on production inputs equal these inputs' production elasticities.

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1. Introduction

Formula Apportionment is a principle applied in the corporate income taxation of multinational enterprises (MNEs). In Germany, municipalities tax corporate income of multi-regional firms by a Formula Apportionment systems that ignores sales as apportionment factor. In contrast, the states in the U.S. employ Formula Apportionment in the corporate income taxation of multi-state enterprises and, during the last decades, more and more increased the formula weight placed on the sales apportionment factor (e.g. Martens-Weiner, 2005).[1] The European Commission (2001) proposed to introduce Formula Apportionment within the boarders of the European Union. It made already great progress in specifying this policy proposal (European Commission, 2007a,b). However, one of the most controversial points is whether the formula should use a sales factor and, if so, whether this factor should be measured on the origin or destination basis. The fear of the Commission, in particular regarding the origin-based sales factor, is that such a factor may bring back into play profit shifting opportunities of MNEs that actually should be avoided by introducing Formula Apportionment (e.g. European Commission, 2007b). The destination-based sales factor is also proposed by McLure (2000) and Fox et al. (2005). An excellent discussion of the pro and cons of different kinds of the sales factor can be found in Hellerstein and McLure (2004).

Within a tax competition model, this note shows that a sales apportionment factor may become obsolete from an efficiency point of view. We first identify fiscal externalities of corporate income taxation under Formula Apportionment, that is the effect of one jurisdiction's tax rate on welfare in other jurisdictions. This effect can be decomposed into externalities that work through the private income of residents (profit income externality and labor income externality) and externalities that work through tax revenues (tax base externality caused by consolidation and formula externality caused by the apportionment mechanism). We then identify conditions under which the sum of these externalities is zero, thereby implying efficient corporate tax rates. More precisely, if the production function is of the constant returns to scale type with substitution elasticity greater than or equal to one, then there always exists a non-sales formula that ensures efficiency. In the special case of a Cobb-Douglas production function, efficiency is attained either if the formula uses only payroll or if the formula weights on production inputs equal these inputs' production elasticities.

These insights contrast the results in Eichner and Runkel (2011) where it is shown that even for constant returns to scale the pure sales formula may be superior to all other formulas. The reason for the difference in results is that we consider a group of jurisdictions that is small compared to the rest of the world and therefore takes as given the interest rate, whereas Eichner and Runkel (2011) use a general equilibrium framework with an endogenous interest rate. Tax rate changes in one jurisdiction

[1] A theoretical and empirical explanation of this observation is given by Anand and Sansing (2000).

then affect other jurisdictions' welfare also via the interest rate, so the nature of fiscal externalities is different. Hence, the results in Eichner and Runkel (2011) are most applicable to a worldwide Formula Apportionment system. In contrast, the results of our analysis may be understood as a justification for a non-sales formula at the local or regional level as, for example, in Germany.

Moreover, note that our results are also different from those derived in Eichner and Runkel (2008) which uses almost the same model as the analysis in this note and shows that an origin-based sales factor may help to internalize fiscal externalities. The crucial difference is, however, that they assume decreasing returns to scale, in contrast to constant returns to scale which is supposed in the present paper. Taken the results of the two papers together we may make an argument in favor of industry-specific apportionment formulas that depend on the degree of returns to scale in the respective industries. Industry-specific formulas are known from the U.S. Formula Apportionment system, and they are currently also discussed in the context of the corporate tax reform in the Europe Union (European Commission, 2007b).

Finally, the analysis in this paper is also related to the studies of Pinto (2007) and Runkel and Schjelderup (2011). The former study shows that there may exist cases where an apportionment formula with a sales factor is preferable, under both centralized and decentralized formula choice, while the latter study makes the point for a capital factor in the apportionment formula, again under centralization as well as decentralization. However, both studies use a framework quite different from ours. More importantly, in contrast to our analysis, the focus in these studies is on decreasing returns to scale and they do not determine the efficient apportionment formula. Hence, they do not obtain the efficiency result derived in the present note.[2]

2. Multinational Firms

Consider a (representative) MNE with subsidiaries in two identical jurisdictions a and b. In jurisdiction $i \in \{a, b\}$, the MNE produces a numeraire good according to the production function $F(k_i, \ell_i)$ where k_i and ℓ_i are mobile capital and immobile labor input, respectively. The production function has the standard properties $F_k, F_\ell > 0$, $F_{kk}, F_{\ell\ell} < 0$ and $F_{k\ell} > 0$. Moreover, it exhibits constant returns to scale with respect to

[2]It should be mentioned that also Wellisch (2004) considers the decentralized formula choice. In his model, however, corporate taxation is modelled as a source-based tax on capital where total investment of the multinational is fixed and serves as the consolidated tax base. Wellisch (2004)'s approach is not consistent with real world cooperate tax systems. Other related studies on Formula Apportionment can be found in, for example, Sørensen (2004), Pethig and Wagener (2007), Riedel and Runkel (2007) and Nielsen et al. (2010). But none of these studies derives the efficiency result established by our analysis.

capital and labor, so the Euler equation implies $F = k_i F_k + \ell_i F_\ell$, $k_i F_{kk} + \ell_i F_{k\ell} = 0$ and $F_k F_\ell/(F F_{k\ell}) = \varepsilon$ where ε is the elasticity of substitution between capital and labor. The two jurisdictions are small compared to the rest of the world, so the world interest rate $r > 0$ is taken as given. In contrast, the wage rate in jurisdiction i is determined on the local labor market by the equilibrium condition

$$\ell_i = \bar{\ell}. \tag{1}$$

This condition equates the MNE's labor demand ℓ_i and the inelastic labor supply $\bar{\ell}$.

Tax bases in the two jurisdictions are consolidated and then apportioned according to a certain formula. The consolidated tax base of the MNE reads[3]

$$\Phi = F(k_a, \ell_a) + F(k_b, \ell_b) - w_a \ell_a - w_b \ell_b. \tag{2}$$

The share

$$A(k_a, k_b, \ell_a, \ell_b, w_a, w_b) = \gamma \frac{k_a}{k_a + k_b} + \sigma \frac{F(k_a, \ell_a)}{F(k_a, \ell_a) + F(k_b, \ell_b)} + \varphi \frac{w_a \ell_a}{w_a \ell_a + w_b \ell_b} \tag{3}$$

of the consolidated tax base is taxed by jurisdiction a and the share $1 - A(\cdot)$ by jurisdiction b. Note that (3) reflects all three apportionment factors employed in practice: a property factor, a sales factor and a payroll factor. The formula weights are γ, σ and φ, respectively. These weights satisfy $\gamma, \sigma, \varphi \in [0, 1]$ and $\gamma + \sigma + \varphi = 1$. Our main question below will be whether the jurisdictions' tax policy can be efficient if $\sigma = 0$.

The after-tax profit of the MNE can be written as

$$\Pi = (1 - \bar{\tau})\Phi - r(k_a + k_b), \tag{4}$$

where

$$\bar{\tau} = \tau_a A(k_a, k_b, \ell_a, \ell_b, w_a, w_b) + \tau_b [1 - A(k_a, k_b, \ell_a, \ell_b, w_a, w_b)] \tag{5}$$

is the MNE's effective tax rate on the consolidated tax base and τ_i is jurisdiction i's statutory tax rate. The first-order conditions for the MNE's profit-maximizing investment and labor input in jurisdiction i read

$$(1 - \bar{\tau}) F_k(k_i, \ell_i) - r - (\tau_a - \tau_b) A_{k_i}(\cdot)\, \Phi = 0, \tag{6a}$$

$$(1 - \bar{\tau})[F_\ell(k_i, \ell_i) - w_i] - (\tau_a - \tau_b) A_{\ell_i}(\cdot)\, \Phi = 0. \tag{6b}$$

Totally differentiating these conditions, taking into account the labor market equilibrium condition (1) and restricting our attention to a symmetric situation with equal

[3] We refrain from modeling profit shifting activities of the MNE because these activities become obsolete when consolidating tax bases, see e.g. Nielsen et al. (2010).

tax rates $\tau_i = \bar{\tau} = \tau$, we obtain the comparative static results

$$\frac{\partial k_i}{\partial \tau_i} = \frac{1}{2(1-\tau)F_{kk}} \left[F_k + \frac{\Phi}{2} \left(\frac{\gamma}{k} + \frac{\sigma F_k}{F} \right) \right] < 0, \tag{7a}$$

$$\frac{\partial k_j}{\partial \tau_i} = \frac{1}{2(1-\tau)F_{kk}} \left[F_k - \frac{\Phi}{2} \left(\frac{\gamma}{k} + \frac{\sigma F_k}{F} \right) \right] \gtreqless 0, \qquad j \neq i, \tag{7b}$$

$$\frac{\partial w_i}{\partial \tau_i} = -\frac{\Phi}{4(1-\tau)} \left(\frac{\varphi}{\bar{\ell}} + \frac{\sigma F_\ell}{F} \right) + F_{k\ell} \frac{\partial k_i}{\partial \tau_i} < 0, \tag{7c}$$

$$\frac{\partial w_j}{\partial \tau_i} = \frac{\Phi}{4(1-\tau)} \left(\frac{\varphi}{\bar{\ell}} + \frac{\sigma F_\ell}{F} \right) + F_{k\ell} \frac{\partial k_j}{\partial \tau_i} \gtreqless 0, \qquad j \neq i, \tag{7d}$$

$$\frac{\partial (k_j + k_i)}{\partial \tau_i} = \frac{F_k}{(1-\tau)F_{kk}} < 0, \quad \bar{\ell}\, \frac{\partial (w_j + w_i)}{\partial \tau_i} = \frac{\bar{\ell} F_k F_{k\ell}}{(1-\tau)F_{kk}} < 0, \quad j \neq i. \tag{7e}$$

The rationale of these results is as follows. An increase in the corporate tax rate of jurisdiction i triggers a tax base effect and a formula effect. According to the tax base effect, the MNE receives the incentive to decrease investment in both jurisdictions since taxes fall on the consolidated tax base. The formula effect states that the MNE reallocates capital from jurisdiction i to jurisdiction j in order to reduce the share of the consolidated tax base assigned to the tax-increasing jurisdiction i. Considering the tax base and formula effects together, an increase in jurisdiction i's corporate tax rate decreases investment in jurisdiction i and total investment, while the change in investment in jurisdiction j is indeterminate in sign. The tax base and formula effects also hold with respect to changes in the MNE's labor demand and, thus, wage rates. They are amplified by the complementarity between capital and labor ($F_{k\ell} > 0$). The total effect of jurisdiction i's tax rate on wages in jurisdiction i and total payroll is thus negative, while the sign of the effect on wages in jurisdiction j is indeterminate.

3. Tax competition

Having investigated the impact of taxation on the behavior of the MNE, we can now turn to tax competition between the jurisdictions. Governments are assumed to maximize welfare of their residents. Without loss of generality we consider a representative resident in each jurisdiction and assume that the mass of residents in each jurisdiction is normalized to one. The preferences of jurisdiction i's resident are represented by the quasi-concave utility function $U(x_i, g_i)$ where x_i is consumption of a private good and g_i represents consumption of a locally provided public good in jurisdiction i. The resident has three sources of income to finance her private consumption: interest income $r\bar{k}$ from the inelastic supply of the given capital endowment $\bar{k}$, labor income $w_i\bar{\ell}$ from the inelastic supply of labor endowment $\bar{\ell}$ and profit income $\theta_i \Pi = \Pi/n$ from owing a share $\theta_i = 1/n$ of the MNE. The private budget constraint can thus be written as

$$x_i = r\bar{k} + w_i \bar{\ell} + \Pi/n. \tag{8}$$

The governments finance their expenditures for the local public good by means of the tax revenues from the corporate income tax. The fiscal budget constraints read

$$g_a = \tau_a A(\cdot)\Phi, \tag{9}$$
$$g_b = \tau_b (1 - A(\cdot))\Phi. \tag{10}$$

Making use of (8), (9) and (10) in $U(x_i, g_i)$ yields the welfare functions

$$W^a(\tau_a, \tau_b) = U\left(r\bar{k} + w_a\bar{\ell} + \Pi/n, \tau_a A(\cdot)\left[F(k_a, \bar{\ell}) + F(k_b, \bar{\ell}) - (w_a + w_b)\bar{\ell}\right]\right), \tag{11}$$
$$W^b(\tau_b, \tau_a) = U\left(r\bar{k} + w_b\bar{\ell} + \Pi/n, \tau_b[1 - A(\cdot)]\left[F(k_a, \bar{\ell}) + F(k_b, \bar{\ell}) - (w_a + w_b)\bar{\ell}\right]\right). \tag{12}$$

The government of jurisdiction a chooses its tax rate to maximize welfare (11) taking the tax rate of jurisdiction b as given, but taking into account the comparative static results (7a) and (7c). Welfare maximization of jurisdiction b is analogous. The Nash equilibrium tax rates of the tax competition game between the jurisdictions are determined by $\partial W^i(\cdot)/\partial \tau_i = 0$ for $i \in \{a, b\}$. To assess the efficiency properties of the Nash equilibrium we calculate the fiscal externalities, i.e. the effect of jurisdiction i's tax rate on jurisdiction j's welfare. Differentiating W^j with respect to τ_i, accounting for (6a) and (6b) and imposing the symmetry assumption ($\tau_i = \bar{\tau} = \tau$) we obtain

$$\frac{\partial W^j}{\partial \tau_i} = \text{PE} + \text{LE} + \text{TE} + \text{FE}, \tag{13}$$

where

$$\text{PE} = \frac{1}{n}\frac{\partial \Pi}{\partial \tau_i} U_x = -\frac{1}{n}\left[\frac{\partial \bar{\tau}}{\partial \tau_i}\Phi + (1-\tau)\bar{\ell}\,\frac{\partial (w_i + w_j)}{\partial \tau_i}\right] U_x, \tag{14}$$

$$\text{LE} = \bar{\ell}\,\frac{\partial w_j}{\partial \tau_i} U_x, \tag{15}$$

$$\text{FE} = \tau\Phi\left[A_{k_j}\frac{\partial (k_j - k_i)}{\partial \tau_i} + A_{w_j}\frac{\partial (w_j - w_i)}{\partial \tau_i}\right] U_g, \tag{16}$$

$$\text{TE} = \frac{\tau}{2}\left[F_k \frac{\partial (k_j + k_i)}{\partial \tau_i} - \bar{\ell}\,\frac{\partial (w_j + w_i)}{\partial \tau_i}\right] U_g, \tag{17}$$

for $j \neq i$. If jurisdiction i sets its tax rate, it does not account for the impact on the MNE's after-tax profit and thus on profit income of jurisdiction j's residents. This effect constitutes the profit income externality PE in (14). In addition, jurisdiction i also ignores the impact on the wage rate in jurisdiction j and hence on the labor income of residents in jurisdiction j. As a consequence there emerges the labor income externality LE from (15). While PE and LE relate to the income of residents in jurisdiction j, the remaining externalities work through the public budget. The formula externality FE in (16) is based on the above mentioned formula effect. If jurisdiction i increases its tax rate, the MNE will increase both capital and labor demand in jurisdiction j in order to increase the share of the consolidated tax base taxed by jurisdiction j. Analogously, the tax base externality TE from (17) draws back to the above mentioned tax base effect. If jurisdiction i changes its tax rate, the tax base and tax revenue in jurisdiction j are altered since the MNE decreases total investment and total payroll. TE is indeterminate in sign because the reduction in total investment lowers the consolidated tax base (negative effect) whereas the reduction in total payroll increases the consolidated tax base and hence goes in opposite direction (positive effect).

In order to determine the efficiency properties of the equilibrium tax rates, we have to find out the sign of the fiscal externality in (13). Taking advantage of (7b), (7d) and (7e) the expressions in (14) – (17) can be written as

$$\mathrm{PE} = -\left(F - \bar{\ell}F_\ell + \frac{\bar{\ell}F_k F_{k\ell}}{F_{kk}}\right)\theta_i U_x \gtreqless 0, \tag{18}$$

$$\mathrm{LE} = \left[\frac{F - \bar{\ell}F_\ell}{2(1-\tau)}\left(\frac{\varphi}{\bar{\ell}} + \frac{\sigma(F_\ell F_{kk} - F_k F_{k\ell})}{F F_{kk}} - \frac{\gamma F_{k\ell}}{k F_{kk}}\right) + \frac{F_k F_{k\ell}}{2(1-\tau)F_{kk}}\right] \gtreqless 0. \tag{19}$$

$$\begin{aligned}\mathrm{FE} = \frac{\tau \Phi^2 U_g}{8(1-\tau)F_{kk}}\Bigg\{\frac{\varphi}{F_\ell}\left[F_{kk}\left(\frac{\varphi}{\bar{\ell}} + \frac{\sigma F_\ell}{F}\right) - F_{k\ell}\left(\frac{\gamma}{k} + \frac{\sigma F_k}{F}\right)\right] \\ - \left(\frac{\gamma}{k} + \frac{\sigma F_k}{F}\right)^2\Bigg\} > 0.\end{aligned} \tag{20}$$

$$\mathrm{TE} = \frac{\tau F_k (F_k - \bar{\ell}F_{k\ell})U_g}{2(1-\tau)F_{kk}} \gtreqless 0. \tag{21}$$

Hence, while the formula externality is positive, the sign of all other externalities is indeterminate, in general. This raises the question whether there are conditions under which the sum of the externalities vanishes so that tax rates become efficient.

As motivated in the Introduction, in answering this question we are interested in the case where the jurisdictions cannot or are not willing to use the sales factor. Hence, we set $\sigma = 0$ and $\gamma = 1 - \varphi$. Using this together with the constant returns to scale property of the production function, the fiscal externalities in (18) – (21) become

$$\mathrm{PE} = \mathrm{LE} = 0, \tag{22}$$

$$\mathrm{FE} = -\frac{\tau U_g}{2(1-\tau)}\frac{k^2 F_k^2}{F_{kk}}\left[\frac{\varphi^2}{k^2} - \left(\frac{2}{k^2} - \frac{F_k}{\varepsilon k F}\right)\varphi + \frac{1}{k^2}\right] > 0, \tag{23}$$

$$\mathrm{TE} = -\frac{\tau U_g}{2(1-\tau)}\frac{k^2 F_k^2}{F_{kk}}\left[\frac{\bar{\ell}F_\ell}{\varepsilon k^2 F} - \frac{1}{k^2}\right] \gtreqless 0. \tag{24}$$

For the sum of externalities we obtain

$$\mathrm{PE}+\mathrm{LE}+\mathrm{FE}+\mathrm{TE} \;=\; -\frac{\tau U_g}{2(1-\tau)}\frac{k^2F_k^2}{F_{kk}}\left[\frac{\varphi^2}{k^2}-\left(\frac{2}{k^2}-\frac{F_k}{\varepsilon kF}\right)\varphi+\frac{\bar{\ell}F_\ell}{\varepsilon k^2F}\right]. \quad (25)$$

It depends on the formula weight φ whether the sum of externalities vanishes. Formally, equation (25) is quadratic in φ. Its discriminant reads

$$\Delta=\frac{4}{k^2}\left[1-\frac{1}{\varepsilon}+\left(\frac{kF_k}{2\varepsilon F}\right)^2\right]. \quad (26)$$

It is obvious from (26) that $\varepsilon\geq 1$ ensures a strictly positive discriminant $\Delta>0$. In this case, the sum of externalities in (25) has two distinct real roots.[4] Applying Viétes rule, the roots can be computed as

$$\check{\varphi}=1-\frac{kF_k}{2\varepsilon F}-\sqrt{1-\frac{1}{\varepsilon}+\left(\frac{kF_k}{2\varepsilon F}\right)^2}, \qquad \hat{\varphi}=1-\frac{kF_k}{2\varepsilon F}+\sqrt{1-\frac{1}{\varepsilon}+\left(\frac{kF_k}{2\varepsilon F}\right)^2}. \quad (27)$$

Recall that constant returns to scale imply $F=kF_k+\ell F_\ell$ and, thus, $kF_k/F\in]0,1[$. This property together with the assumption $\varepsilon\geq 1$ yields $1-kF_k/(2\varepsilon F)\in]0,1[$ and $1-kF_k/(2\varepsilon F)>\sqrt{1-1/\varepsilon+[kF_k/(2\varepsilon F)]^2}>0$. It follows that the solution $\check{\varphi}$ in equation (27) lies in the interval $]0,1[$. Hence, we have proven

Proposition 1. *Suppose the tax competition game under Formula Apportionment attains a symmetric Nash equilibrium with $\tau_i=\tau$. Furthermore, consider a constant returns to scale production function with substitution elasticity $\varepsilon\geq 1$. Then the equilibrium tax rate τ is efficient if $(\gamma,\sigma,\varphi)=(1-\check{\varphi},0,\check{\varphi})$ with $\check{\varphi}\in]0,1[$.*

The important message of Proposition 1 is that for a constant returns to scale production function with substitution elasticity above or equal to one there always exists at least one economically meaningful apportionment formula that implements efficient corporate tax rates without using the sales apportionment factor. The intuition of this result becomes obvious in light of the externalities given in (22) – (24). The income externalities PE and LE become zero since constant returns to scale imply zero after-tax profit of the multinational firm. The formula externality FE and the tax base externality TE are both decreasing in the substitution elasticity ε. However, while FE stays always positive, TE becomes negative for a sufficient large ε, since for a large degree of substitution between labor and capital the negative effect of tax rates on the consolidated tax base via a decline in investment overcompensates the positive effect via a reduction in wages. Hence, if the substitution elasticity is large enough, the formula weights can always be set such that the positive formula externality FE just outweighs the negative tax base externality TE and the tax rates become efficient.

[4] If $\Delta<0$, then $\mathrm{FE}+\mathrm{TE}$ is strictly positive for all φ and tax rates are inefficiently low.

Thus far we focused on the first solution $\check{\varphi}$ in (27). The problem of the second solution $\hat{\varphi}$ is that it does not necessarily lie between zero and one. But for the special case of $\varepsilon = 1$ which is tantamount to Cobb-Douglas production functions $F(k, \ell) = k^{\alpha}\ell^{1-\alpha}$ with $\alpha \in]0, 1[$ we can immediately derive from (27)

Proposition 2. *Suppose the tax competition game under Formula Apportionment attains a symmetric Nash equilibrium with* $\tau_i = \tau$. *Furthermore, consider the Cobb-Douglas production function* $F(k, \ell) = k^{\alpha}\ell^{1-\alpha}$ *with* $\alpha \in]0, 1[$. *Then the equilibrium tax rate* τ *is efficient if* $(\gamma, \sigma, \varphi) = (0, 0, 1)$ *or* $(\gamma, \sigma, \varphi) = (\alpha, 0, 1 - \alpha)$.

Proposition 2 shows that under a constant returns to scale Cobb-Douglas production function efficiency is attained under two formulas. The first one relies solely on payroll while the second one weights the capital factor with the production elasticity of capital, α, and the payroll factor with the production elasticity of labor, $1 - \alpha$. The rationale can again be illustrated by referring to the externalities in (22) – (24). The income externalities PE and LE are still zero, while the remaining externalities can be written as $\text{FE} = \theta[\varphi^2 - (2 - \alpha)\varphi + 1]$ and $\text{TE} = -\theta\alpha$ with $\theta := -\tau F_k^2 U_g / [2(1 - \tau)F_{kk}] > 0$. The tax base externality is negative and proportional to the production elasticity of capital. The formula externality is also proportional to the production elasticity of capital but positive. In view of the above expressions for FE and TE efficient tax rates can be attained by either placing the total formula weight on payroll or by weighting each production factor by its production elasticity.[5]

4. Discussion

The results of the present note are obtained with the help of the assumption that the group of jurisdictions under consideration is small compared to the rest of the world, so the tax policy of the group does not affect the world interest rate. As already mentioned in the Introduction, our results can therefore be used to justify a non-sales formula on the local or regional level. For example, the municipalities in Germany are rather small and even if we take all municipalities together, their corporate income tax policy will hardly have an effect on the world interest rate. If, in addition, the constant returns to scale Cobb-Douglas function is a good approximation of the production process of firms in German municipalities, our analysis may justify the pure payroll formula currently used in the corporate income taxation on the local level in Germany. It is sometimes

[5]In our setting efficiency can also be attained with the sales factor. For example, with Cobb-Douglas production we obtain $\text{sign}\,[\text{PE}+\text{LE}+\text{FE}+\text{TE}] = \text{sign}\,[\alpha\varphi + (\gamma + \alpha\sigma)^2 - \alpha]$. For $\alpha = 1/3$ and $(\gamma, \sigma, \varphi) = (0.366025, 0.633975, 0)$ it holds $\alpha\varphi + (\gamma + \alpha\sigma)^2 - \alpha = 0$ such that equilibrium tax rates are efficient. Note, however, that our main question is whether efficiency can be obtained even *without* the sales apportionment factor, as motivated in the Introduction.

argued that using payroll as the sole apportionment factor is unfair since it places the whole tax burden on the production factor labor. If so, our analysis shows that an alternative may be to use the production elasticities as formula weights.[6]

Our results are also in contrast to those obtained in the case with decreasing returns to scale. As mentioned in the Introduction, the previous literature has shown that with decreasing returns to scale a sales factor may be helpful in internalizing fiscal externalities. This difference in results raises the question whether real world production functions are characterized by constant or decreasing returns to scale. Duffy and Papageorgiou (2000) estimate an aggregate CES production function based on a panel of 82 countries over a 28-year period. They find that the homogeneity degree is approximately one and that the elasticity of substitution is significantly greater than one. This evidence supports the conditions identified in Proposition 1. However, it should be noted that there are other studies that estimate CES functions with decreasing returns to scale (e.g. Chirinko et al., 2004). From this mixed evidence we draw a further policy conclusion. It might be useful to use industry-specific formulas. In industries with decreasing returns to scale the formula should include a sales factor, while in industries with constant returns to scale the sales factor is not needed. Industry-specific formulas are not unusual. For example, corporate income taxation in the U.S. knows such formulas and they are also considered in the policy discussion in Europe.

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