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The Double Dividend of Taxing Nonqualified Labour More Heavily Than Qualified Labour

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Wolfram F. Richter*

Taxing Human Capital Efficiently – The Double Dividend of Taxing Nonqualified Labour More Heavily Than Qualified Labour

Abstract
Assuming isoelastic returns to education and an endogenous supply of qualified and nonqualified labour, it is shown to be second-best efficient not to distort the choice of education. Furthermore, taxation should set incentives so that qualified labour is substituted for nonqualified labour. As a result, it is efficient to tax labour income regressively with respect to qualification and to tax the monetary cost of education at a level that restores efficiency in education. A tax on capital income alleviates the distortion that progressive taxation of labour income exerts on human-capital investment.

JEL Classification: H21, I28, J24

Keywords: Endogenous choice of education and labour, efficient taxation of human and nonhuman capital, double-dividend hypothesis

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1. Introduction

Human-capital accumulation is expected to be the driving engine of economic growth and development in the new century. Hence human-capital policy should be highly ranked on the agenda. Unfortunately, the economic understanding of optimal human-capital policy is still in its infancy. In particular, an integrated approach is still lacking which allows one to cope with the various sources of tax distortions and market failure. Economic analysis is rather eclectic in this field. The list of issues researched is long. It covers reasons of potential market failure such as positive external effects of education, incomplete markets for educational loans, and missing private opportunities to insure against educational risks. It extends to issues raised by distortionary taxation and includes key words such as income uncertainty (Eaton and Rosen, 1980; Varian, 1980), informational asymmetry (Mirrlees, 1971), credibility of government policy (Boadway et al., 1996; Andersson and Konrad, 2003), and asymmetric income taxation of human and physical capital (Heckman, 1976; Nerlove et al., 1993; Nielsen and Sörensen, 1997), to mention just a few prominent ones.

One of the areas where systematic analysis has only begun is that of the imperfect taxation of rent income generated by the endogenous choice of education. The analysis has been triggered off by some numerical simulations carried through by Trostel (1993) on the basis of a representative-agent general-equilibrium model. This study finds a significant negative effect of proportional income taxation on human capital. By means of further simulation experiments, Trostel (1996) shows that it is second-best efficient to supplement an income tax with a subsidy to higher education. In independent theoretical studies Wigger (2003 and 2004) and Bovenberg and Jacobs (2005) look more closely at the question of when educational subsidies are efficiency-enhancing. These studies differ from Trostel (1996) and the present one in the attempt to integrate two sources of imperfections in one single model: the imperfect taxation of rent income generated by education, and the imperfect taxation of rent income generated by informational asymmetry in the Mirrlees tradition. Although similar in design, the studies suggest strikingly different conclusions. Whereas Bovenberg and Jacobs (2005) find strong theoretical evidence for subsidizing human-capital investment, Wigger (2004) proves that social welfare can never be increased by supplementing a nonlinear income tax with a subsidy to higher education. The conclusions raise the question less of who is right or wrong than of which modelling features are able to explain such contradictory results. This is where the present paper ties in. It offers a simple framework of analysis which allows one to give structure to a strand of literature which threatens to become more and more confusing. It does so by going one step back in the literature and returning to the isolated analysis of the effects that the imperfect taxation of ability rents has on efficient human-capital policy. It is the author's strong belief that these effects have not been well understood till now and that they are of key importance for the design of optimal human-capital policy.

The paper is structured as follows. Section 2 sets up a simple model of a representative taxpayer, with the only endogenous choices concerning education and labour supply. Returns to education are decreasing and are the source of rent income, which cannot be fully skimmed off by a proportional tax on consumption. As a result, the production efficiency theorem of Diamond and Mirrlees (1971) is not applicable. Section 3 introduces policy instruments and the planner's objective function. In Section 4 it is shown to be efficient not to distort educational decisions. Only distortions in the supply of labour should be tolerated. The result is illustrated by means of an example in Section 5. Section 6 derives the result that it is second-best efficient to tax labour income regressively with respect to qualification and to restore efficiency in education by taxing its monetary cost. If regressive labour taxation is politically not feasible, this leads us to study third-best policies. Options are discussed in Section 7. Section 8 deals with the question to what extent education subsidies are needed to enhance efficiency. Section 9 highlights the conflict between distributive equity and efficiency in education. Section 10 summarizes. Major proofs are relegated to a technical Appendix.

2. A representative household model

Consider a representative household which has to choose between supplying nonqualified and qualified labour, L_l and L_h, respectively. The household derives utility $U(C, L_l, L_h)$ from consumption C and the two differentiated forms of labour. Nonqualified labour has to be divided between time spent in the market, $L_l - E$, and time spent on education, *E*. It earns a constant wage rate ϖ_l if supplied to the market. The productivity of qualified labour depends on the amount of education. The choice of E is part of the household's optimization problem. Qualified labour is paid $\varpi_h H(E)$, where ϖ_h is constant while the *earnings function H*(*E*) displays positive but diminishing returns, $H' > 0 > H''$. It is well known that the aggregate empirical earnings function tends to be log-linear with increasing returns in *E*. The focus of the present analysis is however on the individual choice of education, and thus diminishing returns are more plausible.

The representative household is assumed to maximize utility in C, L_l, L_h, E subject to the budget constraint

$$qC = \varpi_l (L_l - E) + \varpi_h H(E) L_h - \pi E = \varpi_l L_l + \varpi_h H(E) L_h - (\varpi_l + \pi) E .$$

Education has a cost in *forgone earnings*, which is captured by $\varpi_l E$. *Monetary costs of education* like college fees come on top of these and are modelled by πE. The *effective* (*unit*) *cost of education* is given by $\phi \equiv \varpi_l + \pi$. Finally, q is the consumer price of consumption. All prices are after tax and subsidy, and the question is which combination of taxes and subsidies is second-best efficient.

It must be stressed that the model assumes two separate time constraints, one for nonqualified labour and one for qualified labour. A more structured model would have to differentiate between two explicit lifetime periods, with the household providing nonqualified labour when young and qualified labour when old (Bovenberg and Jacobs, 2001). Not to differentiate consumption C implicitly requires utility of consumption to be homothetic and weakly separable from leisure.

The analysis relies on the dual approach to optimal taxation. This means that the focus is shifted from the household's (indirect) utility function to its (net) expenditure function. The task of minimizing (net) expenditures subject to an exogenous utility constraint is best solved in a two-step approach. At the first step rent income derived from education is maximized while keeping the level of qualified labour supply, L_h, fixed. Let rent income be denoted by $Y(\varpi_h,\phi,L_h) \equiv \max_E[\varpi_h H(E)L_h - \phi E]$, and the optimal amount of education by $E(\varpi_h,\phi,L_h)$. Note that the primary source of rent income is education and its diminishing return. The qualified-labour supply increases rent income only indirectly via increased incentives for education. Let the social cost of qualified labour be denoted by w_h, and the effective social cost of education by *p*. Clearly, $E(\varpi_h,\phi,L_h) = E(w_h,p,L_h)$ holds if $\phi/\varpi_h = p/w_h$. In what follows $\phi/\varpi_h = p/w_h$ is interpreted as the condition guaranteeing an efficient choice of education relative to the given value of L_h. For the sake of brevity, we refer simply to *efficiency in education* whenever $\phi/\varpi_h = p/w_h$ holds.

The expenditure function is defined as

$$e(q,\varpi_l,\varpi_h,\pi;u) \equiv \min[qC - \varpi_l L_l - Y(\varpi_h,\varpi_l+\pi,L_h)] \text{ in } C,L_l,L_h$$

$$\text{such that } U(C,L_l,L_h) \geq u .$$

Hotelling's lemma yields $e_q = C$, where $C = C(q,\varpi_l,\varpi_h,\pi;u)$ solves the optimization and where the subscript *q* denotes a partial derivative. One likewise derives the identities $e_\pi = E$ and $e_l \equiv \frac{\partial e}{\partial \varpi_l} - (L_l - E)$. Just like *C*, the functions L_l and L_h are Hicksian ones to be evaluated at $q, \varpi_l, \varpi_h, \pi$, and *u*. As a result, the fully specified education function reads $E = E(\varpi_h,\varpi_l+\pi,L_h(q,\varpi_l,\varpi_h,\pi;u))$.

3. Policy instruments

The analysis studies the efficient mix of three policy instruments. The characteristic of the benchmark regime is that consumption is taxed. As it turns out, it is convenient to define the tax rate *t* in *inclusive* form. Treating consumption as a numéraire good with a producer price of one, this means that *t* satisfies the condition $q(1-t) = 1$. In other words, the base of the consumption tax includes the tax payment. The second instrument is a tax ϑ_l on nonqualified labour. It is convenient to define this tax in *exclusive* form. This requires $w_l \mid (1\,2\,\vartheta_l)\varpi_l$, where w_l stands for the wage rate before tax. In the benchmark regime, qualified labour is assumed to remain untaxed: $\varpi_h \mid w_h$. Given that consumption is taxable, nothing is gained by introducing a tax ϑ_h on qualified labour. It would only provide a redundant instrument which could be duplicated by an appropriate choice of the three other policy instruments. If qualified-labour income remains untaxed, a negative (positive) ϑ_l can be interpreted as implying progressive (regressive) taxation of labour income. The third and final instrument is a subsidy to education, *s*. This is again defined in exclusive form, requiring $f \mid (1\,2\,s)\pi$, where *f* is the monetary social cost of education. All social costs, w_l, w_h, and *f*, are treated as exogenous parameters of the planner's optimization. There is a need to raise tax revenue in order to finance exogenous government expenditures.

Government's net tax revenue amounts to

$$T\,\Sigma \frac{t}{1\,4\,t} C\,2\,\frac{\vartheta_l}{1\,2\,\vartheta_l} w_l (L_l\,4\,E)\,4\,\frac{s}{1\,2\,s} fE\,.$$

By invoking Hotelling's lemma, this can be written as

$$T = (q\,4\,1)e_q\,2\,(\varpi_l\,4\,w_l)e_l\,2\,(\pi\,4\,f)e_\pi\,. \qquad (1)$$

The social planner is assumed to maximize tax revenue *T* subject to the condition that private net expenditure remains constant at zero level, *e*=0. A set of instruments *t*, ϑ_l, and *s* is said to be second-best efficient if it solves the planner's maximization problem. As it turns out, the *effective subsidy to the cost of education* will play a key role in characterizing efficient policy. The effective subsidy is denoted by ω and defined by $(1\,2\,\omega)\phi\,/\,\varpi_h \mid p\,/\,w_h \mid (w_l\,2\,f)\,/\,w_h$. As

$$\phi \mid \varpi_l\,2\,\pi \mid \frac{w_l}{1\,2\,\vartheta_l}\,2\,\frac{f}{1\,2\,s}$$

holds by definition, efficiency in education holds in the benchmark regime with $\varpi_h \mid w_h$ if, and only if,

$$\omega = 0 \quad \Diamond \quad \frac{s}{1\,2\,s} f \mid 4\,\frac{\vartheta_l}{1\,2\,\vartheta_l} w_l\,. \qquad (2)$$

Efficiency in education hence requires subsidizing (taxing) the monetary cost of education if labour income is taxed progressively (regressively) with respect to qualification.

4. Efficient education policy

Maximizing government's net tax revenue T in t, ϑ_l, and s, subject to a balanced-budget constraint on the taxpayer (e=0), yields a problem that can easily be solved by applying standard Lagrangian technique. Maximizing in t, ϑ_l, and s is obviously equivalent to maximizing in q, ϖ_l, and π. After taking partial derivatives with respect to q, ϖ_l, π and after eliminating the Lagrange multiplier, one ends up with a system of two first-order conditions:

$$(q\,4\,1)\left(\frac{e_{ql}}{e_l}\,4\,\frac{e_{q\pi}}{e_\pi}\right) = (\varpi_l\,4\,w_l)\left(\frac{e_{l\pi}}{e_\pi}\,4\,\frac{e_{ll}}{e_l}\right) + (\pi\,4\,f)\left(\frac{e_{\pi\pi}}{e_\pi}\,4\,\frac{e_{\pi l}}{e_l}\right), \tag{3}$$

$$(q\,4\,1)\left(\frac{e_{qq}}{e_q}\,4\,\frac{e_{q\pi}}{e_\pi}\right) = (\varpi_l\,4\,w_l)\left(\frac{e_{l\pi}}{e_\pi}\,4\,\frac{e_{lq}}{e_q}\right) + (\pi\,4\,f)\left(\frac{e_{\pi\pi}}{e_\pi}\,4\,\frac{e_{\pi q}}{e_q}\right). \tag{4}$$

This system is best restated in a form that admits interpretation in the spirit of Ramsey. For this purpose define the derivation operator $\div$ to be applied to functions $X \mid X(q,\varpi_l,\pi;u)$ as follows:

$$\div X\,\Sigma(q\,4\,1)X_q\,2\,(\varpi_l\,4\,w_l)X_l\,2\,(\pi\,4\,f)X_\pi\,. \tag{5}$$

Making use of the $\div$-notation, it is shown in the Appendix that the system of equations (3) and (4) can be transformed and restated in equivalent form:

$$\frac{\div L_l}{L_l} \mid \frac{\div E}{E}, \tag{6}$$

$$\frac{\div C}{C} \mid \frac{\div E}{E}. \tag{7}$$

This shows that efficiency is achieved if the policy induces equiproportionate reductions in consumption C, education E, and nonqualified labour L_l when all these behavioural functions are interpreted in the Hicksian sense.

Proposition 1: Efficient policy requires equiproportionate reductions in consumption, education, and nonqualified labour.

It is informative to restate (6) and (7) in still another form by making use of elasticities denoted by $\kappa_{X/x} = \frac{x}{X}\frac{\partial X}{\partial x}$:

$$t(\kappa_{L_l/q} - \kappa_{E/q}) = \vartheta_l(\kappa_{L_l/\varpi_l} - \kappa_{E/\varpi_l}) + s(\kappa_{L_l/\pi} - \kappa_{E/\pi}), \tag{6'}$$

$$t(\kappa_{C/q} - \kappa_{E/q}) = \vartheta_l(\kappa_{C/\varpi_l} - \kappa_{E/\varpi_l}) + s(\kappa_{C/\pi} - \kappa_{E/\pi}). \tag{7'}$$

This form draws attention to the question of which values the policy instruments t, ϑ_l, and s should take on in the optimum. A remarkably strong result is obtained if the individual earnings function is assumed to be isoelastic in education: $H(E) = hE^{\xi}$, $\xi < 1$.

Proposition 2: If the individual earnings function is isoelastic, it is efficient not to distort the choice of education: ω=0.

The proof is given in the Appendix. The generality of Proposition 2 is striking. Beyond the standard regularity assumptions of household optimization, there are no additional ones needed to constrain the choice of utility functions. However, isoelasticity of the individual earnings function is indispensable. It is needed to prove the following remark, of which the proof of Proposition 2 makes heavy use. The proof is again relegated to the Appendix.

Remark 1: Assuming $H(E) \mid hE^{\xi}$, $\xi \{ 1$, one obtains $\kappa_{Y/q} = \kappa_{E/q}$ and

$$\kappa_{Y/x} = \kappa_{E/x} + \frac{x}{\varpi_l \, 2 \, \pi} \qquad \text{for } \; x \mid \pi, \varpi_l \, . \tag{8}$$

According to the remark, isoelasticity of H allows one to translate relative changes in education into relative changes in the rent income of education according to the stated simple formulae.

Proposition 2 is strongly suggestive of a result derived by Bovenberg and Jacobs (2005) and by Jacobs and Bovenberg (2006). These authors equally identify circumstances under which the choice of education should remain undistorted. There are notable differences, however. Bovenberg and Jacobs focus on the optimal trade-off between equity and efficiency when skill formation is endogenous, and they enlarge the set of policy instruments by assuming that a poll tax is available. In substituting the equity objective for the objective of generating tax revenue, their analysis goes beyond the present one. On the other hand, these authors are only able to derive efficiency of education for a scenario in which the costs of education are purely monetary ones. Costs of forgone earnings are ruled out. It is as if nonqualified labour L_l were exogenously fixed. As a result, education E degenerates to an intermediate good and – in contrast to the authors' own suggestions in Jacobs et al. (2006) – the production efficiency theorem of Diamond and Mirrlees (1971) applies. This is different here. Proposition 2 holds for costs of forgone earnings and hence for a scenario for which Bovenberg and Jacobs fail to derive any efficiency result.

The analysis of Bovenberg and Jacobs seems to suggest that Proposition 2 is much less robust than the production efficiency theorem. The proposition holds here where the government is assumed to meet fiscal needs, while it apparently does not extend to the setting integrating an equity objective. This kind of conclusion gains support from Bovenberg and Jacobs (2001). That paper is an earlier version of Bovenberg and Jacobs (2005), and it comes closer to the present analysis by additionally modelling forgone earnings. The paper shows that it is not optimal to leave education undistorted if individuals differ with respect to the productivity of qualified labour, w_h, and if efficiency has to be traded off against equity. In Section 9 it is however argued that this may not be the end of the story. There is evidence that redistributive policy just needs well-designed instruments, and if these are available, Proposition 2 is conjectured to survive.

Proposition 2 requires setting ω=0. According to (2) this can be ensured by either subsidizing the monetary cost of education and taxing labour income progressively with respect to qualification or by doing just the reverse, i.e., by taxing the monetary cost of education and taxing labour income regressively. The former strategy is clearly the more conventional one, found throughout the world. It will be shown next that the competing strategy is more efficient. This will first be shown by means of an example.

5. An Example

Assume quasi-linear utility, $U \equiv C - V(L_l) - V(L_h)$, equally elastic disutility of labour, $V(L) \equiv L^{\frac{\tau}{\tau-1}}, \tau \neq 1$, and isoelastic returns from education, $H(E) = E^{\xi}$, ξ<1. It turns out that the problem is well behaved only in the sense that conditions of second order are fulfilled if $\xi\tau < 1$. The specific appeal of this example comes from vanishing income effects. Maximizing the household's utility yields the following conditions of first order: $\frac{\varpi_l}{q} = V'(L_l)$, $\frac{\varpi_h}{q} H(E) = V'(L_h)$, and $\varpi_h H'(E) L_h = \phi$. Solving these equations for L_l, L_h, E yields $E = [a\xi \frac{q}{\phi}\left(\frac{\varpi_h}{q}\right)^{\tau}]^{\frac{1}{1-\tau\xi}}$, $L_l = a\left(\frac{\varpi_l}{q}\right)^{\tau-1}$, and $L_h = a\left(\frac{\varpi_h}{q}E^{\xi}\right)^{\tau-1}$ with $a \equiv (\frac{\tau-1}{\tau})^{\tau-1}$. This implies the following elasticities:

$\kappa_{L_l/q} = -(\tau-1)$, $\kappa_{L_l/\varpi_l} = \tau-1$, $\kappa_{E/q} = -\frac{\tau-1}{1-\xi\tau}$, $\kappa_{E/x} = -\frac{x}{\varpi_l+\pi}\frac{1}{1-\xi\tau}$ for $x = \varpi_l, \pi$.

Plugging these values into (6) and setting ω=0 yields

$$\vartheta_l = \frac{\xi\tau}{1-\xi\tau} t.$$

Hence it is efficient to tax nonqualified labour, $\vartheta_l>0$, if consumption is taxed as well, $t>0$. Furthermore, ϑ_l increases in t and in the elasticities of the individual earnings function and the disutility of labour. The following section is an attempt to generalize the efficiency result concerning positivity of ϑ_l. Before proceeding, note that ϑ_l is a function of the consumption tax rate and independent of the wage rates w_i $(i=l,h)$. This will be interpreted below as evidence that Proposition 2 may well extend to a setting where the government targets an equity objective. More precisely, the planner will not trade off equity against efficiency in education if the necessary policy instruments are available.

6. The double dividend of taxing labour income regressively

According to Proposition 2, efficient policy should refrain from distorting human-capital investment. In more technical terms, when setting t, ϑ_l, and s, the planner should respect $\omega=0 \Leftrightarrow w_l + f = p = \phi = \varpi_l + \pi$ as a constraint. On substituting $\phi = p$, the expenditure function takes the form $e(q,\varpi_l,\varpi_h;u) \equiv \min[qC - \varpi_l L_l - Y(\varpi_h,p,L_h)]$ in C, L_l, L_h such that $U(C,L_l,L_h) \geq u$. In this case, Hotelling's lemma yields $e_q = C$ and $e_l = -L_l$, so that the government's tax revenue can be written as

$$T = \frac{t}{1-t}C + \frac{\vartheta_l}{1+\vartheta_l} w_l (L_l - E) - \frac{s}{1+s} fE$$

$$= (q-1)C + (w_l - \varpi_l)(L_l - E) - (f - \pi)E$$

$$= (q-1)C + (w_l - \varpi_l)L_l - (p - \phi)E$$

$$= (q-1)e_q + (\varpi_l - w_l)e_l \; .$$

Consider a marginal change in ϖ_l when starting from $\varpi_l = w_l \Leftrightarrow \vartheta_l = 0$. The change is compensated in q subject to the balanced-budget constraint $e=0$. The latter implies $\frac{dq}{d\varpi_l} = -\frac{e_l}{e_q}$. The effect that such a *marginal* reform has on government revenue is captured by

$$\left.\frac{dT}{d\varpi_l}\right|_{\varpi_l \,|\, w_l} \;|\; [\frac{\in T}{\in \varpi_l} \,2\, \frac{\in T}{\in q}\frac{dq}{d\varpi_l}]\Big|_{\varpi_l \,|\, w_l} \;|\; [\frac{\in T}{\in \varpi_l} \,4\, \frac{e_l}{e_q}\frac{\in T}{\in q}]\Big|_{\varpi_l \,|\, w_l}$$

$$= \;(q\,4\,1)e_{ql} \,2\, e_l \,4\, \frac{e_l}{e_q}[e_q \,2\, (q\,4\,1)e_{qq}]$$

$$= \;(q\,4\,1)e_l\left(\frac{e_{ql}}{e_l} \,4\, \frac{e_{qq}}{e_q}\right)$$

$$= \;\frac{q\,4\,1}{q}L_l\,[\,\kappa_{C/q} \,-\, \kappa_{L_l/q}\,]\;.$$

The bracketed expression on the RHS is negative if, and only if, the direct effect that a change in q has on consumption is stronger than the indirect effect that q has on the supply of nonqualified labour:

$$\kappa_{C/q} < \kappa_{L_l/q}\;. \qquad \text{(A1)}$$

The assumption (A1) holds if the demand for consumption and nonqualified leisure is not too substitutional. (A1) fails to hold if nonqualified labour reacts strongly and negatively to an increase in q, i.e., if nonqualified *leisure* reacts strongly and positively to an increase in q. For constant utility the latter is conceivable only if both consumption and nonqualified leisure decrease in q. If, instead, the demand for consumption is complementary to nonqualified leisure, then the RHS is positive while the LHS is negative, and (A1) holds trivially.

Proposition 3: Assume (A1), and consider a marginal tax on nonqualified labour which is compensated by a decrease in the consumption tax and by a marginal tax on the monetary cost of education which restores efficiency in education. Such a reform enhances efficiency.

Consider a scenario in which consumption remains untaxed and in which qualified labour is taxed instead at the rate ϑ_h. One way of subsidizing education is by granting tax deductibility to monetary costs. The question then arises at what rate and to what extent deductibility should be granted. Corollary 1 provides an answer. The choice of education remains undistorted if

$$\frac{p}{w_h} | \frac{\phi}{\varpi_h} | \frac{p/(1\,2\,\omega)}{w_h/(1\,2\,\vartheta_h)} \quad \Diamond \quad \vartheta_h | \omega .$$

Under such circumstances $\vartheta_l \} \vartheta_h = \omega | \frac{\vartheta_l \varpi_l \, 2 \, s\pi}{\varpi_l \, 2 \, \pi}$ implies $s \{ \omega$.

Corollary 1: Assume (A1) and a tax on nonqualified-labour income which marginally exceeds the tax ϑ_h on qualified labour. Efficiency is enhanced if the effective cost of education is subsidized at the level of ϑ_h. This requires setting $s < \vartheta_h \{ \vartheta_l$. In other words, it is efficient not to grant full tax deductibility to the monetary cost of education.

Of the two options (i) subsidizing the monetary cost of education and taxing labour income progressively and (ii) taxing the monetary cost of education and taxing labour income regressively, the latter tends to be the more efficient policy. The intuition is straightforward, and there is a strong parallel with the double-dividend hypothesis (in weak form) known from environmental taxation (Goulder, 1995; Bovenberg and de Mooij, 1994). According to this hypothesis, it is more efficient to encourage socially desirable behaviour by taxing non-compliance than by subsidizing compliance. By taxing non-compliance, which means supplying nonqualified labour to the market in the present framework, tax revenue is increased, which allows one to decrease the overall level of distorting taxes. The competing policy would mean subsidizing compliance in the form of education, which however requires increasing revenue via distorting taxes.

By taxing nonqualified labour income more heavily, the household is induced to reduce $L_l \, 4 \, E$ and to increase E. Note however that this shift in the use of time is not induced by subsidizing the monetary cost of education, but by giving incentives to substitute qualified labour for nonqualified labour. By setting incentives to increase L_h at the cost of L_l, incentives to increase E are given indirectly.

7. Third-best policies

Policy makers will find it little appealing to tax labour income regressively with respect to qualification. The conflict with equity is obvious. Hence a natural question is to ask which policy is efficient in a third-best sense if labour income cannot be taxed regressively for exogenous political reasons. The answer requires a more thorough analysis than can be given here. This section is meant to give tentative answers only and to indicate connections to the literature.

7.1 Taxing labour income proportionally

The most straightforward way of excluding regressive taxation of labour income is to assume proportional taxation. In the benchmark case this can be modelled by excluding ϑ_l from the set of available policy instruments. Hence, assume $\varpi_l \mid w_l$, and focus on the efficient choice of t and s or of q and π. Government's net tax revenue then amounts to

$$T \sum \frac{t}{1 4 t} C 4 \frac{s}{1 2 s} fE .$$

By Hotelling's lemma, this can be written as

$$T = (q 4 1)e_q 2 (\pi 4 f)e_\pi .$$

Consider a marginal change in π when starting from $\pi \mid f \;\; \Diamond \;\; s$=0. The change is compensated in q subject to the budget constraint e=0. The latter implies

$$\frac{dq}{d\pi} \mid 4 \frac{e_\pi}{e_q} \{ 0,$$

i.e., an increase in s must be compensated by an increase in t. The total variation of tax revenue is captured by

$$\left.\frac{dT}{d\pi}\right|_{\pi| f} \;|\; \left.[\frac{\in T}{\in \pi} 2 \frac{\in T}{\in q}\frac{dq}{d\pi}]\right|_{\pi| f} \;|\; \left.[\frac{\in T}{\in \pi} 4 \frac{e_\pi}{e_q}\frac{\in T}{\in q}]\right|_{\pi| f}$$

$$= (q\,4\,1)e_{q\pi}\;2\;e_\pi\;4\;\frac{e_\pi}{e_q}[e_q\;2\;(q\,4\,1)e_{qq}]$$

$$= (q\,4\,1)e_\pi\left(\frac{e_{q\pi}}{e_\pi}\;4\;\frac{e_{qq}}{e_q}\right)$$

$$= \frac{q\,4\,1}{q}E\,[\,\kappa_{E/q}\;-\;\kappa_{C/q}\,]\,.$$

The bracketed expression on the RHS is negative if the elasticity of education is larger in absolute terms than the elasticity of consumption with respect to the price of consumption,

$$\kappa_{E/q} < \kappa_{C/q}\;. \qquad \text{(A2)}$$

Proposition 4: Introducing a marginal subsidy to the monetary cost of education and compensating this by a marginal increase in the consumption tax enhances efficiency if, and only if, (A2) holds.

The assumption (A2) looks different from (A1). Closer inspection, however, reveals that the two assumptions are equivalent if the individual earnings function is isoelastic.

Remark 2: If $H(E)\,|\;hE^{\xi}$, the assumptions (A1) and (A2) are equivalent.

The equivalence is easily proved as follows. By differentiating the expenditure function $e\,|\;qC\,4\,\varpi_l L_l\,4\,Y$ with respect to q and by making use of $e_q\;|\;C$, one obtains

$$qC_q\;|\;\varpi_l L_{lq}\;2\;Y_{L_h}\;(L_{hq}\;. \qquad (9)$$

Relying on e=0, some simple algebraic manipulation yields equivalence of (A1) and the inequality $\kappa_{C/q} > \kappa_{Y/q}$. By Remark 1, equality of $\kappa_{Y/q}$ and $\kappa_{E/q}$ holds if the individual earnings function is isoelastic. This proves Remark 2.

Corollary 2: Assume (A1) and an isoelastic earnings function. Introducing a marginal subsidy for the monetary cost of education and compensating this by a marginal increase in the consumption tax enhances efficiency.

The intuition for this result is as follows. The consumption tax reduces the demand for consumption. Utility remains constant only if the labour supplies L_h and/or L_l are reduced as well. If qualified labour reacts negatively, incentives to invest in education are weakened. This case then calls for subsidizing the monetary cost of education. However, the taxpayer could also react by reducing nonqualified labour. If this effect is strong, then (A1) holds with reversed inequality sign and it is efficient to tax the monetary cost of education. However, this is the less likely case.

From an *a priori* point of view, the case for subsidizing education is not that obvious. See also the discussion in Section 8. Education is a factor generating quasi-rent income which cannot be fully taxed away. There are results in the literature suggesting that policy should not encourage profit-generating behaviour if the profit accrues to the private sector. More precisely, it may well be efficient to tax factors when they generate pure profit and pure profit cannot be taxed away. See e.g. Huizinga and Nielsen (1997). In the present context, this might have given support to the expectation that tax efficiency calls for *taxing* the cost of education (Richter, 2006). This is so because education generates non-taxable rent income and this effect conflicts with tax efficiency in a framework with distortionary taxation. Proposition 4 invalidates this kind of reasoning.

In the present framework a consumption tax is perfectly equivalent to a proportional tax on labour income, $\vartheta_l \mid \vartheta_h \sum \vartheta$. Given such proportionality of labour taxation, subsidizing the monetary cost of education translates into choosing a rate s which marginally exceeds rate ϑ. If subsidization is provided by means of granting tax deduction to the monetary cost of education, the rate of deduction should exceed one hundred percent.

7.2 Taxing capital income

By investing in one's own human capital, future consumption is increased at the cost of current consumption. The same effect is reached by saving out of nonqualified labour income. If the return to saving is taxed, this way of providing for the future becomes less attractive. Hence taxing capital income sets incentives to reduce the market supply of nonqualified labour and to substitute qualified labour for nonqualified labour. As is well known, there are many further effects of taxing capital income (Trostel, 1993). Still, the effect of discriminating against saving is a major one and one which is easily integrated in the present analysis. Just assume that lifetime falls into two explicit periods. In the first one, the household has to divide non-leisure time between education, E, and labour supplied to the market, $L_l - E$. For the sake of simplicity assume that all consumption is shifted to the second period. As a result, all income earned in the first period must be spent either on education or on savings:

$$S = \varpi_l (L_l - E) - \pi E = \varpi_l L_l - (\varpi_l + \pi) E .$$

Second-period consumption is constrained by income earned:

$$qC = \psi S + \varpi_h H(E) L_h \ .$$

As before, q is the price of consumption, while ψ is the gross rate of return to saving. For some exogenous political reasons let the planner be constrained to tax labour income progressively, $\varpi_l \geq w_l, \varpi_h = w_h$. Assume, furthermore, that the only policy instruments available are a tax on consumption, $q>1$; a tax/subsidy to the monetary costs of education, $\pi \gtrless f$; and a tax on capital income, $\psi<r$. By applying the same technique as before and by assuming an isoelastic earnings function, one can show that it is efficient not to distort the choice of education,

$$\psi \frac{\varpi_l + \pi}{\varpi_h} = r \frac{w_l + f}{w_h} . \tag{10}$$

This condition is clearly fulfilled if capital and the monetary costs of education are taxed so that $\psi | \; r\frac{w_l}{\varpi_l} \{ \; r$ and $\pi | \; \frac{r}{\psi} f \} \; f$ results. Starting from this situation and assuming (A1), the following reform enhances efficiency: ψ is decreased marginally, and this decrease is compensated by variations in π and q so that (10) continues to hold and the utility of the taxpayer remains constant. The result suggests that a positive tax on capital income has the potential to alleviate the negative incentives that progressive taxation of labour income has on human-capital investment. This confirms earlier conclusions of Jacobs and Bovenberg (2005). The conclusions are not, however, fully compatible with Nielsen and Sörensen (1997). In fact, they are just the logical reverse of what Nielsen and Sörensen try to convey. Those authors argue in favour of a policy which aims at *discouraging* human-capital investment. They derive their recommendation by keeping the capital income tax exogenous, by ignoring monetary costs of education, and by then proving optimality of progressivity in labour income taxation. This result is compatible with (10) only if f=0 as then $\psi \{ \; r$ implies $\varpi_l / \varpi_h \} \; w_l / w_h$. The result does not however hold if f>0. In this case it is clearly more efficient to sustain efficiency in education by taxing the monetary costs of education than by subsidizing non-qualified labour income.

8. To what extent are education subsidies efficiency-enhancing?

The role of subsidies paid to education and the effect such subsidies have on the equity–efficiency trade-off in the taxation of labour income is a big topic in the literature. The conclusions derived are irritatingly opposing. According to Bovenberg and Jacobs (2005) “redistribution and education subsidies are Siamese twins”. Subsidies on education are shown to alleviate the tax distortions on learning induced by redistributive policies. The more eager the distributive objectives are, the more strongly policy must rely on educational subsidies. Quite to the contrary, Wigger (2003, 2004) proves that social welfare can never be increased by supplementing a nonlinear income tax with a subsidy to the cost of education. Although the present paper focuses on efficiency only, it helps to understand these seemingly conflicting views of education subsidies.

From the literature on the optimal labour taxation in the Mirrlees tradition it is well known that highly productive labour income should not be taxed at the margin if the tax planner wants to redistribute income between two productivity types of individuals and if low and high types cannot be identified on an individual basis. In present notation this requires setting $\vartheta_h \mid 0$. Relying on this famous result and on quasi-linear utility functions, Wigger proves that a subsidy to the monetary cost of education effectively lowers social welfare. Hence it is optimal to set $s < \vartheta_h \mid 0$. This comes close to Corollary 1 above. In fact, Corollary 1 is stronger than Wigger's result in that it relies on weaker assumptions. Utility functions need not be quasi-linear. They have to satisfy (A1) only. Furthermore, the present analysis makes clear that $s < \vartheta_h$ follows from pure efficiency considerations, while $\vartheta_h \mid 0$ follows from the government's need to respect an informational participation constraint when redistributing income from high to low productivity types of individuals.

Bovenberg and Jacob's (2005) results are less easy to summarize. The reason is that these authors study education subsidies in varying frameworks. The most general one allows for costs of forgone leisure. With respect to the feasible choice of utility functions it is even more general than Wigger's analysis. The price Bovenberg and Jacobs pay is a loss in the simplicity and clarity of results. They are only able to prove that non-pecuniary educational costs may have an increasing effect on optimal education subsidies, especially if they are complementary to work effort. In the less ambitious part of their paper, Bovenberg and Jacobs ignore non-pecuniary educational costs. They demonstrate that optimal subsidies on education ensure efficiency in human-capital accumulation even if the government values equity and pursues a redistributive policy. If tax rates on labour increase, optimal subsidies on education should do so as well in order to alleviate the tax distortions on learning.

Such a conclusion comes close to Propositions 3 and 4 above. Proposition 3 suggests that it is efficient to combine regressive taxation of labour income with a tax on the monetary cost of education. If, however, equity concerns rule out the use of regressive taxation, then efficiency requires subsidizing education, as stated by Proposition 4. As has already been argued, the present analysis should however not be considered a replication of Bovenberg and Jacobs (2005). Bovenberg and Jacobs only derive an efficiency result when ignoring non-pecuniary educational costs. In this case, education degenerates to an intermediate good, and the production efficiency theorem of Diamond and Mirrlees (1971) is applicable. In contrast, Proposition 2 holds even in the case when education is a leisure-time consuming activity generating rent income that cannot be fully taxed away.

In Bovenberg and Jacobs (2005) the argument runs as follows. Because of distributive concerns it is efficient to rely on a distortional tax on labour income. As a poll tax allows skimming off pure ability rents, the production efficiency theorem is applicable, and this requires leaving educational investment undistorted. In the present analysis distortions arise from taxing consumption. A poll tax is not available, but labour income can be taxed according to qualification, which is not the case in Bovenberg et al. (2005). Ability rents accrue to the taxpayer, and yet it is efficient to leave the educational choice undistorted.

One may well debate whether tax rates should be allowed to depend on educational characteristics or not. From a positive point of view it is difficult to justify any dependence. No country is known to condition tax rates on educational characteristics explicitly. This common reluctance is however more and more questioned from a normative perspective. Most prominent is the idea of introducing graduate taxes; see e.g. Garcia-Penalos and Wälde (2000) or Poutvaara (2004). Such taxes are attractive in that school qualification and university degrees are certainly not difficult to verify by tax authorities. Even more, failure to use this information is conceptually not really plausible, given the framework of Bovenberg and Jacobs (2005). These authors assume that the government can subsidize individual monetary costs of education. Hence the government should be able to differentiate tax rates according to subsidies received. If not, the framework is not too far from the one discussed in Section 7.1. It relies on the assumption that labour income tax rates cannot be differentiated according to qualification for some unspecified exogenous reason: $\vartheta_l \mid \vartheta_h \Sigma \vartheta$. The analysis in Section 7.1 shows that, given non-differentiation, the monetary cost of education should be subsidized at a rate s that exceeds ϑ. This result confirms simulation results of Trostel (1996). It however contradicts Bovenberg and Jacobs (2005), who prove $s=\vartheta$ in the less ambitious part of their paper. This is further evidence to the claim that the results of Bovenberg and Jacobs (2005) and the ones presented here are only similar in spirit but different in substance.

As has already been stressed, Proposition 3 is best interpreted with reference to the double-dividend hypothesis known from the literature on environmental taxation. If it is socially desirable to encourage education at the margin, one should do so by taxing noncompliant behaviour and not by subsidizing compliant behaviour. This is the so-called weak form of the double-dividend hypothesis. See Goulder (1995). The first dividend is the positive effect on education, and the second dividend comes from the generated revenue, which can be used to cut back distorting taxes. There have been other, less convincing attempts in the literature to relate double dividends to optimal education policy. Jacobs (2005) suggests speaking of a double dividend if education subsidies produce more equality in before-tax incomes and also generate efficiency gains in taxation. He refers to Dur and Teulings (2004). These authors argue in favour of educational subsidies. By promoting education and relying on general-equilibrium effects, the distortionary cost of progressive taxation may be reduced. According to Jacobs (2005), a “double dividend” of education subsidies generating more equality in before-tax wages through general-equilibrium effects and lower distorting tax rates is however not likely to occur. Corollary 1 of the present paper is another blow against the thesis of Dur et al. The monetary cost of education should not even be granted full tax deductibility if labour income can be taxed according to qualification. In other words, for pure reasons of efficiency, education should be taxed and not subsidized on a net basis. The conjecture is that this result perfectly extends to a general-equilibrium framework.

9. Efficiency in education and distributive policy

According to Bovenberg and Jacobs (2001), efficiency in education fails to be optimal when education causes costs of forgone earnings and when there are distributional concerns. If nothing more could be said, this result would provide a critical argument against the practical relevance of Proposition 2. However, more can be said when taking a closer look at the example discussed in Section 5. According to this example it is efficient not to distort human-capital investment and to tax nonqualified labour income at a rate ϑ_l which is a function of the consumption tax rate but else independent of the wage profile w_i (i=l,h). Bovenberg and Jacobs (2001) model taxpayers' heterogeneity by assuming a non-degenerate distribution of the productivity of qualified labour as measured by w_h. Taxpayers are assumed to differ neither by w_l and nor by the elasticity of the individual earnings function, ξ. In the example of Section 5, differences in w_h would not show up in the efficient ratio of ϑ_l to t but in their absolute values only. This observation suggests conjecturing that an optimizing planner would choose to address equity concerns by relying on a personal tax on lifetime consumption. This is not beyond what economists consider a reasonable idea. The only problem is that ϑ_l would have to increase in t. The more productive the taxpayer is, the more regressively his or her labour income has to be taxed with respect to qualification. This recommendation is clearly difficult to translate into practical policy. When the taxpayer is young and not qualified, the necessary information concerning w_h is typically missing. The idea of differentiating ϑ_l according to w_h will fail in practice. If however a non-differentiating tax ϑ_l is applied, the planner runs into a conflict. Equity calls for high tax rates ϑ_h on labour income when w_h is high, while efficiency calls for just the reverse monotonicity. In practice, the planner has no choice but to compromise on efficiency in education when enhancing equity. Although this conclusion is not really surprising, it makes one point clear: The practical limits to the applicability of Proposition 2 are not set by equity concerns as such, but by the lack of information about future productivity differentials before individuals start to reap the returns to their human-capital investments.

This discussion deserves to be qualified in one notable respect. The strongest predictor of educational success is known to be the family background. Hence parents' income should be an empirically informative signal of w_h. Insofar as this is the case, it gives reason to tax nonqualified labour income at a rate which increases with *parents*' income. Although this is a daring idea, it is theoretically not without appeal. It is an idea that may have practical potential in relaxing the conflict between equity and efficiency in education. A more conventional policy is to subsidize the education of highly productive individuals at a higher rate than the education of less productive individuals. The German practice of financing university education by taxes and leaving it to the private sector to finance apprenticeships may well be interpreted along these lines. Such a policy, however, fails to be second-best efficient.

10. Summary

The policy conclusions derived from this paper's analysis are as unambiguous as they are unpopular. They are unambiguous in the sense that it could be shown under fairly broad assumptions to be efficient not to distort educational choice when education generates ability rents. Distortions should be tolerated only in the supply of labour. Given that the necessary policy instruments are available, it is second-best efficient to tax labour income regressively with respect to qualification and to tax the monetary cost of education at a level that allows one to sustain efficiency in education. Such a policy aims at leaving education undistorted while setting incentives for substituting qualified labour for nonqualified labour. The intuition reminds one of the double-dividend hypothesis well known from environmental taxation. According to this hypothesis it is more efficient to tax noncompliant behaviour than to subsidize compliant behaviour. In the present context noncompliant behaviour takes the form of supplying nonqualified labour to the market, while compliant behaviour refers to non-leisure time spent on education. The results derived in this paper allow one to give a consolidated interpretation of various other results that have been produced in the literature and that tend to be contradictory and confusing.

The policy implications derived from this paper's analysis are certainly not very popular. Not many people would be willing to tax nonqualified labour more heavily than qualified labour. The implications are, however, not so unreasonable if interpreted with care. There are two options of careful and reasonable interpretation: a defensive one and an offensive one. According to the offensive interpretation, the analysis suggests pursuing the equity objective by redistributing lifetime consumption and providing incentives to restore efficiency in educational choice. A theoretically appealing way to achieve this goal is to tax nonqualified labour at a rate that increases in a reliable predicator of the returns to education. Parents' income may be a good candidate. Although it is a daring idea to tax nonqualified labour income according to parents' income, it certainly deserves to be discussed in more detail than could be done here. According to the defensive interpretation, no particular policy recommendation is derived. The primary value of the analysis is seen in stressing the social efficiency cost of progressive taxation. Progressive taxation with respect to qualification is just the opposite of what is needed to encourage human-capital investment. This negative incentive effect magnifies the negative disincentives for labour choice highlighted by Mirrlees (1971) and others.

A final remark concerns the simplicity of the model used in the present paper. One must admit that major results do not hold if the individual earnings function fails to be isoelastic. Even if this assumption is accepted, it is not clear whether the results derived hold in more realistic settings. The time structure has only been implicit and rudimentary, and the accumulation of physical capital has not been modelled at all. Furthermore, labour has been assumed to be immobile, and the model is the one of a closed economy. Although such modelling shortcomings cannot be denied, there is hope that some of them can be overcome by future research. For example, there is evidence (Schuppert, 2007) that efficiency in education is something to which jurisdictions should stick even if migration incentives are distorted. Hence, more research is needed to find out how robust the policy implications of this paper are.

11. Appendix

The proof of *Proposition 1* makes use of $e_q \,|\, C$, $e_l \,|\, 4(L_l \, 4 \, E)$, and e_π=*E*. Equation (7) is easily seen to be perfectly equivalent to (4). Equation (6) follows just from verifying the equality

$$\frac{÷E}{E} \,|\, \frac{÷e_\pi}{e_\pi} \,\underset{(3)}{|}\, \frac{÷e_l}{e_l} \,|\, \frac{÷(L_l \, 4 \, E)}{L_l \, 4 \, E} \,|\, \frac{÷L_l \, 4 \, ÷E}{L_l \, 4 \, E}.$$

Remark 1 is only proved for the case in which the equality of elasticities is claimed to hold with respect to variations in *q*. The cases concerning variations in π and ϖ_l are proved along the same lines. The definition $Y(\varpi_h, \phi, L_h) \,|\, \varpi_h H L_h \, 4 \, \phi E$ and the first-order condition $\varpi_h H' L_h \,|\, \phi$ imply $Y_q \,|\, \varpi_h H L_{hq}$ and $E_q \,|\, 4\frac{H' L_{hq}}{H'' L_h}$. Making use of $\xi \, \Sigma E H'/H$, one obtains $Y \,|\, H\frac{\phi}{H'} 4 \, \phi E \,|\, \phi(\frac{1}{\xi} 4 \, 1)E$. Hence $\kappa_{Y/q}$ = $\kappa_{E/q}$ ◊ $\frac{\varpi_h H L_{hq}}{\phi(\frac{1}{\xi} 4 \, 1)E} \,|\, \frac{Y_q}{Y} \,|\, \frac{E_q}{E} \,|\, 4\frac{H' L_{hq}}{H'' L_h E}$ ◊ $\frac{1}{1 \, 4 \, \xi} \,|\, \frac{H}{(\frac{1}{\xi} 4 \, 1) E H'} \,|\, 4\frac{H'}{H'' E}$, which clearly holds if *H* is isoelastic.

The proof of *Proposition 2* requires some preparatory considerations. Note first that (9) holds in more general terms:

$$qC_x \,|\, \varpi_l L_{lx} \, 2 \, Y_{L_h} \, ĺL_{hx} \quad \text{for} \quad x \,|\, q, l, \pi. \qquad (11)$$

Making use of (5) and (11), one easily derives

$$q÷C \,|\, \varpi_l ÷L_l \, 2 \, Y_{L_h} \, ḟ÷L_h \,. \qquad (12)$$

Assuming (6ℜand isoelasticity of *H*, (7ℜis shown to hold if, and only if, $\phi \,|\, p$:

$$\frac{÷C}{C} \,\underset{(12)}{|}\, \frac{1}{qC}[\varpi_l ÷L_l \, 2 \, Y_{L_h} \, ḟ÷L_h]$$

$$\overset{(6)}{|}\ \frac{\varpi_l L_l}{qC}\frac{\div E}{E} + \frac{1}{qC}Y_{L_h}\ \div L_h$$

$$\overset{(8)}{|}\ \frac{\varpi_l L_l}{qC}\frac{\div E}{E} + \frac{1}{qC}\frac{Y}{E}\div E\, 2\, \frac{Y}{qC}\frac{(\varpi_l\, 4\, w_l)\, 2\, (\pi\, 4\, f)}{\varpi_l\, 2\, \pi}$$

$$= \frac{\varpi_l L_l\, 2\, Y}{qC}\frac{\div E}{E} + \frac{Y}{qC}\frac{\phi\, 4\, p}{\phi}$$

$$= \frac{\div E}{E} \quad \text{if, and only if, } \phi \mid p.$$

References:

Andersson, F. and K.A. Konrad, 2003, Human capital investment and globalization in extortionary states, Journal of Public Economics 87, 1539–1555.

Boadway, R., N. Marceau, and M. Marchand, 1996, Investment in education and the time inconsistency of redistributive tax policy. Economica 63, 171–189.

Bovenberg, A.L. and B. Jacobs, 2001, Redistribution and education subsidies are Siamese twins, CEPR Disc. Paper No. 3099.

Bovenberg, A.L. and B. Jacobs, 2005, Redistribution and education subsidies are Siamese twins, Journal of Public Economics 89, 2005–2035.

Bovenberg, A.L. and R.A. de Mooij, 1994, Environmental levies and distortionary taxation, American Economic Review 94, 1085–1089.

Diamond, P. and J.A. Mirrlees, 1971, Optimal taxation and public production, I Production efficiency, II Tax rules, American Economic Review 61, 8–27, 261–278.

Dur, R. and C.N. Teulings, 2004, Are education subsidies an efficient redistributive device? in: Labor Market Institutions and Public Regulation, J. Agell, M. Keen, and A.J. Weichenrieder, eds., Cambridge, MA, 123–161.

Eaton, J. and H.S. Rosen, 1980, Labour supply, uncertainty, and efficient taxation, Journal of Public Economics 14, 365–374.

Garcia-Penalosa, C. and K. Wälde, 2000, Efficiency and equity effects of subsidies to higher education, Oxford Economic Papers 52, 702–722.

Goulder, L.H., 1995, Environmental taxation and the double dividend: A reader's guide, International Tax and Public Finance 2, 157–183.

Heckman, J.J., 1976, A life-cycle model of earnings, learning, and consumption, Journal of Political Economy 84, S11–S44.

Jacobs, B., 2005, The double dividend of education subsidies for redistribution, Discussion Paper.

Jacobs, B. and A.L. Bovenberg, 2005, Human capital and optimal positive taxation of capital income, Tinbergen Institute, Disc. Paper TI 2005-035/3.

Jacobs, B. and A.L. Bovenberg, 2006, Redistribution and education subsidies are Siamese twins (II) – A Correction and Further Generalizations, mimeo.

Huizinga, H.P. and S.B. Nielsen, 1997, Capital income and profit taxation with foreign ownership of firms, Journal of International Economics 42, 149–165.

Mirrlees, J.A., 1971, An exploration in the theory of optimum income taxation, Review of Economic Studies 38, 175–208.

Nerlove, M., A. Razin, E. Sadka, and R.K. von Weizsäcker, 1993, Comprehensive income taxation, investment in human and physical capital, and productivity, Journal of Public Economics 50, 397–406.

Nielsen, S.B. and P.B. Sörensen, 1997, On the optimality of the Nordic system of dual income taxation, Journal of Public Economics 63, 311–329.

Poutvaara, P., 2004, Educating Europe: Should public education be financed with graduate taxes or income-contingent loans? CESifo Economic Studies 50, 663–684.

Richter, W.F., 2006, Efficiency effects of tax deductions for work-related expenses, International Tax and Public Finance 13, 685–699.

Schuppert, C., 2007, Does mobility of educated workers undermine decentralized education policies? Disc. Paper, University of Dortmund.

Trostel, P.A., 1993, The effect of taxation on human capital, Journal of Political Economy 101, 327–350.

Trostel, P.A., 1996, Should education be subsidized? Public Finance Quarterly 24, 3–24.

Varian, H.R., 1980, Redistributive taxation as social insurance, Journal of Public Economics 14, 49–68.

Wigger, B.U., 2003, Finanzierung der Hochschulbildung und Einkommensbesteuerung, in: Hochschulökonomie – Analysen interner Steuerungsprobleme und gesamtwirtschaftlicher Effekte, U. Backes-Gellner and C. Schmidtke, eds., Berlin, 129–144.

Wigger, B.U., 2004, Are higher education subsidies second best?, Scandinavian Journal of Economics 106, 65–82.