



# Optimal factor tax incidence in two-sector human capital-based models<sup>☆</sup>

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## ABSTRACT

This paper studies the optimal factor tax incidence in a standard two-sector, human capital-based endogenous growth model elucidated by Lucas (1988). Capital income taxes generate dynamic inefficiency for capital accumulation and labor income taxes create dynamic inefficiency for human capital accumulation. A factor tax incidence is a tradeoff between these two inefficiencies. A switch from capital income taxes to labor income taxes reduces the long-run welfare coming from lower leisure and increases the long-run welfare originated from higher economic growth and higher consumption. Because the representative agent's learning time and human capital are inseparable and thus affect learning activities at the same degree, we find that based on the current US income tax code, it is optimal to first tax capital income, and to resort to taxing labor income only when tax revenue is insufficient to cover government expenditure.

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## 1. Introduction

If the government's only option is to tax factor income, should the government tax capital income or labor income? The pivotal work by Judd (1985) and Chamley (1986) argued that the government should tax only labor income and not capital income in the long run. Their claim was based on dynastic growth models in which physical capital is accumulated over time while labor does not embody human capital. Several studies have revisited the issue by relaxing key assumptions and found the result to be robust; for example, see Chari et al. (1994), Chari and Kehoe (1999) and Atkeson et al. (1999). The reason for the result is that capital accumulates over time and the capital income taxation creates a dynamic inefficiency for capital accumulation. Therefore, it is not optimal to tax capital income.

If labor embodies human capital, one might wonder whether capital income should be taxed instead of labor income. Lucas (1990) was the first to study the question of the optimal factor tax incidence in a two-sector human capital-based endogenous growth model. In a two-sector, human capital-based growth model, both physical capital and human capital accumulate over time; thus the capital income taxation creates a dynamic inefficiency for capital accumulation and labor

income taxation generates a dynamic inefficiency for human capital accumulation. Factor income taxation then is a tradeoff between these two kinds of dynamic inefficiencies. In Lucas (1990), the learning activity that forms human capital is linear with regard to the representative agent's current level of human capital and concave in the representative agent's learning time. Because the contribution of the representative agent's learning time to the formation of human capital in the future is smaller than the contribution of the agent's human capital, in the long run it is optimal to tax labor/human capital income and not to tax capital income. Later, Jones et al. (1993, Model II) studied an otherwise identical model. In their model, although material goods are an input, their learning function is intrinsically like that revealed by Lucas (1990) wherein the contribution of the agent's learning time is smaller than the contribution of the agent's human capital in the formation of future human capital. As a consequence, the paper reached the same conclusion as Lucas (1990). The upshot was preserved in a similar but more complicated model by Jones et al. (1997).<sup>1</sup>

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<sup>1</sup> In Jones et al. (1997), the learning technology activity is the same as that demonstrated by Jones et al. (1993, Model II). Moreover, the labor input into the goods sector is generated not only by human capital-embodied labor hours into the working activity but also by the investment flow allocated to the working activity. Readers are also referred to Milesi-Ferretti and Roubini (1998) and Judd (1999, Section 7) who obtained optimal factor taxation similar to that of Jones et al. (1997) in endogenous growth models wherein the learning function uses material goods as input. In a similar model, Reis (2007) showed that if the government cannot distinguish between consumption and human capital investment, then the optimal capital tax is zero when the level of capital does not influence the relative productivity of human capital.

In this paper, we revisit the question of the optimal factor tax incidence in an otherwise standard two-sector, human capital-based growth model by Lucas (1988) as well as Bond et al. (1996) and Mino (1996), wherein human capital is embodied in and inseparable from learning hours and they are not separable. The representative agent's learning time and the embodied human capital affect the learning function at the same degree and thus, the contribution of the representative agent's learning time is the same as the contribution of the agent's human capital in the formation of human capital in the future.<sup>2</sup> Ever since the form was proposed by Lucas (1988), it has been used by many authors; to name just a few, Lucas (1993), Benhabib and Perli (1994), Bond et al. (1996), Ladrón-de-Guevara et al. (1997, 1999). The fact that many established authors have used the form indicates that this is an important alternative form. It is thus valuable and essential to understand the implication on the capital tax in a model when the form is used. As it turns out, the implication on the capital tax is exactly opposite to that in Lucas (1990). While the optimal capital tax is zero in the Lucas (1990) model, capital should be taxed to a maximum in our model. As a result, it is optimal to tax capital income first. Labor income is to be taxed only if the revenue gained from capital income taxes is insufficient to cover government expenditure.

Our benchmark framework is based on the model put forth by Lucas (1988) with an extension to consider leisure and factor income taxes in the goods sector in order to finance a given stream of the government expenditure as a lump-sum transfer. We analyze the long-run welfare effect of a switch from a pre-existing tax code to a higher capital tax rate and a lower labor tax rate in order to finance given government expenditure. There are three effects at work. First, leisure is lower as a lower labor tax rate increases the price of leisure. Second, the economic growth rate is higher because a higher capital tax rate discourages physical capital accumulation. Because capital and human capital are complements in the production of goods, less labor is allocated to the goods production and more is allocated to the learning activities. Learning activity is the engine of economic growth, so the economic growth rate increases. Finally, consumption is increased relative to physical capital because a higher capital income tax rate reduces the price of consumption relative to investment. While lower leisure leads to a negative welfare effect, higher economic growth and higher consumption create positive welfare effects. If the first effect dominates, it is optimal to tax labor income completely. If the latter two effects dominate, it is optimal to tax capital income completely. Finally, if these three effects completely offset each other, there is an interior mix of optimal income tax rates.

We calibrate our benchmark model in the long run in order to reproduce key features representative of the US economy with the pre-existing average capital income and average labor income tax rates at 30% and 20%, respectively, in 1960–2007, thus with tax revenue accounting for 23% of total output. In a revenue-neutral tax reform experiment, as we switch from the current US income tax code by increasing the capital income tax rate and decreasing the labor income tax rate in order to finance a given fraction of the

government expenditure in output as a lump-sum transfer, we find that leisure is decreasing while the ratio of consumption to capital and economic growth are increasing in the long run. As the welfare is increasing in leisure, the ratio of consumption to capital and economic growth, lower leisure reduces welfare while higher economic growth and a higher consumption to capital ratio increase welfare in the long run. It turns out that the negative welfare effect coming from lower leisure is quantitatively dominated by the positive welfare effect originated from higher consumption and economic growth. As a consequence, it is optimal to tax capital income.

In particular, we find that when capital income is taxed above a rate, the labor tax rate is negative, thus providing a subsidy to working labor. Then, the incentive to accumulate human capital is so large and the incentive to accumulate physical capital is so small such that physical capital accumulates slowly and the human capital to capital ratio is increased by a large margin. Because of large increases in human capital, the economic growth rate is almost double that from the baseline rate. With such a high economic growth rate accompanied by a small incentive to accumulate physical capital, consumption is increased substantially, increasing the consumption to capital ratio by more than several times from its baseline level. Conversely, the decrease in the leisure time is flat which indicates a small welfare loss. As a result of large welfare gains due to a higher consumption to capital ratio and higher economic growth and a small welfare loss due to lower leisure time, it is always welfare improving if the capital tax is increased. We find that it is optimal to raise the capital tax rate to the highest possible rate that gives feasible allocation. We also find that a feasible allocation is obtained and the agent still saves when the capital tax rate is less than 100%. Our quantitative exercises indicate that the optimal tax mix is to tax 99.99% of the capital income and –10.00% of the labor income.

In order to obtain an optimal capital tax rate below 99%, we restrict to a corner solution by imposing a non-negativity constraint on the labor tax rate. This assumption is reasonable because in reality the labor tax rate cannot be negative on average, although there are situations wherein some laborers' income is subsidized. After imposing the constraint, we find that the optimal capital tax rate is  $\tau_k = 76.67\%$ , a drop by more than 23 percentage points from an interior solution. Yet, the restriction to a corner solution also reduces the welfare gain of a tax reform.

Finally, we study a model with a general learning function that uses both human capital and physical capital proposed by Bond et al. (1996) and Mino (1996). In this economy, although capital is used in the learning activity, the representative agent's learning time contributes to the formation of human capital in the future at the same degree as the embodied human capital. As a result, this economy features a similar taxation effect as the benchmark economy. Our calibration results stipulate that as the capital income tax rate is increasing and the labor income tax rate is decreasing from a pre-existing tax code, the effects are quantitatively similar to those in the benchmark model. Thus, it is optimal to tax capital income and not to tax labor income. We find that our results are robustness with regard to progressive or regressive tax policies and different choices in spending the factor tax revenue. Even if the human capital formation is via learning-by-doing, it is optimal to tax capital income.

Other related literature found a positive optimal capital tax rate, including Guo and Lansing (1999), Cassou and Lansing (2006) and Chen (2007) which incorporated positive externalities, productive public capital or market imperfections into dynastic models. In life-cycle models, the driving mechanism for positive taxes on capital is to mimic age-dependent taxes on labor income. Garriga (2001) and Erosa and Gervais (2002) demonstrated that mimicking an age-dependent tax on labor income was a substantial motive for a positive tax on capital. Conesa et al. (2009) discovered that this motive was large in a model with exogenous human capital accumulation. Peterman (2012) showed that including endogenous human capital

<sup>2</sup> We cannot find empirical evidence which will directly support either our form or the form used in Lucas (1990). Nevertheless, our setup is reasonable within a private perspective because one's human capital is embodied in the length of time one commits to learning something. One cannot tell which of one's learning time and the human capital embodied in learning time contributes more to one's learning. It is not easy to tell one's learning time and the human capital embodied in one's learning time in the data. Moreover, in the data an individual's learning may be affected by others, an externality which is assumed to be zero in our model. When one learns things in a group with more knowledgeable or more creative people, one learns better and is more creative; for example, casual evidence might show that economists do not just read papers but also try very hard to participate in a conference/group in order to learn things along with well-established economists. Given these constraints, it is thus difficult to use data to distinguish the contribution of private learning time from the contribution of the human capital embodied in learning time.

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