The Incidence of Capital Taxation and the Magnitude of Its Burden[1]

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Abstract

Decreasing the tax on capital may increase after-tax incomes of capital and labor by reducing the deadweight loss associated with inefficiently low levels of capital investment. This paper identifies five key considerations that impact the effect of decreasing the capital tax rate: the elasticity of substitution between capital and labor, capital's and labor's shares of total output, the presence and magnitude of capital externalities, the elasticity of capital supply and the extent of the initial tax distortion. An open economy model highlights the impact that these factors have on capital tax incidence and the magnitude of the capital tax burden.

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1 Introduction

Despite the inefficiencies created by capital taxation, most developed countries still collect a significant proportion of revenue from the taxation of capital. Most economists agree that capital taxation results in welfare losses; the magnitude of these losses and the sufferers of the losses, however, remain unclear. An increasingly global economy has changed the way economists analyze the incidence of a capital tax. The imposition of a capital tax in an open economy encourages capital to flee, leaving workers at home with less capital, thereby lowering labor productivity. Magnifying this effect is the distinct possibility that capital creates positive externalities. The loss of capital externalities lowers the productivity of both capital and labor. The introduction of mobile capital and capital externalities has added new dimensions to capital tax incidence. In this paper, an open economy model highlights the five key parameters that impact the effect of capital taxes on the after-tax incomes of labor and capital. These parameters are the elasticity of substitution between capital and labor, capital's and labor's shares of total output, the presence and magnitude of capital externalities, the elasticity of capital supply and the extent of the initial tax distortion.

With the significant costs of capital taxation known, it is likely that policy-makers believe there are benefits to capital taxation that outweigh the costs. One such benefit may be the presumed progressivity that capital taxes add to the tax regime. Capital taxation may lead to a more equal distribution of after-tax income, but the costs associated with it may mean a lower level of income for all individuals across the distribution. This paper shows that a revenue-neutral decrease in the capital tax rate can be Pareto-improving in an open economy, even a large open economy. By reducing the tax on capital and replacing this revenue with an increased tax on labor, the after-tax incomes of labor and capital increase. In addition, the gap between the after-tax incomes of capital and labor grows. The five parameters considered influence not only the incidence of a capital tax but also the magnitude of its burden.

Many authors have demonstrated the impact of various parameters on the effects of capital taxation. The goal of this paper is to create a model that underscores the importance of five critical parameters and reduces the complexity of existing models by eliminating features that do not have a large impact on the effects of capital taxation. Chirinko (2002) suggests the need for 'simple' analyses of the factors that are determinants of the effects of capital taxation. By simplifying the model, it becomes easier to assess the impact of each of these parameters individually. Fox and Fullerton (1991) show that focusing on key parameters can often explain just as much as models with more complex features, and using a simplified model eases the interpretation of results. This approach also makes it easier for policy analysts to compare the effects of capital taxes across countries that may have different values of the parameters of interest.

The next section motivates the choice of the five key parameters by emphasizing the previous literature and its findings. Section 3 develops the model and derives the theoretical implementation of a revenue-neutral decrease in the tax on capital. Section 4 discusses the choice of baseline parameters and reveals the impact of each of the five parameters on the effects of reducing the capital tax rate. Section 5 explains the implication of these results on tax incidence; the final section concludes.

2 Motivation: The Five Key Parameters

The difficulty of estimating the effects of a capital tax in a general equilibrium setting has lead to a large body of literature that provides many insights but never a consensus view. Throughout the literature, there are five factors that authors often point out as having a major impact on the welfare losses from capital taxation. These are the elasticity of substitution between capital and labor, the elasticity of capital supply, the share of total output received by capital and labor, the size of the capital externality and the initial tax distortion. No paper to this point has examined these five parameters simultaneously; this paper aims to fill that gap. Additionally, I examine the impact of these factors on the incidence of the capital tax.

Chirinko (2002) emphasizes the importance of the elasticity of substitution between capital and labor on the welfare effects of capital taxes. Cobb-Douglas is the most commonly used production function in the capital tax literature, but more recent literature has introduced CES production functions into the capital tax literature. While Cobb-Douglas is perhaps the most convenient function, Antras (2004) and Pessoa et al. (2005) find that the elasticity of substitution between capital and labor falls between 0.6 and 0.9 suggesting that a CES production function may lead to more accurate results. The importance of this elasticity is also highlighted in Chamley (1981) who finds that the excess burden of capital taxes depends proportionately on the elasticity of substitution between capital and labor.

The share of total output received by capital and labor impacts investment decisions by altering the after-tax return to capital. When labor receives a higher share of total output, the marginal benefit from investing in capital is lower. Thus, the level of investment for which the after-tax return exceeds the marginal cost of capital occurs at a lower level of capital. Stokey and Rebelo (1995) show that factor shares are a critical parameter in determining growth in a representative agent model with taxes. They also find the elasticity of intertemporal substitution, the elasticity of labor supply, and depreciation rates to be key determinants of the effects of a capital tax. However, they do not believe that the elasticity of substitution between capital and labor is important.

The existence of capital externalities has been a widely debated area of economic literature. Romer (1986) shows the importance of externalities for capital stock growth. Many others have followed his AK-model approach to assess the impact of externalities on economic growth. Capital externalities increase the social return to capital investment and increase the likelihood that an economy benefits from a decrease in capital taxation. Knoop and Matheny (2000) find that capital externalities magnify the effects of reducing the tax on capital using a model developed by Cooley and Hansen (1992). Knoop and Matheny (2000) find that even a small external return of ten percent increases the welfare benefits of tax reform by one-third. Allgood and Snow (2006) use a constant returns to scale production function but allow for capital externalities by having an individual's education depend on their own education and the average education of others. They find that a revenue-neutral decrease in the capital tax is welfare improving when the tax is replaced by a tax on labor. Their model allows individuals to make education choices, and therefore, a large focus of their paper is on the impact of human capital investment.

The elasticity of capital supply affects capitalists' responses to a decrease in the tax on capital. If the capital supply is fairly elastic, then changing the capital tax rate results in large changes in capital investment. The more investment in capital created by a decrease in the tax on capital, the more likely labor is to benefit from a decrease in the tax on capital. The elasticity of capital supply is directly related to the openness of a country. Razin and Yuen (1996) show that the increase in growth due to a decrease in the capital tax is much larger in an open economy. Fuest and Huber (2001) use an open economy model with perfect capital mobility and immobile labor to find that the source-based tax on capital should be zero if the elasticity of substitution between capital and labor is finite.

The benefit of eliminating some marginal tax distortion increases with the size of the initial tax distortion. This obviously has important implications for the benefit of reducing the capital tax rate. If the tax on capital is initially low, then the marginal distortion created by this tax will also be relatively low. It is less likely in this case that reducing the capital tax rate will be Pareto-improving. Caucutt, Imrohoroglu, and Kumar (2003) emphasize the importance of the initial tax distortion by using a calibrated heterogeneous agent model to show that a decrease in tax progressivity increases growth but a change in flat taxes does not. Their complex model involves skilled workers, unskilled workers and entrepreneurs; workers choose their child's human capital accumulation and entrepreneurs make physical capital accumulation decisions.

A separate and equally extensive body of literature examines the incidence of the capital tax. Harberger (1995) finds that the burden of a corporate tax more than fully shifts to labor in an open economy and estimates that the burden on labor may be 2 to 2.5 times as large as the corporate tax revenue raised. Randolph (2006) and Gravelle and Smetters (2006) both develop open economy general equilibrium models with fixed capital stocks to examine the incidence of the corporate tax. Randolph concludes that labor bears 70 percent of the corporate tax. Gravelle and Smetters focus on product substitutability and find that labor bears less than 70 percent of the corporate tax if products are not perfectly substitutable. A low savings elasticity and the ability of a country to affect world prices also reduce labor's burden in their model. However, by ignoring the effect of corporate taxes on the growth of capital, these models likely underestimate the impact of corporate taxes on labor. Most tax incidence literature in an open economy setting has focused on the burden borne by labor. This paper emphasizes the magnitude of the capital tax burden and the relative burden borne by labor.

3 Model

In order to analyze the effects of a revenue-neutral decrease in a source-based tax on capital, I develop an open economy model with production and international capital mobility. On the production side, firms seek to maximize profits in a competitive market using capital and labor inputs. I use a standard CES function with Harrod-Neutral technology to describe the production possibilities as seen in equation (1). Using a CES function allows me to consider

$$Q = \left[\gamma (AL)^{\frac{\sigma-1}{\sigma}} + (1-\gamma) K^{\frac{\sigma-1}{\sigma}} \right]^{\frac{\sigma}{\sigma-1}} \tag{1}$$

the impact of the elasticity of substitution between capital and labor on the outcomes from decreasing the capital tax rate. Consistent with a competitive equilibrium model, factors are paid their private marginal productivities as displayed in equation (2) and (3). This model also enables me to consider capital

$$w \equiv MPL = \frac{\partial Q}{\partial L} = \gamma A^{\frac{\sigma-1}{\sigma}} L^{\frac{-1}{\sigma}} \left[\gamma (AL)^{\frac{\sigma-1}{\sigma}} + (1-\gamma) K^{\frac{\sigma-1}{\sigma}} \right]^{\frac{1}{\sigma-1}} \tag{2}$$

$$r \equiv MPK = \frac{\partial Q}{\partial K} = (1-\gamma) K^{\frac{-1}{\sigma}} \left[\gamma (AL)^{\frac{\sigma-1}{\sigma}} + (1-\gamma) K^{\frac{\sigma-1}{\sigma}} \right]^{\frac{1}{\sigma-1}} \tag{3}$$

that produces positive externalities. Equation (4) describes the potential capital externalities where *n* is the number of firms in the economy. In this specification

$$A = \left(\bar{K}\right)^{\theta} \quad where\ \bar{K} \equiv nK \tag{4}$$

of the model, aggregate capital in the economy produces labor-augmenting externalities if $\theta > 0$. I compare the economy's response to a decrease in the capital tax rate with and without capital externalities and determine what magnitude of externality is needed to make a reduction in the capital tax rate Pareto-improving.

Many researchers have assumed a similar AK-model, and empiricists have found evidence that technology is labor-augmenting.[2] In this model the capital externality represented by A is labor-biased if the elasticity of substitution between capital and labor is greater than one (gross substitutes) and is capital-biased if this elasticity of substitution is less than one (gross complements). As discussed in the following section, most researchers estimate the elasticity of substitution between capital and labor to be less than one, implying that the true capital externality is likely to be capital-biased. In addition to the elasticity of substitution between capital and labor, relative factor shares are a critical factor in determining the effects of decreasing the tax on capital and can be derived from the above formulation.

Using an open economy model with internationally mobile capital and a fixed and internationally immobile labor supply, I determine the impact of a revenue-neutral decrease in the capital income tax rate. This specification abstracts from individual consumption and leisure decisions. This greatly simplifies the model and, in addition, may more accurately describe the current global economy. Investors from around the world invest until the marginal after-tax return to capital is equal to the marginal cost of an additional unit of capital. The supply of capital is formulated in equation (5), and equation (6) describes the

$$(1-\tau_K)\frac{\partial Q}{\partial K} = \lambda(K) \tag{5}$$

$$\lambda(K) = aK^{\beta} \tag{6}$$

marginal cost of capital. β is assumed to be between zero and one creating a marginal cost which is increasing at a decreasing rate. In this formulation, capital is assumed to be imperfectly mobile, and thus, the model allows for consideration of a large open economy. In my simulations, I choose *a* in the baseline case such

[2] For example, see Romer (1990) and Acemoglu (2003).

that the marginal cost of capital is equal to the sum of the real interest rate and the depreciation rate. Changing β in equation (6) allows me to look at the impact of the elasticity of capital supply on the effects of decreasing the tax on capital. When β is zero, capital is perfectly mobile. However, for β greater than zero, capital is imperfectly mobile allowing the real interest rate to increase with capital, and thus, marginal cost increases with capital.

The decrease in the capital income tax rate has several channels by which to affect labor. The increase in capital created by the decrease in capital taxes increases the marginal productivity of labor through both an increase in capital and an increase in the externality from capital. In this competitive equilibrium model, an increase in labor productivity results in an increase in wages. It is unclear, however, if the increase in wages will be large enough to offset the extra taxes labor must pay in order to keep government revenue constant. Using the above model, we can analyze these effects and determine the parameters for which decreasing the tax on capital increases after-tax labor income.

Theoretical Implementation of a Revenue-Neutral Decrease in the Capital Income Tax Rate

Consider a revenue-neutral decrease in the capital income tax rate. The decrease in the tax on capital will have an impact on the tax revenue collected from capital as seen in (7); this change causes the tax on labor to adjust in order to preserve revenue-neutrality as shown in equation (11). The change in the tax on labor does

$$\frac{\partial TR_K}{\partial \tau_K} = n\left(\frac{\partial Q}{\partial K}\cdot K + \tau_K K\left[\frac{\partial^2 Q}{\partial K^2}\cdot\frac{\partial K}{\partial \tau_K} + \frac{\partial^2 Q}{\partial K \partial A}\cdot\frac{\partial A}{\partial \tau_K}\right] + \tau_K \cdot \frac{\partial Q}{\partial K}\cdot\frac{\partial K}{\partial \tau_K}\right) \tag{7}$$

$$\frac{\partial TR_L}{\partial \tau_K} = n\left(\tau_L L\left[\frac{\partial^2 Q}{\partial L \partial K}\cdot\frac{\partial K}{\partial \tau_K} + \frac{\partial^2 Q}{\partial L \partial A}\cdot\frac{\partial A}{\partial \tau_K}\right]\right) \tag{8}$$

$$\frac{\partial TR_K}{\partial \tau_L} = 0 \tag{9}$$

$$\frac{\partial TR_L}{\partial \tau_L} = n\left(\frac{\partial Q}{\partial L}\cdot L\right) \tag{10}$$

$$\frac{\partial TR}{\partial \tau_K}\cdot d\tau_K + \frac{\partial TR}{\partial \tau_L}\cdot d\tau_L = 0 \tag{11}$$

not impact the tax revenue collected from capital because the amount of labor in this model is fixed. However, both tax changes impact the revenue collected from labor as displayed in equations (8) and (10). In most cases, decreases in the tax on capital cause a decrease in the revenue collected from capital, and in these instances, the tax on labor increases. However, if the decrease in the capital tax rate results in a large increase in capital, then it is possible for the tax revenue from capital to actually increase resulting in a decrease in the tax on labor. In this occurrence, labor and capital always earn higher after-tax incomes as a result of the decrease in the tax on capital. Including the initial tax rate on capital allows me to change the initial level of distortion in the economy created by income taxes.[3] This initial distortion impacts the effects of decreasing the capital tax rate.

In addition to altering the tax rates on labor and capital, decreasing the capital tax rate evokes a response from investors as shown in equation (12). This

$$\frac{\partial K}{\partial \tau_K} = \frac{\partial Q / \partial K}{(1-\tau_k)\left[\frac{\partial^2 Q}{\partial K^2} + \frac{\partial^2 Q}{\partial K \partial A}\left(\theta \bar{K}^{\theta-1} n\right)\right] - \lambda'(K)} \tag{12}$$

equation is derived from the supply condition given in equation (5). The marginal effect of the capital tax on the amount of capital is a discontinuous function at the point where $\theta = 1$. As we would expect, the capital tax rate has a negative effect on capital for realistic values of the capital externality.[4] Equation (12) highlights the impact of the slope of the marginal cost function on investors' decisions. The rate at which the marginal cost increases with capital has a negative impact on the additional capital investment resulting from a decrease in the tax on capital.[5] In other words, investors are more responsive to a tax change in more open economies. The change in capital due to a change in the capital tax rate has a direct effect on the response of capital externalities to changes in the capital tax rate as seen in equation (13).

$$\frac{\partial A}{\partial \tau_K} = \theta \bar{K}^{\theta-1}\left(\frac{\partial K}{\partial \tau_K} \cdot n\right) \tag{13}$$

The change in capital and the labor-augmenting capital externality has effects on both the marginal productivity of capital and the marginal productivity

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[3] The labor income tax rate does not create a distortion in this model because labor supply is fixed.
[4] For $\theta > 1$, returns to scale in production exceed 190%, and in this unlikely occurrence, the capital tax rate can have a positive effect on the amount of capital.
[5] This is true for $\theta < 1$.

of labor. Equation (14) shows the effect of a change in capital on the marginal productivity of capital, and equation (15) shows the effect of a change in the

$$\frac{\partial^2 Q}{\partial K^2} = -\frac{1}{\sigma}(1-\gamma)K^{\frac{-1-\sigma}{\sigma}}\left[\gamma(AL)^{\frac{\sigma-1}{\sigma}} + (1-\gamma)K^{\frac{\sigma-1}{\sigma}}\right]^{\frac{1}{\sigma-1}} + \frac{1}{\sigma}(1-\gamma)^2 K^{\frac{-2}{\sigma}}\left[\gamma(AL)^{\frac{\sigma-1}{\sigma}} + (1-\gamma)K^{\frac{\sigma-1}{\sigma}}\right]^{\frac{2-\sigma}{\sigma-1}} \quad (14)$$

$$\frac{\partial^2 Q}{\partial K \partial A} = \left(\frac{1}{\sigma}\right)\gamma(1-\gamma)K^{\frac{-1}{\sigma}} L^{\frac{\sigma-1}{\sigma}} A^{\frac{-1}{\sigma}}\left[\gamma(AL)^{\frac{\sigma-1}{\sigma}} + (1-\gamma)K^{\frac{\sigma-1}{\sigma}}\right]^{\frac{2-\sigma}{\sigma-1}} \quad (15)$$

capital externality on the marginal productivity of capital. An increase in capital always has a negative effect on the marginal productivity of capital, but the increase in the externality created by the increase in capital always has a positive effect on the marginal productivity of capital. Thus, the net effect of an increase in capital on the marginal productivity of capital is ambiguous and depends on the values of the parameters. Equation (16) shows the effect of a change in capital on

$$\frac{\partial^2 Q}{\partial L \partial K} = \gamma(1-\gamma)\left(\frac{1}{\sigma}\right)A^{\frac{\sigma-1}{\sigma}} L^{\frac{-1}{\sigma}} K^{\frac{-1}{\sigma}}\left[\gamma(AL)^{\frac{\sigma-1}{\sigma}} + (1-\gamma)K^{\frac{\sigma-1}{\sigma}}\right]^{\frac{2-\sigma}{\sigma-1}} \quad (16)$$

the marginal productivity of labor; an increase in capital always increases the marginal productivity of labor. However, the effect of the increase in the capital externality caused by the increase in capital has an ambiguous effect on the marginal productivity of labor as shown in equation (17).

$$\frac{\partial^2 Q}{\partial L \partial A} = \gamma\left(\frac{\sigma-1}{\sigma}\right)A^{\frac{-1}{\sigma}} L^{\frac{-1}{\sigma}}\left[\gamma(AL)^{\frac{\sigma-1}{\sigma}} + (1-\gamma)K^{\frac{\sigma-1}{\sigma}}\right]^{\frac{1}{\sigma-1}} + \gamma^2\left(\frac{1}{\sigma}\right)(AL)^{\frac{\sigma-2}{\sigma}}\left[\gamma(AL)^{\frac{\sigma-1}{\sigma}} + (1-\gamma)K^{\frac{\sigma-1}{\sigma}}\right]^{\frac{2-\sigma}{\sigma-1}} \quad (17)$$

The equilibrium effect of a change in the capital income tax rate on after-tax income depends on the change in the marginal productivities, the change in the amount of capital, the change in the size of the externality, and the change in the tax rates. Equations (18) and (19) describe the impact of the change in the tax

$$\frac{\partial Y_K}{\partial \tau_K} = -\frac{\partial Q}{\partial K}\cdot K + (1-\tau_K)\left[\frac{\partial^2 Q}{\partial K^2}\cdot\frac{\partial K}{\partial \tau_K} + \frac{\partial^2 Q}{\partial K \partial A}\cdot\frac{\partial A}{\partial \tau_K}\right]K + (1-\tau_K)\left[\frac{\partial Q}{\partial K}\cdot\frac{\partial K}{\partial \tau_K}\right] \quad (18)$$

$$\frac{\partial Y_K}{\partial \tau_L} = 0 \qquad (19)$$

on capital and labor, respectively, on the after-tax incomes of capital. Similarly, equations (20) and (21) illustrate the effect of the change in the tax rates on labor

$$\frac{\partial Y_L}{\partial \tau_L} = -\frac{\partial Q}{\partial L} \cdot L \qquad (20)$$

$$\frac{\partial Y_L}{\partial \tau_K} = (1-\tau_L)\left[\frac{\partial^2 Q}{\partial L \partial K} \cdot \frac{\partial K}{\partial \tau_K} + \frac{\partial^2 Q}{\partial L \partial A} \cdot \frac{\partial A}{\partial \tau_K}\right] \cdot L \qquad (21)$$

and capital, respectively on the after-tax incomes of labor. Increases in the tax rate paid by labor always have a negative impact on the after-tax income of labor and never have any impact on the after-tax income of capital because labor is assumed to be perfectly inelastic. The effects of a decrease in the tax on capital are ambiguous on both the after-tax incomes of capital and labor. This occurs because of the opposite effects of the change in capital and the change in the magnitude of the capital externality.

To get the total effect on labor and capital we must multiply the above effects by the change in tax rates in order to appropriately weight each effect. The total effect of altering the capital income tax on the after tax incomes of labor and capital are shown in equations (22) and (23), respectively.

$$\frac{\partial Y_L}{\partial \tau} = \frac{\partial Y_L}{\partial \tau_K} \cdot d\tau_K + \frac{\partial Y_L}{\partial \tau_L} d\tau_L \qquad (22)$$

$$\frac{\partial Y_K}{\partial \tau} = \frac{\partial Y_K}{\partial \tau_K} \cdot d\tau_K + \frac{\partial Y_K}{\partial \tau_L} d\tau_L \qquad (23)$$

4 Results

The first step in analyzing the model is choosing a set of baseline parameters. This is not an easy task; some of the parameters have generally accepted values while others have been debated in economic literature for the last few decades. A list of the baseline parameters can be found in Table 1.

I assume the elasticity of substitution between capital and labor to be 0.6. This elasticity has been the subject of a vast literature. A summary of the estimates from this literature can be found in Chirinko (2002). Most current literature agrees that the elasticity of substitution is below one, ruling out the previously favored Cobb-Douglas production function.[6] Estimates of the elasticity of substitution range from 0 to 1.809, but most estimates fall between 0.4 and 0.8. Pessoa, Pessoa and Rob (2005) estimate the elasticity to be 0.7 using a CES production function with Hicks-Neutral technology. Antras (2004) also uses Hicks-Neutral technological change and finds estimates of σ between 0.924 and 1.245. Antras (2004), Kalt (1978) and David and Van de Klundert (1965) use a CES production function with biased technological change to estimate σ. In contrast to the Hicks-Neutral results, Antras finds the elasticity of substitution using Harrod-Neutral technological change to be between 0.6 and 0.9. He shows that estimates based on Hicks-Neutral technology are biased toward one. My baseline parameter of 0.6 for the elasticity of substitution is consistent with the literature and is particularly close to the literature that assesses this estimate using a Harrod-neutral CES production function. The elasticity of substitution plays a central role on the impact of decreasing the capital tax rate; this will be analyzed later in the paper.

The magnitude of the capital externality is dependent upon the exponent placed on aggregate capital in my formulation of the capital externality. Several attempts have been made to estimate the magnitude of capital externalities but without much consensus. Burnside (1996) and others believe that there is no capital externality which would imply that the exponent in my formulation is zero. Many authors, however, find positive and small estimates for the exponent. Liu and Turnovsky (2003) assume the value of this exponent to be 0.1 in a Cobb-Douglas production specification. Benarroch (1997) finds increasing returns to scale in Canada of 130 to 160 percent using Canadian manufacturing data. Caballero and Lyons (1990) look at four European countries and estimate increasing returns to scale of 113 to 159 percent. I assume the exponent of the capital externality to be 0.14 which produces increasing returns to scale of 110% in the baseline case. This seems to be consistent with the literature. The value chosen for this exponent has major implications on the effects of decreasing the capital tax rate, and in my analysis I explain the effects of changing this exponent on the results.

To model the elasticity of capital supply, I set the marginal cost of capital equal to aK^{β} as shown in equation (6). In an open economy, an increase in capital in the U.S. should not have a large impact on the marginal cost of capital implying that β should be close to zero. However, in a closed economy increasing capital has a larger impact on the cost of capital implying that β should be closer

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[6] There are some exceptions. See Masanjala and Papageorgiou (2003) and Karagiannis, Palivos and Papageorgiou (2004).

to one. I initially assume that β is equal to 0.4 and explain the effects that β has on the results of the model. In order to maintain a reasonable value for the marginal cost of capital, I choose *a* such that the marginal cost is equal to 0.12. In this way, the marginal cost will be equal to an approximate value of the real interest rate plus the depreciation rate.

In the U.S. it is generally accepted that labor's share of total output is roughly two-thirds. This is the assumption I make in my calculations, and I adjust the distribution parameter, γ, to achieve this end. To analyze the initial distortion of the economy due to income taxes, I set the tax on capital to 35 percent and government's share of total output to 25 percent. The initial tax on labor is chosen in order to keep government revenue a constant share of total output; this choice of the labor income tax rate does not impact the final results because labor supply is assumed to be fixed.

After establishing values for the five key parameters, I must fill in the rest of the model. To determine the capital to labor ratio, I use data from the Bureau of Economic Analysis. For capital, I use the 2005 current-cost net stock of private non-residential fixed assets; this value is $13.54 trillion. For labor, I use the 2005 compensation of employees; this value is $7.04 trillion. The capital to labor ratio is fixed in my model to 1.923. The actual values for capital and labor are chosen by setting the after-tax return to capital equal to the marginal cost of capital. I assume the number of firms to be 16,736, which is the total number of private firms in the U.S with more than 500 employees.

Using the parameters defined in Table 1, I analyze the impact of a one percentage point decrease in the capital tax rate. Table 2 displays these results. In order to keep government revenue constant, the tax on labor increases by .35 percentage points in response to the one percentage point decrease in the tax on capital. The total amount of capital in the economy increases by 1.14 percent. This increase in capital and the decrease in taxes on capital leads to an increase of 1.59 percent on the after-tax incomes of capital and a .26 percent increase on the after-tax incomes of labor. Thus, in the baseline case, a decrease in the capital tax rate benefits both capital and labor.

In the following paragraphs I examine the effects of altering the five key parameters on the effect of decreasing the capital tax rate by one percentage point. In order to isolate the effect of one parameter, I change the value for that parameter while holding the values of the other four parameters constant. The elasticity of substitution is always set at 0.6 except when analyzing the effects of changing the elasticity of substitution. The capital externality is held constant by setting θ equal to .14. The distribution parameter, γ, is chosen to hold labor's share constant at 0.67. The initial tax on capital is always 35 percent. The marginal cost of capital is held constant at 0.12; β is always 0.4 but *a* varies to keep the marginal cost at 0.12. The capital to labor ratio is always 1.923, but the values for capital and labor always satisfy the capital supply equation.

Elasticity of Substitution

The elasticity of substitution has a major impact on the change in after-tax incomes and in additional capital investment due to a one percentage point decrease in the tax on capital. This effect is shown in Table 3. When capital and labor are more substitutable, there are essentially more uses for capital. Thus, as capital grows, the marginal productivity of capital falls, but this decrease in the marginal productivity of capital will be lower when capital and labor are highly substitutable. This leads to two major effects resulting from differences in the elasticity of substitution. First, as capital and labor become more substitutable, investors respond to a decrease in the capital tax rate with higher levels of investment as seen in Figure 1. Second, increased substitutability reduces the increase in the marginal productivity of labor due to an increase in capital. These two effects impact the change in after-tax incomes of capital in the same direction. Higher elasticities of substitution result in higher after-tax incomes for capital due to a decrease in capital income tax rate. However, these two effects work in opposite directions on the change in after-tax labor income. Higher values of the elasticity of substitution lead to increased capital investment which helps labor by increasing output and increasing labor's productivity. However, higher values of this elasticity imply that capital and labor are more substitutable, leading to smaller wage increases for labor due to increased capital. When the first effect outweighs the second, labor benefits from higher values of the elasticity of substitution. Figure 2 shows the effect of the elasticity of substitution on the change in after-tax incomes due to a decrease in the capital income tax rate.

Capital Externality

The magnitude of the capital externality is perhaps the most critical of the five parameters. A larger capital externality results in larger increasing returns to scale. As the capital externality increases, investors' response to a one percentage point decrease in capital income tax rate increases as seen in Figure 3. The increase in the after-tax incomes of labor and capital closely follows the increase in capital investment. As seen in Figure 4, as the capital externality increases, the change in after-tax incomes due to a one percentage point decrease in the tax on capital increases for both labor and capital. Using the baseline parameters, capital and labor always benefit from a decrease in the tax on capital, even under constant returns to scale production. Table 4 shows the impact of the capital externality on the effects of a one percentage point decrease in the capital tax rate.

Factor Shares

Table 5 displays the effect of factor shares on the outcomes due to a decrease in the tax on capital. As labor's share increases, investors respond to a decrease in the tax on capital by creating a smaller amount of additional investment as seen in Figure 5. Marginal investment decreases because the marginal benefit of capital (MPK) decreases as labor's share increases, but the marginal cost of investing hasn't changed. Thus, the level of investment for which the marginal return to capital exceeds the marginal cost of capital occurs at a lower level of capital. As the change in capital investment falls, so does the change in the after-tax incomes of capital and labor due to a decrease in the capital income tax rate. This is shown in Figure 6.

Initial Distortion

Higher initial taxes on capital create larger initial distortions in the economy. The effects of this initial distortion on the impact of a decrease in the capital tax rate can be found in Table 6. With a high initial tax, investors respond more to a decrease in the tax on capital. This occurs because the after-tax return to capital decreases less as capital increases if the initial tax is high. Figure 7 shows the effect of the initial tax on capital on the additional capital investment in response to a one percentage point decrease in the tax on capital. In Figure 8 we can see that the higher levels of additional investment increase the change in the after-tax income of labor and capital.

Elasticity of Capital Supply

The marginal cost of capital is an increasing function of capital; the rate at which the marginal cost increases has an effect on investors' response to a decrease in the tax on capital. This can be seen in Figure 9. If the marginal cost rises quickly (i.e. a relatively closed economy), capital increases less in response to a decrease in the capital tax rate which leads to a smaller change in the after-tax income of labor. Figure 10 shows that both capital and labor benefit more from a decrease in capital income tax rate if the marginal cost of capital increases at a slow rate (i.e. a relatively open economy).

5 Capital Tax Incidence

In the previous section, I showed the effect of a revenue-neutral decrease in the capital income tax rate on after-tax incomes of capital and labor. To look at the marginal burden and incidence of the capital tax, the change in the labor income tax must be set to zero. Thus, in this section, I am no longer looking at a revenue-neutral decrease in the tax on capital but instead focusing on a one percentage point decrease in the capital income tax rate. Using the baseline parameters, the change in after-tax incomes of capital and labor combined is 3.07 times the change in the tax revenue collected. Of this burden, 52% is borne by labor.

Each of the five parameters has an impact on the magnitude of the capital tax burden and the incidence of that burden. The impact of the elasticity of substitution on the marginal burden from a one percentage point change in the capital tax rate is shown in Figure 11. When capital and labor are more substitutable, there are more uses for capital. Thus, any tax that causes less capital investment results in a larger burden when the elasticity of substitution between capital and labor is high. In addition, Figure 12 shows that higher elasticities of substitution between capital and labor result in labor bearing a lower share of the tax burden. When the elasticity of substitution is low, labor receives a large benefit from additional capital in the form of higher marginal productivities and thus, higher wages. Therefore, labor bears a large share of the total tax burden when the elasticity of substitution is low.

As expected, higher capital externalities result in a larger marginal tax burden from a one percentage point change in the capital tax rate as seen in Figure 13. In a constant returns to scale economy, the burden of a one percentage point increase in the capital tax rate is approximately two times the change in tax revenue; this tax burden grows exponentially as the returns to scale increase. With larger capital externalities, labor's share of the burden increases as shown in Figure 14.

Figure 15 shows that factor shares have a non-monotonic effect on the marginal tax burden resulting from a one percentage point change in the capital tax rate. There are two factors to consider. First, a higher labor's share results in smaller increases in the after-tax incomes of both capital and labor as a result of a decrease in the capital tax rate. The percentage change in total after-tax income is roughly linear with labor's share. Second, the percentage change in tax revenue is decreasing at an increasing rate with labor's share of total output. The ratio of these two effects is non-monotonic. Predictably, labor's share of the tax burden increases as labor's share of total output increases as displayed in Figure 16.

Higher levels of initial tax distortion result in larger marginal tax burdens from changing the capital tax rate as seen in Figure 17. Using the baseline parameters, the marginal tax burden of a one percentage point change in the capital tax rate is 3.07 times the change in tax revenue. The total tax burden can be analyzed from the marginal tax burdens presented in Figure 17. The marginal burden of increasing the capital tax rate from zero to one is about 2 times the tax revenue collected. Thus, the total tax burden from a 35 percent tax rate on capital is between 2 and 3 times the tax revenue collected. Much of the tax incidence literature focuses on the marginal tax burden from the change in the capital tax rate; by looking at the effect of the initial capital tax rate on the marginal tax burden, we can transform marginal tax burdens into total tax burdens. Labor's share of the change in tax burden also increases with the initial capital tax rate as found in Figure 18.

Figure 19 shows that more open economies face higher marginal tax burdens from a change in the capital tax rate, and Figure 20 shows that labor bears more of the tax burden in a more open economy. In a small open economy where changes in capital do not influence the return to capital, the burden of a one percentage point increase in the capital tax rate is over 4 times the change in tax revenue collected. In a closed economy, that burden falls to just over 2 times the change in tax revenue.

6 Conclusion

This paper develops a theoretical model to examine capital tax incidence and the magnitude of the capital tax burden. The model combines the five key parameters that have been highlighted in the existing literature as having a large impact on the effects of capital taxes. Using baseline parameters based on data from the U.S., the model predicts that a one percentage point decrease in the capital tax rate will increase the after-tax income of capital by 1.59 percent and the after-tax income of labor by 0.26 percent. Thus, reducing the capital tax rate in the U.S. creates a Pareto-improvement, but also, increases inequality.

The model offers two important contributions to the existing literature. First, the impact of each of the five factors is analyzed independently of the other factors. This aids in the comparisons of ideal tax policies across countries and helps policy-makers when estimates of baseline parameters are imprecise. Countries with high capital tax rates, large levels of capital externalities, high elasticities of substitution between capital and labor, a low labor's share of total output and more open economies will benefit the most from decreasing the capital income tax rate.

Second, the model provides estimates of the marginal capital tax burden and the share of this burden borne by labor. In the baseline case, a one percentage point decrease in the capital tax rate decreases the after-tax incomes of capital and labor by approximately three times the additional tax revenue collected. Labor bears slightly more than half of this burden. As economies become more open the burden of capital taxes increases as does the share of the burden borne by labor. Therefore, the importance of understanding capital tax incidence continues to grow as the economy becomes more global.

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Table 1: Baseline Parameters

Elasticity of Substitution: σ	0.6
Capital Externality: Θ	0.14
Elasticity of Capital Supply: β	0.4
Initial Distortion: τ_K	0.35
Labor's Share	0.67
Capital to Labor Ratio	1.923
Number of Firms: n	16736
Government's Share	0.25

Table 2: Results Using Baseline Parameters

Change in After-Tax Capital Income	1.59%
Change in After-Tax Labor Income	0.26%
Change in the Tax on Labor	0.0035
Change in Capital	1.14%

Table 3: The Impact of the Elasticity of Substitution on the Effects of a 0.01 Decrease in the Tax on Capital

Elasticity of Substitution	Change in After-Tax Capital Income	Change in After-Tax Labor Income	Change in Capital	Change in the Tax Rate on Labor
0.4	1.17%	0.19%	0.84%	0.0042
0.5	1.39%	0.23%	0.99%	0.0038
0.6	1.59%	0.26%	1.13%	0.0035
0.7	1.77%	0.29%	1.26%	0.0032
0.8	1.93%	0.32%	1.38%	0.0029
0.9	2.08%	0.34%	1.48%	0.0027

Figure 1: The Effect of the Elasticity of Substitution on Capital Investment Due to a .01 Decrease in the Capital Income Tax Rate

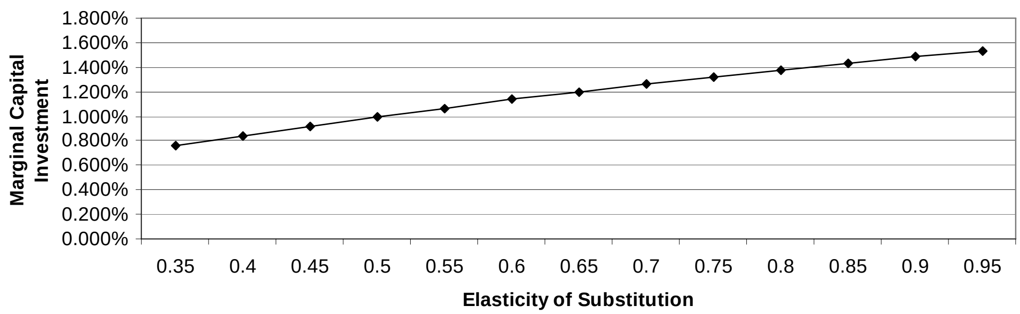

Figure 2: Elasticity of Substitution's Effect on the Change in After-Tax Incomes Due to a .01 Decrease in the Capital Income Tax Rate

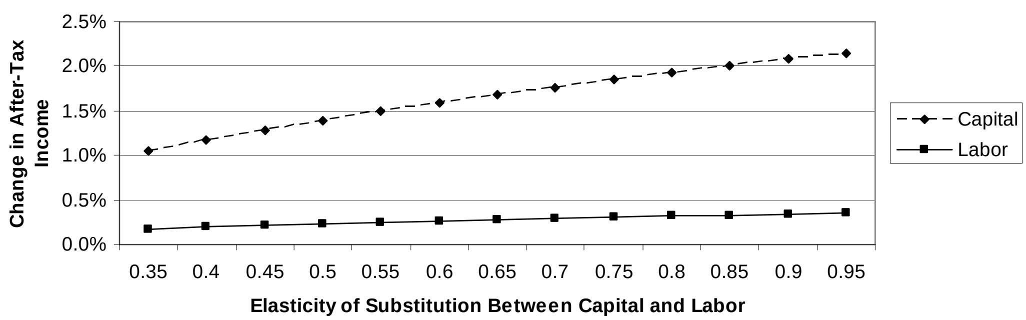

Table 4: The Impact of the Capital Externality on the Effects of a 0.01 Decrease in the Tax on Capital

Capital Externality (θ)	Returns to Scale	Change in After-Tax Capital Income	Change in After-Tax Labor Income	Change in Capital	Change in the Tax Rate on Labor
0.05	103.56%	1.48%	0.13%	1.06%	0.0039
0.1	107.22%	1.54%	0.20%	1.10%	0.0037
0.15	110.99%	1.60%	0.28%	1.14%	0.0035
0.2	114.87%	1.67%	0.37%	1.19%	0.0032
0.25	118.87%	1.75%	0.46%	1.25%	0.0030
0.3	122.98%	1.83%	0.56%	1.31%	0.0027
0.35	127.22%	1.92%	0.68%	1.37%	0.0024
0.4	131.59%	2.02%	0.80%	1.44%	0.0020

Figure 3: The Effect of the Capital Externality on Capital Investment Due to a .01 Decrease in the Capital Income Tax Rate

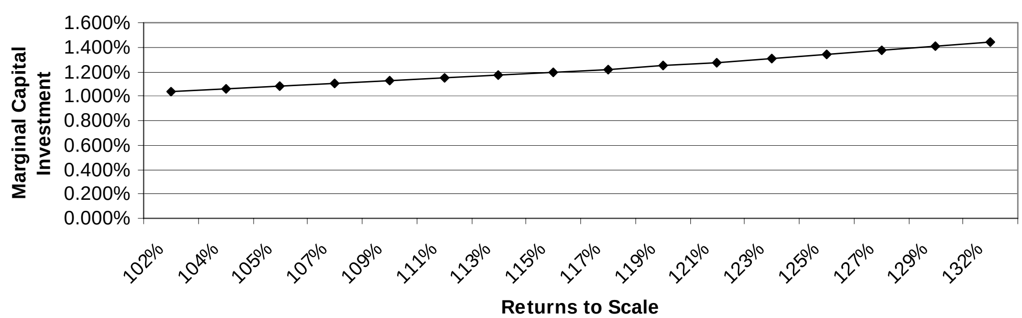

Figure 4: Capital Externality's Effect on the Change in After-Tax Incomes Due to a .01 Decrease in the Capital Income Tax Rate

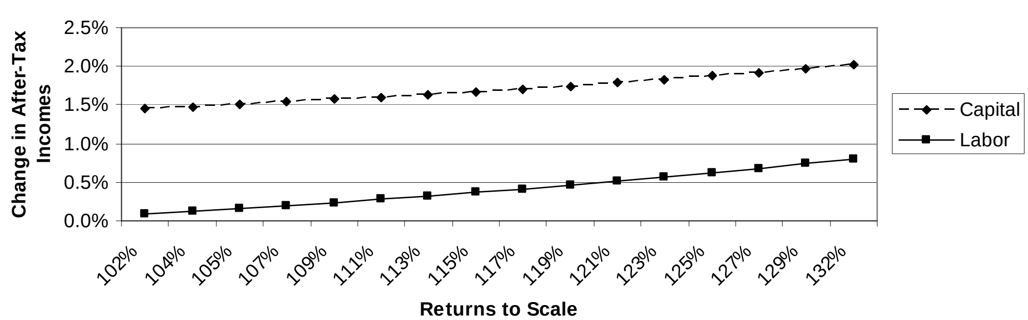

Table 5: The Impact of Labor's Share of Total Output on the Effects of a 0.01 Decrease in the Tax on Capital

Labor's Share	Change in After-Tax Capital Income	Change in After-Tax Labor Income	Change in Capital	Change in the Tax Rate on Labor
50.67%	1.91%	0.37%	1.37%	0.0067
55.50%	1.80%	0.33%	1.29%	0.0056
60.71%	1.70%	0.29%	1.21%	0.0045
66.43%	1.59%	0.26%	1.14%	0.0035
72.90%	1.49%	0.23%	1.06%	0.0026
77.86%	1.42%	0.22%	1.01%	0.0019
83.70%	1.35%	0.20%	0.96%	0.0013
87.22%	1.31%	0.19%	0.93%	0.0009
91.57%	1.26%	0.18%	0.90%	0.0004

Figure 5: The Effect of Labor's Share on Capital Investment Due to a .01 Decrease in the Capital Income Tax Rate

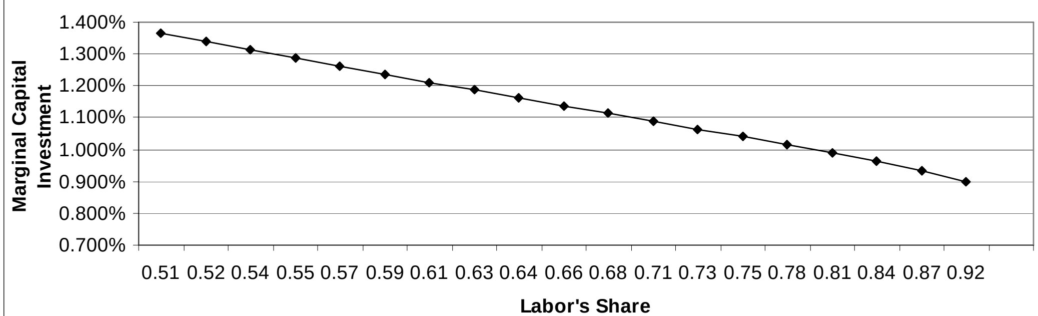

Figure 6: The Effect of Labor's Share on the Change in After-Tax Incomes Due to a .01 Decrease in the Capital Income Tax Rate

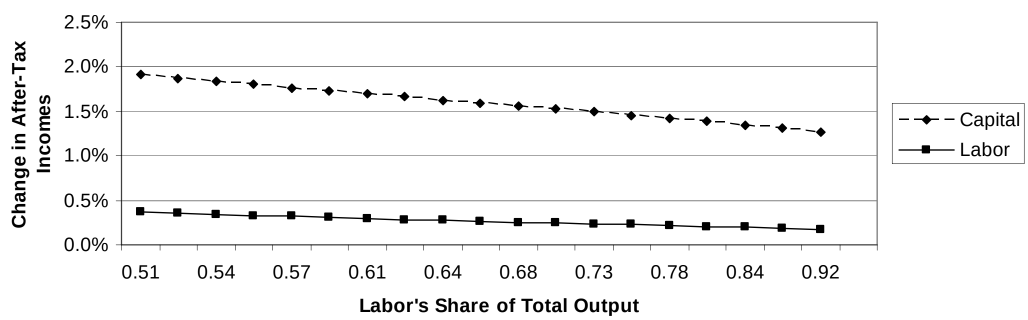

Table 6: The Impact of the Initial Distortion on the Effects of a 0.01 Decrease in the Tax on Capital

Initial Tax On Capital	Change in After-Tax Capital Income	Change in After-Tax Labor Income	Change in Capital	Change in the Tax Rate on Labor
0	1.03%	-0.07%	0.74%	0.0033
0.1	1.15%	0.01%	0.82%	0.0033
0.2	1.29%	0.10%	0.92%	0.0034
0.3	1.48%	0.20%	1.05%	0.0035
0.4	1.72%	0.33%	1.23%	0.0036
0.5	2.07%	0.49%	1.48%	0.0037
0.6	2.58%	0.72%	1.84%	0.0039
0.7	3.44%	1.08%	2.46%	0.0042
0.8	5.16%	1.80%	3.69%	0.0049
0.9	10.33%	3.91%	7.38%	0.0069

Figure 7: The Effect of the Initial Capital Tax Rate on Capital Investment Due to a .01 Decrease in the Capital Income Tax Rate

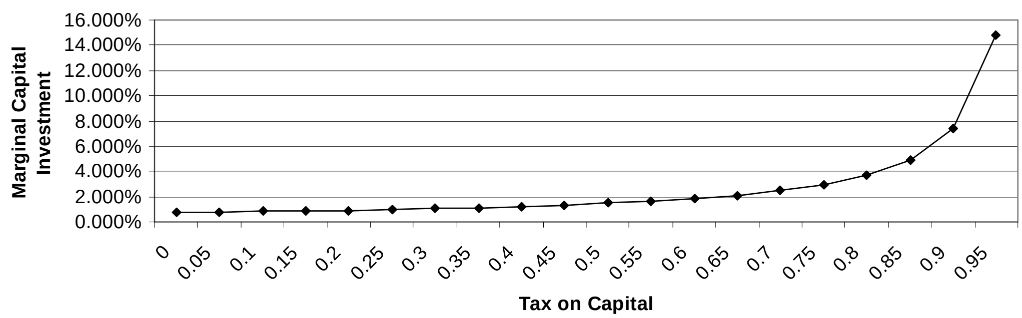

Figure 8: The Effect of the Initial Capital Tax Rate on the Change in After-Tax Incomes Due to a .01 Decrease in the Capital Income Tax Rate

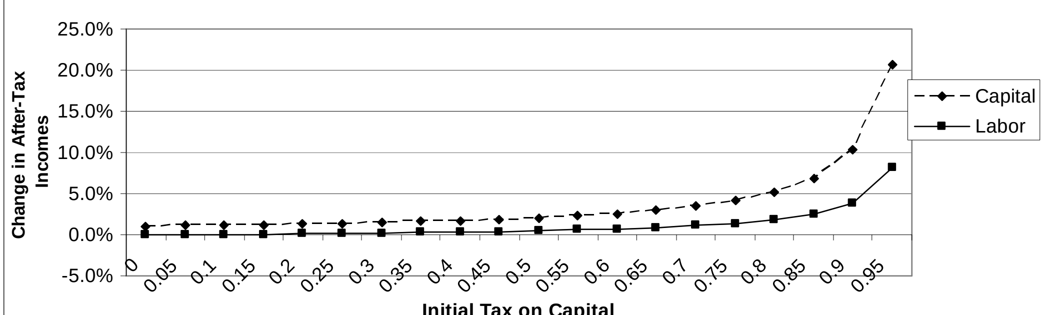

Table 7: The Impact of the Elasticity of Capital Supply on the Effects of a 0.01 Decrease in the Tax on Capital

Marginal Cost Parameter (β)	Change in After-Tax Capital Income	Change in After-Tax Labor Income	Change in Capital	Change in the Tax Rate on Labor
0.1	1.60%	0.51%	1.46%	0.0031
0.2	1.60%	0.42%	1.33%	0.0033
0.3	1.59%	0.33%	1.23%	0.0034
0.4	1.59%	0.26%	1.13%	0.0035
0.5	1.59%	0.20%	1.06%	0.0036
0.6	1.58%	0.15%	0.99%	0.0037
0.7	1.58%	0.10%	0.93%	0.0038
0.8	1.58%	0.06%	0.88%	0.0038
0.9	1.58%	0.02%	0.83%	0.0039
1	1.57%	-0.01%	0.79%	0.0040

Figure 9: The Effect of the Elasticity of Capital Supply on Capital Investment Due to a .01 Decrease in the Capital Income Tax Rate

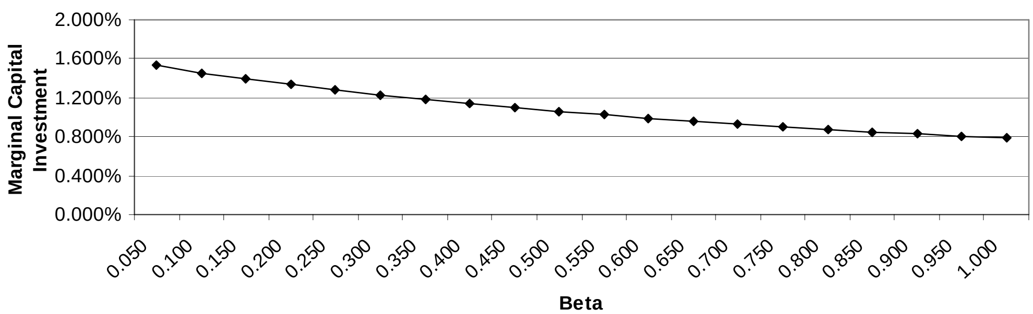

Figure 10: The Effect of the Elasticity of Capital Supply on the Change in After-Tax Incomes Due to a .01 Decrease in the Capital Income Tax Rate

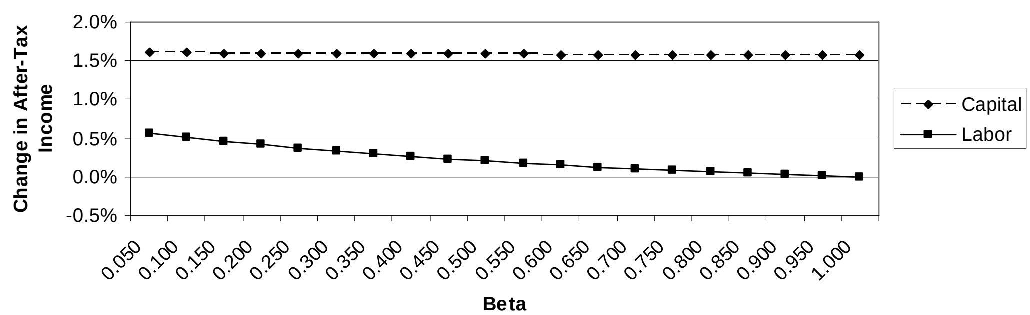

Figure 11: The Effect of the Elasticity of Substitution on the Magnitude of the Marginal Capital Tax Burden

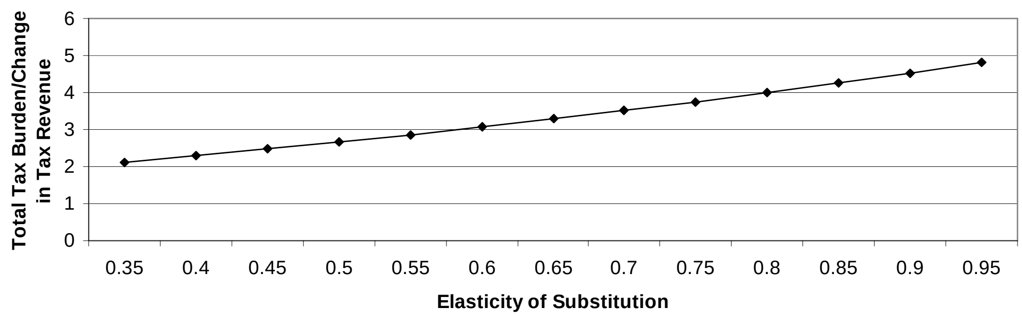

Figure 12: The Effect of the Elasticity of Substitution on Labor's Share of the Marginal Capital Tax Burden

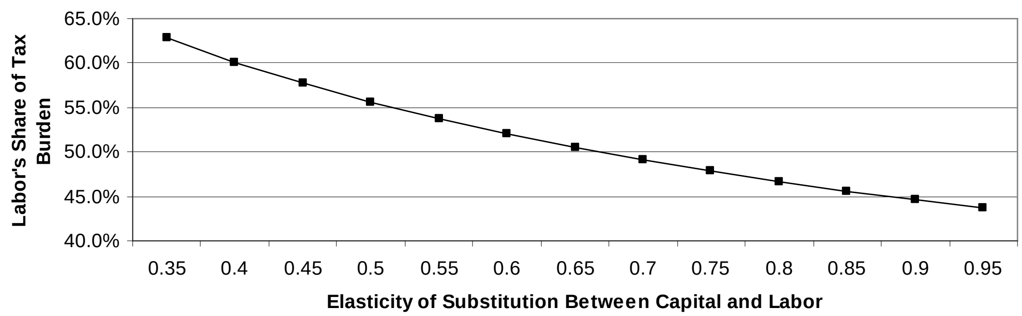

Figure 13: The Effect of Capital Externalities on the Magnitude of the Marginal Capital Tax Burden

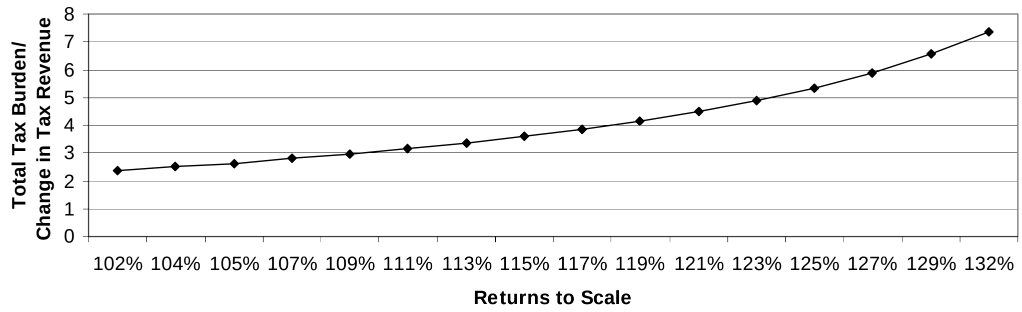

Figure 14: The Effect of Capital Externalities on Labor's Share of the Marginal Capital Tax Burden

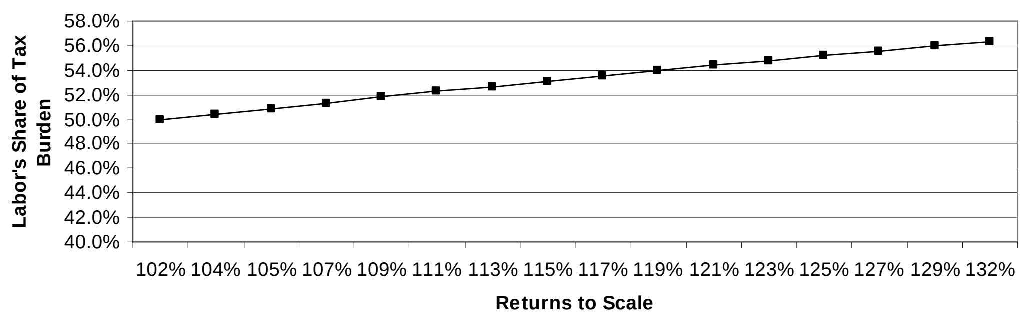

Figure 15: The Effect of Labor's Share of Output on the Magnitude of the Marginal Capital Tax Burden

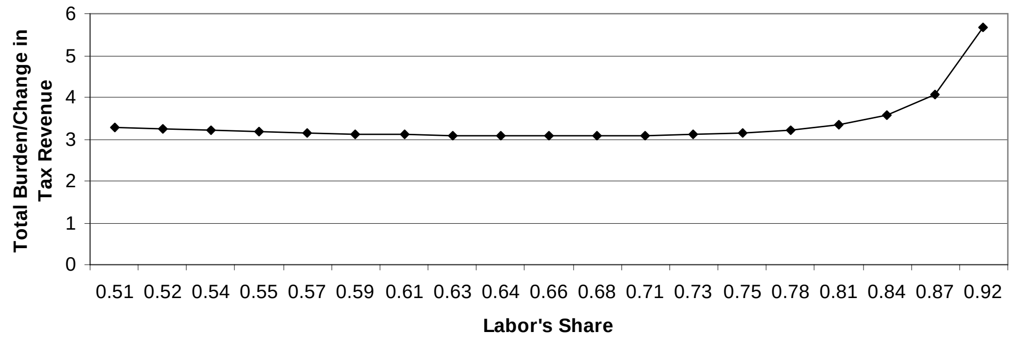

Figure 16: The Effect of Factor Shares on Labor's Share of the Marginal Capital Tax Burden

Figure 17: The Effect of the Initial Capital Tax Rate on the Magnitude of the Marginal Capital Tax Burden

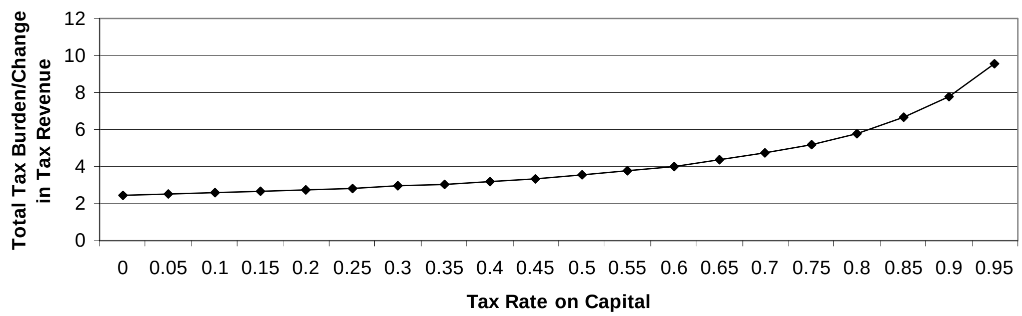

Figure 18: The Effect of the Initial Capital Tax Rate on Labor's Share of the Marginal Capital Tax Burden

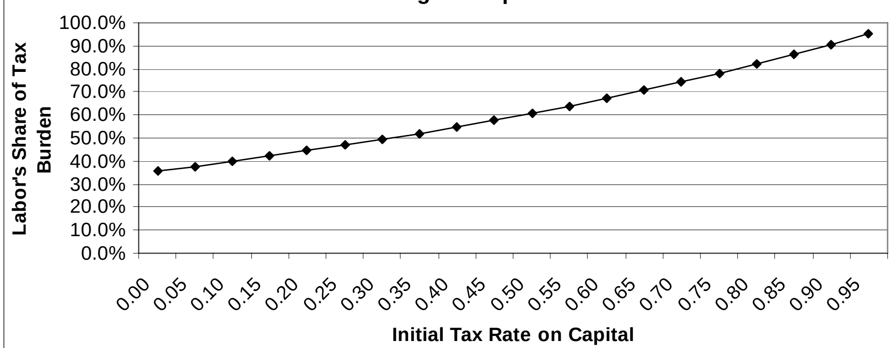

Figure 19: The Effect of the Elasticity of Capital Supply on the Magnitude of the Marginal Capital Tax Burden

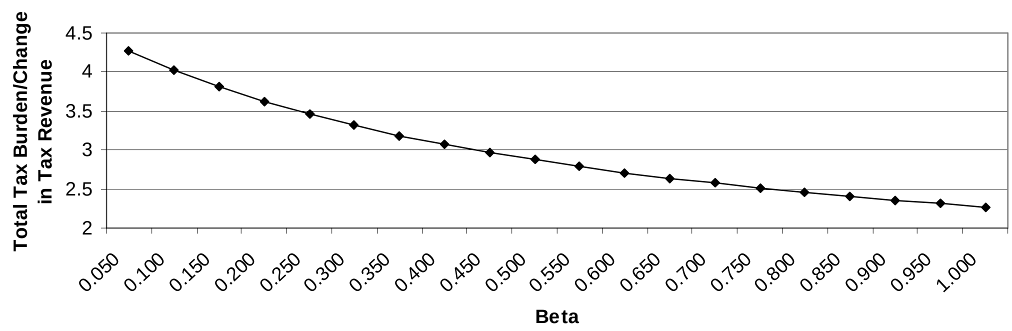

Figure 20: The Effect of the Elasticity of Capital Supply on Labor's Share of the Marginal Capital Tax Burden