Monopoly Power and Optimal Taxation of Capital Income

Sheikh Tareq Selim

Cardiff University
e-mail: selimsT@cardiff.ac.uk
Phone: (44) 0292 087 5190

First version: May, 2005. Current version: November, 2005.
Cardiff Economics Working Paper Series.

Abstract:

The recent general trend of cutting top marginal income tax rates in industrialized economies and the policy concern of enhancing competition in the US and the EU product markets subtly motivate the question if low income tax rates are optimal in an economy with imperfectly competitive markets. This paper examines long run optimal income tax policy in a model with private market monopoly distortion. It finds that the welfare-maximizing income tax policy is distortion-neutralizing, and the optimal policy may involve capital income tax or subsidy depending on the relative strength of two opposing effects --- the monopoly distortion effect, and the welfare effect of investment. If monopoly power is low (high), the welfare effect of investment (the monopoly distortion effect) dominates which supports a capital income tax (subsidy).

Keywords: Optimal taxation, Monopoly power, Ramsey policy.

***JEL* classification codes:** D42, E62, H21, H30.

Monopoly Power and Optimal Taxation of Capital Income

1.0 Introduction.

What is the optimal capital income tax policy in an economy with monopoly distortion? The relevant literature suggests orthodoxy on one principle --- with monopoly distortion, since output is lower than its optimal level, there must be some form of *Pigovian* element in optimal taxes such that it offsets the distortion created by monopoly power. In other words, with monopoly distortion in private markets optimal taxes need to be welfare-maximizing as well as distortion-neutralizing. This is the key intuition behind Selim's (2005b) key result that optimal labor income tax under imperfectly competitive private market is lower than its competitive market analogue. The questions then remain, does the government's optimal policy for capital income taxation follow the same principle, and with capital income tax, does the optimal labor income tax principle hold.

This paper attempts to answer these questions in a simple two-sector model of optimal income taxation with imperfectly competitive intermediate product market. The simple notion of monopoly distortion through mark up pricing of intermediate goods is introduced in the spirit of Dixit & Stiglitz (1977). The analytical results suggest that the long run optimal policy entails taxing or subsidizing capital income depending on the relative strength of two opposing effects, namely, the distortion effect of monopoly power, and the relative effect of investment on tax distorted equilibrium welfare. It is also established that with the limiting capital tax rule depending on two effects, the optimal tax on labor income from imperfectly competitive sector is lower than the optimal tax on labor income from perfectly competitive sector. The quantitative importance of the results is established by calibrating the model to fit the stylized facts of the post war US economy.

The policy problem addressed in this paper is one of central importance. The *OECD Revenue Statistics* and various issues of *OECD Observer* suggest that there has been a general tendency amongst the OECD countries to cut the top marginal rates of income taxes and shift the revenue reliance more towards general consumption taxes. The revenue share of personal and corporate income tax in the US, UK and OECD average dropped from 48.4%, 36.9% and 35.4% in 1997, to 47.4%, 33.4% and 35.1% in 2001, respectively. This was supported by a sharp rise in the share of general consumption taxes, from 7.8%, 19.5% and 18.0% in 1997, to 16.4%, 30.9% and 31.7% in 2001. In recent years most OECD countries' top marginal rates of income tax have been reduced[1]. Apart from cutting top rates, the number of tax brackets in OECD countries has been reduced. This is in pursuit of making the tax system easier to manage and understand for both taxpayers and administrators. Trends in corporate income tax have followed personal income tax. Various incentive schemes including investment credits and property related tax shelters have been moderated or abolished in numerous countries such as Australia, Austria, Finland, Germany, Iceland, Ireland, Portugal, Spain and the US. Also, several countries have revised the allowances for depreciation of capital equipment that companies can use to cut down on taxable income, bringing them nearer to the actual reduction in the economic value of the equipment. Still, corporate profits and personal capital income (dividends, interest etc.) are generally less heavily taxed than labor income in the OECD area and the EU, mainly because of social security contributions. On the other hand, empirical estimates of price mark ups, such as the Bayoumi *et al.* (2004) estimates of 1.23 for the US economy and 1.35 for the Euro area, motivate research towards designing competition enhancing policy tools. The important question that stems from these facts therefore is: are low income tax rates optimal for economies with high price mark ups?

To my understanding, contributions to the literature on optimal taxation with private market distortions that are of immediate relevance to the current paper are the ones by Stiglitz & Dasgupta (1971), Diamond & Mirrlees (1971), Judd (1997/2003), Guo & Lansing (1999), Auerbach & Hines Jr. (2001), Judd (2002), Golosov *et al.* (2003), and Selim (2005b). One of the main results of Stiglitz & Dasgupta (1971) is that the optimal commodity tax policy for a monopolistic industry with a bound on profit taxation generally includes both differential taxes and subsidies. Diamond & Mirrlees (1971) argue that the existence of pure profits may require a deviation from the productive efficiency condition implying that taxes should generally be levied on final and not on intermediate goods. Of the various important results stemming from the relevant literature on capital taxation in particular, it is however to some extent difficult to establish a general principle of optimal capital taxation. There is one common finding though in Judd (1997 & 2002), Guo & Lansing (1999) and Golosov *et al.* (2003) --- the celebrated result of zero limiting tax on capital income, which stands more or less robust for models with economy-wide competitive market, does not hold in models with imperfectly competitive markets.

[1] It is important to mention in this regard that the reduction in top rates of personal income tax have had very little impact on personal income tax revenues. Across the OECD economies, share of personal tax revenues in GDP was 10.3% in 1999 compared to 10.5% in 1980. This is largely due to two reasons, namely, strong economic growth which elevated taxpayers into higher tax brackets, and many governments partly financed their rate reductions contemporaneously by reducing permissible deductions against taxable income.

Judd (1997 & 2002) establishes that in an economy with imperfectly competitive private market, the optimal tax on capital income is negative, but it is not optimal to subsidize pure profits. Put more elaborately, Judd (1997) finds that if all intermediate goods are affected symmetrically by market power, a homogeneous subsidy of capital goods' purchase would be an appropriate curative policy tool. This result can be generalized to a subsidy of capital income if one distinguishes between income to capital goods and pure profits[2]. Judd (1997) argues that private market distortions act like a privately imposed tax on purchase of intermediate goods and that for a sufficiently flexible set of tax instruments the optimal tax policy will offset the privately created distortions. The key result highlighted in Judd (1997) is that capital formation should be subsidized but not pure profits, and this can be used as a corrective policy device to offset the distortions created by monopoly power[3]. The general principle of optimal capital subsidy in the presence of monopoly distortions stems primarily from the idea that tax policy may involve subsidies to bring buyer price down to social marginal cost. These subsidies, however, would require substantial revenues and the optimal policy would have to tax some goods in order to provide mark up reducing subsidies for other goods, implying that the subsidy principle would further necessitate identifying which goods to tax and which to subsidize. Judd (2002) argues that since mark up on capital goods distort investment just as a capital income tax does, a positive tax on capital income and a mark up on capital good combine to produce non-uniform distortion which is inconsistent with commodity tax principle. Taxing labor income (and consumption) is not associated with such compounding distortions, even if these elevate the more uniform monopoly distortions in labor and consumption decisions. Therefore, the non-uniform distortions due to mark up in the capital market should be reduced with subsidies even if the necessary revenues are generated by taxing labor income and consumption.

Judd's (1997) analysis and the key result of optimal capital subsidy are appealing for further verification because with monopoly distortion the welfare effect of investment as perceived by the planner and the private sector are very likely to be different, which makes

[2] The intuition put forward by Judd (2003) is that if profits are exhausted by fixed costs, the free-entry zero profit oligopoly equilibrium is equivalent to a competitive market where tax revenues finance fixed costs. This is quite insightful in interpreting the equilibrium, but the equivalence concept is oversimplified from welfare cost point of view. Consider Jonsson (2004) who uses a model with private market distortions arising from both product and labor market. In a calibrated version of the model Jonsson (2004) finds that the welfare cost of imperfect competition with distorting taxes with zero steady state profit (but strictly positive fixed cost) is significantly higher than welfare cost of distorting taxes in a perfectly competitive economy.

[3] In a relatively more recent paper, Golosov *et al.* (2003) model taxation in an environment where agents' skills are private information and show that if source of distortion is not only confined to taxation, a positive tax on capital income may be sustainable as a pareto efficient outcome. With a rather different source of private market distortion, the paper's key findings are necessarily banked on the same set of intuitions.

agents either over-invest or under-invest. A general principle of optimal capital subsidy to encourage investment in such a case may not be appropriate. This paper contributes by specifying Judd's (2002 & 2003) finding for a particular range of monopoly distortions. More specifically, this paper shows that with monopoly distortion in private markets, the government's optimal policy may involve a capital income tax or a capital income subsidy depending on the relative strengths of two effects which are of opposite signs. These effects are the monopoly distortion effect and the relative effect of investment on equilibrium welfare. Depending on the level of monopoly distortion, economic agents may under-invest or over-invest which makes one of these effects stronger than the other, and consequently motivates the government to use an optimal policy involving a capital income subsidy or a capital income tax. Through numerical investigation, the paper establishes that for low degrees of monopoly power agents over-invest in search of profits which reduces welfare. This motivates the government to use an optimal capital income tax to discourage investment. For high degrees of monopoly power agents under-invest, which implies the optimal policy involves a capital income subsidy that encourages investment.

This paper, however, is not the first attempt to establish such a 'two effect' result. A somewhat similar result can be found in Guo & Lansing (1999), but unfortunately the intuition behind their result is not particularly convincing. The underlying explanations that they provide are also rather incomplete. In a simple two sector neoclassical model, Guo & Lansing (1999) find that the optimal capital tax rate balances two opposing forces, namely, an underinvestment effect and a profit effect, and depending on their relative strength, can either be negative or positive. First, agents invest less than socially optimal level since return to investment is less than social marginal product of capital. A negative tax on capital income assists to correct this underinvestment effect since it encourages investment. On the other hand, since monopoly power earn pure profit the relative strength of a profit effect motivates the use of a positive tax on capital income. Their interpretation of the two effects leaves room for *two* important questions: for what degrees of monopoly distortion the underinvestment (profit) effect dominates the profit (underinvestment) effect, or more specifically, for what levels of monopoly power the government should tax/subsidize capital income? Is there a case where these two effects completely offset each other which recovers the limiting zero capital tax result with imperfectly competitive market? The analytical findings of Guo & Lansing (1999) do not provide clear-cut answers to these very important questions. Nevertheless, in the quantitative section, Guo & Lansing (1999, p. 987) show that when profits escape all taxation, the underinvestment (profit) effect dominates for very low (high) degrees of monopoly power. Based on their set of intuitions, this implies that government attempts to discourage investment when monopoly distortions and profits are high, which I find rather vague. Investment at a high level of monopoly distortion is not an attractive decision since the private return to capital is much lower than its socially optimal level. For relatively low degrees of monopoly power, agents invest in search of higher profits since the perceived wedge between social and private returns to investment is not remarkably high. A more sensible policy would therefore be to use a tax on capital income for low degrees of monopoly power.

This paper answers these two important questions both analytically and numerically and with strong underlying intuitions. It argues that a more useful and sensible track to understand and interpret the two effects that govern the sign of steady state optimal capital income tax is to demarcate them into monopoly distortion effect and the relative effect of investment on tax distorted equilibrium welfare. Unlike the findings of Guo & Lansing (1999), in the quantitative exercise the current paper shows that it is optimal to *tax* (subsidize) capital income for *low* (high) degrees of monopoly power. It also shows that the magnitude of the optimal Ramsey subsidy is larger for higher levels of monopoly distortion, but is always smaller than the first best subsidy.

These important findings are banked on strong intuitions. With monopoly distortions, investment decision of agents depends on both the discounted real return to capital and the wedge between social and private return to capital. Since investment generates nonzero profits, returns to investment in physical capital as perceived by the private sector and the Ramsey planner do not coincide, which would in an otherwise competitive economy. This is because with profits distributed back to households, capital accumulation becomes an argument in the constraint that restricts the optimal policy to be consistent with equilibrium feedback of taxpayers. This implies investment decisions directly affect welfare. For low degrees of monopoly power, agents over-invest in anticipation of higher profits. This investment is associated with welfare loss, but the relative effect of this investment as perceived by agents is stronger than the wedge. This motivates the government to use a positive tax on capital income in order to discourage welfare distorting investment. On the contrary, agents under-invest when monopoly power is high, since for higher monopoly distortion the rate of increase in the wedge is higher than the rate of increase in realized relative effect of investment. This is the case where the distortion effect dominates, and the optimal policy involves a capital income subsidy. The monopoly distortion effect and the relative effect of investment on equilibrium welfare do not completely offset each other for any plausible set of parameter values. This is because the allocation for which this may hold is not supported by equilibrium prices and policy. Thus with private market imperfection, the optimal policy never involves the celebrated result of zero limiting tax on capital income.

The paper also establishes that whether a tax or a subsidy, the optimal capital income tax policy is distortion-neutralizing. With monopoly distortion, the marginal product of capital is equal to private return to capital grossed up by the price mark up factor. If one considers the equilibrium cost of capital with two sources of distortions, monopoly power actually acts as a second tax rate on capital, which is neutralized by an optimal choice of capital income tax/subsidy. For low degrees of monopoly power, profit-seeking high investment distorts the equilibrium welfare which necessitates a distortion-neutralizing tax on capital income. For high degrees of monopoly power, underinvestment drives the wedge between social and private return to capital at a high level, which necessitates a distortion-neutralizing subsidy on capital income.

The next section presents the model economy and maximization problems of producers and consumers. Section 3.0 formulates and solves the optimal taxation problem. It derives the analytical set of solutions to both the first best and the Ramsey policy problems. It also presents the key propositions based on the analytical results. Section 4.0 explains the intuitions underlying the key propositions. Section 5.0 calibrates the model to fit the stylized facts of the US economy and presents insightful quantitative results. Section 6.0 concludes.

2.0 The Model Economy.

The model economy comprises of households, firms and the government. The economy has two sectors of production indexed by y and z, producing final goods and intermediate goods, respectively. The final good is used for private consumption, government consumption, and private investment, denoted by c_t, g_t and i_t, respectively. The intermediate goods sector uses capital and labor as inputs, and the final goods sector uses intermediate goods and labor as inputs. It will be convenient hereafter to index household's labor supply with subscripts y and z to denote the working time in the final goods sector and the intermediate goods sector, respectively.

Time t is discrete and runs forever. There is a continua of measure one of firms in sector y, which produce the final good, y_t, using labor, n_{yt}, and a continuum of intermediate goods, z_{jt} where $j \in [0,1]$, as inputs. A continuum of $j \in [0,1]$ firms in sector z combine capital, k_t, and labor, n_{zt}, to produce a continuum of intermediate goods, z_{jt}. Market for final goods is characterized by perfect competition, but producers of intermediate good may possess some degree of monopoly power. Initial endowment of capital, one unit of time at each period and property rights of firms are owned by each of a continua of measure one of identical infinitely-lived households.

The constant returns to scale technology used to produce the final good is:

$$y_t = \left\{ \left(\int_0^1 z_{jt}^{1-s} \, dj \right)^{\frac{1}{1-s}} \right\}^n n_{yt}^{\ 1-n} \tag{1.1}$$

where $n \in (0,1)$ is a share parameter, and $s \in [0,1)$ indexes the degree of monopoly power exercised by suppliers of the intermediate good[4].

The technology for intermediate goods sector is defined as:

$$z_{jt} = k_{jt}^{\ a} n_{zjt}^{\ 1-a} \tag{1.2}$$

where $a \in (0,1)$ is the share parameter for capital.

Households have identical preferences over consumption and labor supply. The representative household derives utility from consumption sequences $\{c_t\}_{t=0}^{\infty}$ and disutility from labor service sequences $\{n_{yt}, n_{zt}\}_{t=0}^{\infty}$. Preferences for the representative household are given by:

$$\sum_{t=0}^{\infty} b^t u(c_t, n_{yt}, n_{zt}) \tag{2}$$

where $b \in (0,1)$ is the subjective discount rate. The utility function $u: \mathbf{R}_+^3 \rightarrow \mathbf{R}$ is continuously differentiable, strictly increasing in consumption, decreasing in labor, strictly

[4] With this specification, s^{-1} is the elasticity of substitution between any two intermediate goods, and for $s \rightarrow 0$ $(s \rightarrow 1)$ the intermediate goods sector possesses low (high) monopoly power.

concave, and satisfies standard Inada conditions, namely $\lim_{c_t \to 0}[u_{ns}(t)]^{-1}u_c(t) = \infty$, and $\lim_{c_t \to \infty}[u_{ns}(t)]^{-1}u_c(t) = 0$ for $s = y, z$.

The government consumes exogenous g_t each period and raises the required revenue by taxing capital income, distributed profits, and labor income at rates q_t, kq_t, and t_{st} for $s = y, z$, respectively. The government's period t budget constraint is given by:

$$g_t = t_{yt} w_{yt} n_{yt} + t_{zt} \int_0^1 w_{zjt} n_{zjt} dj + q_t \left[\int_0^1 r_{jt} k_{jt} dj + k \int_0^1 p_{jt} dj \right] \qquad (3)$$

where w_{yt} and w_{zjt} denote wage rates in the final goods and intermediate goods sector, respectively, r_{jt} denotes rental price of capital, and p_{jt} denotes pure profits from intermediate goods sector. The benevolent government has access to an effective commitment technology with which it can sustain all initially announced tax plans. All optimal plans are therefore dynamically consistent. The parameter $k \geq 0$ represents the tax treatment of distributed corporate profits. For instance, the restriction $k \in [0,1]$ in the current setting implies the government's set of tax treatments $[no\,tax, at\ par\ with\ capital\,tax]$ for distributed corporate profits. In principle, ignoring the rather obscure possibility of more than 100% tax on distributed corporate profits, the restriction $q_t^{-1} \geq k \geq 0$ would be more appropriate, since $k = q_t^{-1}$ then would represent the case where distributed profits are taxed at the rate of 100%. But for most parts of the analysis to follow, I will consider $k \in [0,1]$. This is because although a 100% tax on profits is optimal, it is an impractical policy option. The assumption $k \in [0,1]$ is also empirically supported. For instance, using McGrattan & Prescott (2005)'s estimates of tax rate on corporate distributions and Carey & Tchilinguirian (2000)'s estimates of the average effective tax rates on capital income, one can compute $k = 0.6373$ and $k = 0.1222$ for the US and the UK economy, respectively.

2.1 Firms' Problems.

The final good is held as the numeraire. The representative firm in the final goods sector competitively maximizes profits. It faces the following sequence of problems:

$$\max_{z_{jt}, n_{yt}} \left[\left\{ \left(\int_0^1 z_{jt}^{1-s} dj \right)^{\frac{1}{1-s}} \right\}^{n} n_{yt}^{1-n} - \int_0^1 p_{jt} z_{jt} dj - w_{yt} n_{yt} \right] \tag{4.1}$$

where p_j denotes the relative price of intermediate good z_j. The first order conditions are:

$$z_{jt}: \quad p_{jt} = n (y_t)^{1-\frac{1-s}{n}} z_{jt}^{-s} (n_{yt})^{\frac{(1-n)(1-s)}{n}} \tag{4.2}$$

$$n_{yt}: \quad w_{yt} n_{yt} = (1-n) y_t \tag{4.3}$$

Firms in the intermediate goods sector possess monopoly power in pricing and face the demand function *(4.2)* for jth intermediate good. The profit maximization problem of the representative firm in the intermediate goods sectors is:

$$\max_{p_{jt}, n_{zjt}, k_{jt}} [p_{jt} z_{jt} - r_{jt} k_{jt} - w_{zjt} n_{zjt}] \tag{5.1}$$

$$s.t. \quad z_{jt} = k_{jt}^{a} n_{zjt}^{1-a}$$

$$p_{jt} = n (y_t)^{1-\frac{1-s}{n}} z_{jt}^{-s} (n_{yt})^{\frac{(1-n)(1-s)}{n}}$$

Substituting both constraints in *(5.1)* yields a sequence of unconstrained problems for the representative firm which can be maximized with respect to k_{jt} and n_{zjt}. The first order conditions are:

$$n_{zjt}: \quad w_{zjt} n_{zjt} = (1-a)(1-s) p_{jt} z_{jt} \tag{5.2}$$

$$k_{jt}: \quad r_{jt} k_{jt} = a(1-s) p_{jt} z_{jt} \tag{5.3}$$

Consider a symmetric equilibrium where all firms in the intermediate goods sector produce at the same level, employ the same levels of factors and charge the same relative price, such that $n_{zjt} = n_{zt}$, $k_{jt} = k_t$ and $p_{jt} = p_t$ for all j. The model economy's aggregate resource constraint is then given by:

$$c_t + g_t + i_t = k_t^{an} n_{zt}^{n(1-a)} n_{yt}^{1-n} \tag{6.1}$$

where the aggregate production technology exhibit constant returns to scale. Equilibrium profits for the intermediate goods sector is given by:

$$p_t = (ns)k_t^{an} n_{zt}^{n(1-a)} n_{yt}^{1-n} \qquad (6.2)$$

The symmetric equilibrium factor prices expressed in terms of the final good are:

$$w_{yt} = (1-n)(n_{yt})^{-1} y_t \qquad (6.3a)$$

$$w_{zt} = (1-a)n(1-s)(n_{zt})^{-1} y_t \qquad (6.3b)$$

$$r_t = a(1-s)n(k_t)^{-1} y_t \qquad (6.3c)$$

In order to derive the price mark up ratio, it is convenient to redefine the problem of the representative firm in the intermediate goods sector as one of choosing output to maximize profits. Let $TC_t(z_t, w_{zt}, r_t)$ denote the total cost function for the representative firm, and redefine the profit maximization problem as:

$$\max_{z_t} \left[n\, y_t^{1-\frac{1-s}{n}} z_t^{1-s} n_{yt}^{\frac{(1-n)(1-s)}{n}} - TC_t(z_t, r_t, w_{zt}) \right] \qquad (6.4)$$

The first order condition is:

$$z_t: \quad p_t = \frac{1}{(1-s)} MC_t(z_t, r_t, w_{zt}) \qquad (6.5)$$

From *(6.5)*, the price mark up ratio is simply $(1-s)^{-1}$.

2.2 Household's Problem.

The infinitely-lived representative household chooses $\{c_t, n_{yt}, n_{zt}, k_{t+1}\}_{t=0}^{\infty}$ to maximize *(2)* subject to the following constraints:

$$c_t + i_t \le (1-t_{yt})w_{yt}n_{yt} + (1-t_{zt})w_{zt}n_{zt} + (1-q_t)r_t k_t + (1-kq_t)p_t \qquad (7.1)$$

$$i_t = k_{t+1} - (1-d)k_t \qquad (7.2)$$

with standard non-negativity restrictions, $k_0 > 0$ given, and $d \in (0,1)$ as the capital depreciation rate. The first order conditions corresponding to this problem are the period budget constraints and the followings:

$$-u_{ns}(t) = u_c(t)(1 - t_{st})w_{st} \quad \text{for} \quad s = y, z \tag{7.3a}$$

$$bR_{t+1} = \frac{u_c(t)}{u_c(t+1)} \tag{7.3b}$$

$$\lim_{t \to \infty} b^t u_c(t) k_{t+1} = 0 \tag{7.3c}$$

where $R_t \equiv [(1 - q_t)r_t + (1 - d)]$.

2.3 Equilibrium.

The symbols without time subscripts used in the definition denote the one-sided infinite sequence for the corresponding variables, e.g. $n_z \equiv \{n_{zt}\}_{t=0}^{\infty}$.

Definition 1 (Equilibrium). A symmetric equilibrium is an allocation (c, n_y, n_z, k, z, y), a price system (w_y, w_z, p, r), and a government policy (t_y, t_z, q), such that

(1) given the price system and government policy, the allocation solves the firms' problems and the household's problem;

(2) given the price system and allocation, the government policy satisfies the sequence of government budget constraints *(3)*; and

(3) all markets clear in the long run. •

The symmetric equilibrium is characterized by the following system *(8)* in the set of unknowns $\{c_t, n_{yt}, n_{zt}, k_t, w_{yt}, w_{zt}, r_t, p_t, p_t, z_t, y_t, t_{yt}, t_{zt}, q_t\}$.

$$0 < n_{yt} + n_{zt} \leq 1 \tag{a}$$

$$y_t = c_t + g_t + i_t \tag{b}$$

$$y_t = z_t^{n} n_{yt}^{1-n} \tag{c}$$

$$i_t = k_{t+1} - (1-d)k_t \qquad (d)$$

$$z_t = k_t^{a} n_{zt}^{1-a} \qquad (e)$$

$$p_t = n(y_t)^{1-\frac{1-s}{n}} z_t^{-s} (n_{yt})^{\frac{(1-n)(1-s)}{n}} \qquad (f)$$

$$w_{yt} = (1-n)(n_{yt})^{-1} y_t \qquad (g)$$

$$w_{zt} = (1-a)n(1-s)(n_{zt})^{-1} y_t \qquad (h)$$

$$r_t = a(1-s)n(k_t)^{-1} y_t \qquad (i)$$

$$p_t = (ns)k_t^{an} n_{zt}^{n(1-a)} n_{yt}^{1-n} \qquad (j)$$

$$-u_{ny}(t) = u_c(t)(1-t_{yt})w_{yt} \qquad (k)$$

$$-u_{nz}(t) = u_c(t)(1-t_{zt})w_{zt} \qquad (l)$$

$$bR_{t+1} = \frac{u_c(t)}{u_c(t+1)} \qquad (m)$$

$$\lim_{t\to\infty} b^t u_c(t)k_{t+1} = 0 \qquad (n)$$

The system *(8)* characterizes the symmetric equilibrium allocations and prices for the government's choice of tax instruments. It is straightforward to show that each arbitrarily chosen tax policy generates a symmetric equilibrium.

3.0 Optimal Taxation.

Following the primal approach, the optimal taxation problem for the government is to choose allocations $\{c_t, n_{yt}, n_{zt}, k_{t+1}\}_{t=0}^{\infty}$ to maximize welfare defined by *(2)* subject to the aggregate resource constraint *(6.1)* where investment is defined by *(7.2)*, and an implementability constraint that ensures that the resulting taxes, prices and allocations are consistent with equilibrium system *(8)*. This is a characterization of the underlying Ramsey problem. Once the optimal taxation problem is solved, the resulting Ramsey allocations, given the initial conditions $\{R_0, k_0\}$, can be used to recover a sequence of prices $\{w_{zt}, w_{yt}, r_t, p_t\}_{t=0}^{\infty}$ and policy variables $\{t_{zt}, t_{yt}, q_t\}_{t=0}^{\infty}$ that will support the Ramsey allocations as a decentralized equilibrium.

In order to formulate the Ramsey problem, it is convenient to first solve the household's problem using a present-value budget constraint. The present-value budget constraint of the household is:

$$\sum_{t=0}^{\infty} q_t^o c_t = \sum_{t=0}^{\infty} q_t^o (1-t_{yt}) w_{yt} n_{yt} + \sum_{t=0}^{\infty} q_t^o (1-t_{zt}) w_{zt} n_{zt} + \sum_{t=0}^{\infty} q_t^o (1-kq_t) p_t + R_0 k_0 \qquad (9.1)$$

where the Arrow-Debreu price is given by $q_t^o = \left(\prod_{s=1}^{t} R_s \right)^{-1}$ with $R_t \equiv [(1-q_t) r_t + (1-d)]$, and $\prod_{s=1}^{0} R_s \equiv 1$ is the numeraire which makes $q_0^o = 1$.

Consider the problem of the household of choosing $\{c_t, n_{yt}, n_{zt}\}_{t=0}^{\infty}$ to maximize utility defined by *(2)* subject to *(9.1)*. The first order conditions with respect to allocations are:

$$q_t^o u_c(0) = b^t u_c(t) \qquad (9.2a)$$

$$u_{ny}(t) = -u_c(t)(1-t_{yt}) w_{yt} n_{yt} \qquad (9.2b)$$

$$u_{nz}(t) = -u_c(t)(1-t_{zt}) w_{zt} n_{zt} \qquad (9.2c)$$

The implementability constraint is the intertemporal constraint involving only allocations and initial conditions, which is derived by substituting out taxes, factor prices and Arrow-Debreu price in *(9.1)*. The implementability constraint is therefore:

$$\sum_{t=0}^{\infty} b^t [u_c(t) c_t + u_{ny}(t) n_{yt} + u_{nz}(t) n_{zt} - u_c(t)(1-kq_t) p_t] - u_c(0) R_0 k_0 = 0 \qquad (9.3a)$$

where

$$(1-kq_t)p_t = \begin{cases} n s (1-k) k_t^{an} n_{zt}^{(1-a)n} n_{yt}^{1-n} + k_t \dfrac{ks}{a(1-s)} \left[\dfrac{u_c(t-1)}{b u_c(t)} - (1-d) \right] & for\, t \geq 1 \\ (1-kq_0)(n s) k_0^{an} n_{z0}^{n(1-a)} n_{y0}^{1-n} & for\, t = 0 \end{cases}$$

(9.3b)

3.1 The Ramsey Problem.

The Ramsey problem for the government is to choose a policy $\{q_t, t_{yt}, t_{zt}\}_{t=0}^{\infty}$ that maximizes welfare defined by *(2)* subject to the government budget constraint defined by *(3)* such that the resulting policy and the associated allocations and prices are consistent with equilibrium defined by *(8)*. Following the primal approach, this problem can be characterized as one in which the government chooses allocations $\{c_t, n_{yt}, n_{zt}, k_{t+1}\}_{t=0}^{\infty}$ to maximize *(2)* subject to constraints *(6.1)*, *(7.2)* and *(9.3)*. Note that with *(9.3b)* the Pseudo utility function corresponding to the Ramsey problem now incorporates current period capital stocks as one of the arguments. This implies in the tax distorted equilibrium, investment induces both a direct and an indirect welfare effect.

Let $\Phi \geq 0$ represent the utility cost of raising revenue through distorting taxes. The Pseudo utility function for the Ramsey problem is defined as:

$$V(c_t, n_{yt}, n_{zt}, k_t, \Phi) \equiv u(c_t, n_{yt}, n_{zt}) + \Phi[u_c(t)c_t + u_{ny}(t)n_{yt} + u_{nz}(t)n_{zt} - u_c(t)(1 - kq_t)p_t] \qquad (9.4)$$

where $(1 - kq_t)p_t$ is defined by *(9.3b)*. The economy's aggregate resource constraint after substituting for investment is:

$$c_t + g_t + k_{t+1} = k_t^{an} n_{zt}^{n(1-a)} n_{yt}^{1-n} + (1-d)k_t \qquad (9.5)$$

Let $\{c_t\}_{t=0}^{\infty}$ be the sequence of Lagrange multiplier on *(9.5)*. The Lagrangian of the Ramsey problem is defined as:

$$J = \sum_{t=0}^{\infty} b^t \begin{Bmatrix} V(c_t, n_{yt}, n_{zt}, k_t, \Phi) \\ + c_t[k_t^{an} n_{zt}^{n(1-a)} n_{yt}^{1-n} + (1-d)k_t - c_t - g_t - k_{t+1}] \end{Bmatrix} - \Phi u_c(0) R_0 k_0 \qquad (9.6)$$

where $(1-kq_t)p_t$ in $V(.)$ is defined by *(9.3b)*. For exogenously given g_t, R_0 and k_0, the Ramsey problem is to maximize *(9.6)* with respect to $\{c_t, n_{yt}, n_{zt}, k_{t+1}\}_{t=0}^{\infty}$. The first order conditions due to changes in $t \geq 1$ allocations are:

$$c_t: \quad V_c(t) = c_t, \qquad \forall t \geq 1 \qquad (9.7a)$$

$$n_{yt}: \quad V_{ny}(t) = -c_t(1-n)k_t^{an} n_{zt}^{(1-a)n} n_{yt}^{-n}, \qquad \forall t \geq 1 \qquad (9.7b)$$

$$n_{zt}: \quad V_{nz}(t) = -c_t n(1-a)k_t^{an} n_{zt}^{(1-a)n-1} n_{yt}^{1-n}, \qquad \forall t \geq 1 \qquad (9.7c)$$

$$k_{t+1}: \quad c_t = b\left\{V_k(t+1) + c_{t+1}[na\, k_{t+1}^{an-1} n_{zt+1}^{(1-a)n} n_{yt+1}^{1-n} + (1-d)]\right\}, \qquad \forall t \geq 1 \qquad (9.7d)$$

Consolidating *(9.7)* and using *(6.3)*, the Ramsey equilibrium conditions for $t \geq 1$ are:

$$V_{ny}(t) = -V_c(t) w_{yt} \qquad (9.8a)$$

$$V_{nz}(t) = -V_c(t) \frac{w_{zt}}{(1-s)} \qquad (9.8b)$$

$$V_c(t) = b\left\{V_k(t+1) + V_c(t+1)\left[\frac{r_{t+1}}{(1-s)} + (1-d)\right]\right\} \qquad (9.8c)$$

together with the implementability constraint defined by *(9.3)* and aggregate resource constraint for $t \geq 1$. Note that with $s = 0$ *vis a vis* $V_k(t+1) = 0$, equation *(9.8c)* captures the standard intertemporal trade off described by the Euler equation from the household's optimization problem. By contrast, $V_k(t+1) \neq 0$ indicates that returns to investment in physical capital as perceived by the private sector and the Ramsey planner no longer coincide.

In general, for a $T \geq 0$ for which fluctuations in government expenditure is arbitrarily small for all $t \geq T$, the solution to *(9.8)* can be characterized by a set of stationary allocation rules $c_t(c_{t-1}, n_{st-1}, k_t, \Phi)$, $k_{t+1}(c_{t-1}, n_{st-1}, k_t, \Phi)$ and $n_{st}(c_{t-1}, n_{st-1}, k_t, \Phi)$. Given these allocations, one can use *(8g, h & i)*, *(9.2)*, and *(9.5)* to compute a set of stationary rules for the factor price and tax rates for $t \geq T$. The optimal allocations for $t \leq T$ can be computed by solving *(9.8)* backwards in time, starting from $t = T$ and by imposing the stationary allocation rules for $t \geq T$ as the boundary conditions. The entire sequence of allocations, which includes the first order conditions from the Ramsey problem for changes in

$(c_0, n_{y0}, n_{z0}, k_1)$, together with the initial conditions, determines the multiplier Φ such that the implementability constraint *(9.3)* is satisfied.

3.2 The First Best Policy.

If there is an access to lump sum tax $(\equiv \ell_t)$, the government can implement the first best tax policy which generates the equilibrium that coincides with the equilibrium derived by solving the benevolent social planner's problem. The benevolent social planner's problem in this setting is to choose allocations $\{c_t, n_{yt}, n_{zt}, k_{t+1}\}_{t=0}^{\infty}$ to maximize utility defined by *(2)* subject to the economy-wide resource constraint. With $b^t l_t^1$ as the period t Lagrange multiplier, the first order conditions with respect to allocations for the social planner's problem can be summarized as:

$$c_t: \quad u_c(t) = l_t^1 \qquad (10.1a)$$

$$n_{yt}: \quad u_{ny}(t) = -u_c(t)(1-n)(n_{yt})^{-1} y_t \qquad (10.1b)$$

$$n_{zt}: \quad u_{nz}(t) = -u_c(t) n (1-a)(n_{zt})^{-1} y_t \qquad (10.1c)$$

$$k_{t+1}: \quad b\left[n a k_{t+1}^{an-1} n_{zt+1}^{n(1-a)} n_{yt+1}^{1-n} + (1-d)\right] = \frac{u_c(t)}{u_c(t+1)} \qquad (10.1d)$$

The social planner's allocations also satisfy resource constraints *(9.5)* and the Transversality condition *(7.3c)*.

Proposition 1: With social planner's equilibrium implied by *(10.1)*, the first best fiscal policy is to *(a)* set zero tax on labor income from final goods sector (competitive markets); *(b)* set a uniform subsidy on labor income and capital income from intermediate goods sector (imperfectly competitive market), and *(c)* impose

$$\ell_t = g_t + \frac{ns}{(1-s)} y_t [1 - s(1-k)]$$

as a lump sum tax that is strictly greater than planned government consumption expenditure.

Proof: Comparing *(10.1)* with *(7.3)*, it is straightforward to show that $t_{yt} = 0$, $t_{zt} = q_t = \frac{-s}{(1-s)} < 0$. Substituting for these taxes and using equilibrium conditions *(8)* in the government's budget constraint with lump sum taxes yields:

$$\ell_t = g_t + \frac{ns}{(1-s)} y_t [1 - s(1-k)]$$

which is strictly positive, and strictly greater than g_t. •

The intuition behind proposition 1 is clear. Since final goods sector is perfectly competitive, the associated first best labor income tax rate is zero. For the sector where monopoly power is exercised, factor returns are less than their social marginal products, which is compensated by a first best uniform subsidy. In order to finance the subsidies, the lump sum tax is charged at a higher level than government's planned consumption expenditure. For instance, if $k = 0$ (no profit tax), $\ell_t = g_t + p_t$, and if $k = 1$, $\ell_t = g_t + \frac{p_t}{(1-s)}$.

3.3 The Ramsey Policy.

Now consider Ramsey tax policy when lump sum tax is not an option. I will introduce a rather innocuous simplification to the model only for the sake of tractability of analytical results. Assume that $u : \mathbf{R}^3_+ \to \mathbf{R}$ is separable in consumption and labor, and linear in labor[5]. Furthermore, I will restrict my attention to steady state Ramsey tax policy. This is accomplished by assuming that there exists a $T \geq 0$ for which $g_t = \overline{g}$ for all $t \geq T$, and solution to the Ramsey problem converges to a time-invariant allocation.

Recall the Pseudo utility function for this problem, as defined by *(9.4)*. The derivatives of the Pseudo utility function with respect to allocations, evaluated at steady state, and after some algebra, are:

[5] Put technically, this simplification imply $u_{cns}(t) = u_{nsc}(t) = u_{nsns}(t) = u_{nsnl}(t) = 0$ for $s, l = y, z$, and $l \neq s$.

$$V_c = u_c + u_c\Phi\left[1 + \frac{u_{cc}c}{u_c}\left\{1 - s\,n\,\frac{y}{c}\left[(1-k) - (1-d-b^{-1})r^{-1}k\right]\right\}\right] \quad (10.2a)$$

$$V_k = u_c\Phi\left[\frac{ks}{a(1-s)}(1-d-b^{-1}) - ns(1-k)\frac{r}{(1-s)}\right] \quad (10.2b)$$

$$V_{ny} = u_{ny}(1+\Phi) - \Phi u_c n s(1-k)w_y \quad (10.2c)$$

$$V_{nz} = u_{nz}(1+\Phi) - \Phi u_c n s(1-k)\frac{w_z}{(1-s)} \quad (10.2d)$$

The derivatives in *(10.2)* represent the steady state marginal effect of change in allocations on tax distorted equilibrium welfare. For an optimal tax policy, these derivatives represent the long run effect on equilibrium welfare for small changes in allocation decisions. The sector-specific Ramsey tax rules for labor income is analytically computed by comparing the steady state versions of the Ramsey equilibrium conditions *(9.8a & b)*, and equilibrium conditions *(8k & l)*, or *(9.2b & c)*, which are primarily derived from representative household's optimization problem. This gives:

$$(1-t_y) = \frac{\left[1 + \Phi\left(1 + \frac{u_{cc}c}{u_c}\left\{1 - s\,n\,\frac{y}{c}\left[(1-k) - (1-d-b^{-1})r^{-1}k\right]\right\}\right)\right] - \Phi n s(1-k)}{(1+\Phi)} \quad (10.3a)$$

$$(1-t_z) = \frac{\left[1 + \Phi\left(1 + \frac{u_{cc}c}{u_c}\left\{1 - s\,n\,\frac{y}{c}\left[(1-k) - (1-d-b^{-1})r^{-1}k\right]\right\}\right)\right] - \Phi n s(1-k)}{(1+\Phi)(1-s)} \quad (10.3b)$$

It is convenient for the following two propositions (2 and 3) to combine *(10.3a & b)* to derive:

$$\frac{(1-t_z)}{(1-t_y)} = \frac{1}{(1-s)} \quad (10.4)$$

Proposition 2: If all markets are perfectly competitive, it is optimal for the government to tax labor income from the two sectors at the same rate.

Proof: The competitive market analogue of the model economy corresponds to the case where there is no monopoly power in pricing of the intermediate goods. This is tantamount to saying that all markets are competitive if $s = 0$. Equation *(10.4)* with $s = 0$ implies $t_z = t_y$. •

Proposition 3: For $s \in (0,1)$, it is optimal for the government to set the labor income tax in the intermediate goods sector (where monopoly power is exercised) lower than the labor income tax in the final goods sector (competitive market), i.e. $t_z < t_y$ is optimal policy as long as monopoly power is exercised in the intermediate goods sector.

Proof: For any $s \in (0,1)$, $(1-s)^{-1} > 1$ holds. Equation *(10.4)* then implies $t_z < t_y$. •

In order to characterize the steady state optimal capital income tax rate, consider first the time-invariant version of *(9.8c)*:

$$b\left\{V_k + V_c\left[\frac{r}{(1-s)} + (1-d)\right]\right\} = V_c \qquad (11.1a)$$

The steady state condition *(11.1a)* can be compared to the steady state version of equilibrium condition *(8m)*, which is:

$$b\{(1-q)r + (1-d)\} = 1 \qquad (11.1b)$$

Proposition 4: If all markets are perfectly competitive, the steady state level of optimal capital tax is zero, i.e. for $s = 0$, the model recovers the celebrated result of zero capital tax in the long run.

Proof: Consider *(10.2b)* with $s = 0$ which gives $V_k = 0$. Equations *(11.1a & b)* with $s = 0$ and $V_k = 0$ gives $q = 0$. •

Proposition 5: For $s \in (0,1)$, there are two opposing effects that determine the sign and magnitude of the steady state optimal capital tax rate, namely, the distortion effect of monopoly power, and the relative effect of investment on tax distorted equilibrium welfare. For any $k \in [0,1]$, and depending on the relative strength of these two effects, the government's long run optimal policy may involve a capital income subsidy that is smaller in magnitude than the first best subsidy, or a capital income tax.

Proof: Equations *(11.1a & b)* together yield:

$$q = \frac{-s}{(1-s)} + \left(-\frac{V_k}{rV_c}\right) \qquad (11.2)$$

For $s \in (0,1)$, the two effects which determine the sign and magnitude of q are therefore $\frac{-s}{(1-s)}$ which represents the monopoly distortion effect, and $\left(-\frac{V_k}{rV_c}\right)$, which is a measure of the relative effect of investment on equilibrium welfare.

The first effect is the effect due to monopoly power, which is equal to the first best subsidy. The second effect comprises of derivatives of the Pseudo utility function with respect to capital and consumption (evaluated at steady state). Consider first *(10.2b)* with $k \in [0,1]$. Since $(1-d-b^{-1}) < 0$, this implies $V_k < 0$. Moreover, with $k \in [0,1]$, *(10.2c)* implies $V_{ny} < 0$, which together with *(9.8a)* implies $V_c > 0$. Hence the term $\left(-\frac{V_k}{rV_c}\right)$ is strictly positive.

The sign and magnitude of the steady state optimal capital tax therefore depends on the relative strengths of these two effects. If the relative effect of investment on tax distorted equilibrium welfare is stronger (weaker) than the monopoly power effect, the long run optimal policy is a tax (subsidy) on capital income. In any case, the optimal subsidy is smaller than the first best subsidy. •

4.0 Intuitions and Explanations.

Proposition 2 states that if all markets are competitive, the government's optimal policy involves equal labor income taxes across sectors. The intuition behind this result is straightforward, but its implication is strong since unlike in Selim (2005a) the result does not depend on the marginal disutility of effort, or more generally, preference specification. Since all households are identical, in equilibrium they make exactly the same set of decisions. In other words, in equilibrium it must be optimal for the representative household to behave the way everyone else does. The optimal choice of labor income tax rates therefore must induce households to react with equilibrium labor supply to the two sectors, such that the wage rates across sectors are exactly the equilibrium wage rates. Since with economy-wide competitive markets the only source of distortion is the tax policy, it is optimal for the government to set equal labor income tax rates across sectors.

In a competitive setting, there is also a concern of intra and intertemporal smoothing of labor income taxes. Since the government is benevolent, each period it wants to minimize the total disutility of effort for the household, both over two subsequent periods and across the two sectors. Since the disutility is convex, it is best to induce the representative household to supply same number of hours in each period, which suggests that the optimal labor income tax should be smooth over time. Likewise, as long as the marginal rate of substitutions of labor across sectors is unitary, it is best to induce the representative household to supply same number of hours in the two sectors within a period, than making them work different hours in the two sectors with the same total. This implies that the optimal policy with economy-wide competitive markets should be one which smoothes the labor income tax rate across sectors.

Proposition 3 makes the intuition behind proposition 2 even clearer, and the result from proposition 3 is the normative benchmark of optimal labor income taxation where firms in a particular sector practice monopoly power in pricing (see Selim (2005b) for details). Rearranging *(10.4)* one can derive:

$$t_z = \frac{t_y - s}{1 - s} \qquad (11.3)$$

which implies that the optimal labor income tax for the intermediate goods sector is the sum of two elements, namely, the first best subsidy, and the price mark up adjusted optimal labor income tax for the competitive sector. Due to monopoly distortions, the private marginal return to labor in the intermediate goods sector is lower than the social marginal return. It is therefore optimal to set the labor income tax for this sector lower than a competitive sector's labor income tax such that the distorted efficiency margins are corrected. This is the simple Pigovian consideration while optimally designing labor income tax in the presence of monopoly power. This finding is similar to that in Selim (2005b).

Since the sign of optimal tax rate on labor income is inconclusive from *(10.3)*, a simple numerical example using *(11.3)* and assuming $s \in (0,1)$ makes the intuition clearer. Figure *a* is presented to illustrate the function $t_z = 1.23(t_y) - 0.23$, which is derived by setting $s = 0.186$ in *(11.3)*. The choice for s is not arbitrary. Recall from *(6.5)* that the price mark up ratio for the current setting is $(1-s)^{-1}$. For this illustration, I have chosen 1.23 as the price mark up ratio, which is Bayoumi *et al.* (2004)'s average estimate of price mark up ratio for the US economy. For figure *a*, I have considered $t_y \in [0, 0.5]$ which resulted in $t_z \in [-0.23, 0.38]$. Consider, for instance, the case where government sets $t_z = 0$. This implies the optimal policy is simply to set the labor income tax in final goods sector equal to the parameter s. Next, consider the case where the government sets $t_y = 0$, which simply converge to the first best labor income tax policy without lump sum taxes. In principle, an optimal subsidy for labor income in the final goods sector therefore accompanies a larger optimal subsidy for labor income in the intermediate goods sector.

Proposition 4 recovers the celebrated result of zero limiting capital tax, and for the current model this is established by setting $s = 0$. It is more convenient to think of this result in connection with proposition 2. With no monopoly power, the steady state optimal tax policy for the government should be one that minimizes tax distortions, which can be accomplished by taxing labor income only and leaving capital income untaxed. With $s = 0$ there is no Pigovian consideration in designing tax policy, i.e. the only consideration for the government in this case is to minimize the *tax induced* wedge between social and private marginal returns, and not to allow the tax distortions to compound over time. Combining proposition 2 and 4, one can recover the normative benchmark of optimal income taxation in a competitive setting --- smooth labor income taxes with uniform distortions, and zero limiting capital tax.

Proposition 5 is one of the main results of the current paper. What it implies is that a more useful track to explain the optimal capital income tax policy in the presence of monopoly power is to demarcate the effects that motivate the policy into a distortion effect and an investment effect. The first effect, which is due to monopoly distortion, is simply equal to the first best subsidy, or in other words, one minus the price mark up. The second effect is due to Ramsey taxation, since it is not observed in the first best policy. Note first that from *(11.1a)*, one can derive:

$$\frac{V_k}{V_c} = \frac{1}{b} - \left[\frac{r}{(1-s)} + (1-d) \right] \qquad (11.4)$$

The terms V_k and V_c in *(11.4)* are simply the steady state marginal effect of investment and consumption in tax distorted equilibrium welfare. In a zero profit competitive market setting $V_k = 0$, and the Ramsey equilibrium implies $b^{-1} = [r + 1 - d]$. With monopoly distortion and nonzero equilibrium profits in the implementability constraint, equilibrium welfare is adversely affected by profit-seeking investment. For $k \in [0,1]$, $V_k < 0$ and $V_c > 0$, which implies that the relative effect of investment is negative, i.e. investment in the tax and monopoly distorted equilibrium reduces welfare.

The government's optimal capital tax policy, as in *(11.2)*, therefore is determined by the relative strengths of two terms, one representing the distortion effect, and the other representing the welfare effect of investment. If the latter dominates the former, agents invest in search of higher profits and it is optimal to tax capital income to discourage such investment. More intuitively, investment in the presence of monopoly distortion is associated with a much lower private return to capital, but opportunity for more profits. For low degrees of monopoly power, agents invest to increase profits since the realized increase in profits over-rules the realized wedge between social and private returns to capital. Although higher profits increase agents' income, lower returns to factors induce welfare loss. The optimal policy in such case should be one to discourage investment by imposing a capital income tax. For remarkably high degrees of monopoly power, the wedge between social and private returns to factors increases proportionately more than the realized profit gain from investment. This is the situation where agents under-invest, and the optimal policy response should be one that encourages investment through a capital income subsidy.

Is the optimal capital income tax policy distortion-neutralizing? Note that the equilibrium cost of capital in this setting is determined by total distortion created by the interaction of taxation and monopoly power. More specifically, denoting the social marginal product of capital by MP_k, equilibrium condition *(8i)* implies:

$$r = (1 - s)MP_k \tag{11.5a}$$

Equation *(11.5a)* shows that in equilibrium, the marginal product of capital equals the private return to capital grossed up by the price mark up factor $(1-s)^{-1}$. In an efficient outcome $r = MP_k$; which means the distortion in the demand for capital is created by monopoly power. With $\tilde{r} \equiv (1-q)r$, which is the after tax return to capital, equation *(11.5a)* implies that the equilibrium cost of capital is expressed by the following equation:

$$\tilde{r} = (1-s)(1-q)MP_k \tag{11.5b}$$

Equation *(11.5b)* shows that monopoly power is equivalent to a privately imposed tax rate of s, and the optimal choice of q neutralizes this distortion.

Finally, there remains a question if proposition 5 implies a corollary of a limiting zero capital tax result when the two effects completely offset each other. In principle the answer is no, since the case where these two effects completely offset each other is inconsistent with equilibrium conditions. To show it formally, note that *(11.4)* and *(11.2)* together imply:

$$q = 1 - \frac{1}{r}\left[\frac{1 - b(1-d)}{b}\right] \tag{11.6}$$

and $q = 0$ if and only if $b^{-1} = [r + 1 - d]$. Given the current setting, $b^{-1} = [r + 1 - d]$ cannot hold in equilibrium for $s \in (0,1)$, implying that $q \neq 0$.

5.0 Calibration and Computation.

In this section the steady state of the model is calibrated to fit the stylized facts of the US economy for data period of 1960-2001. The time interval is considered to be one year which is consistent with frequency of revision of fiscal decision. In calibrating, the parameters of the model are pinned down so that the steady state of the model matches characteristics identified from the US data for time period 1960-2001.

Consistent with the standard assumptions of the utility function and the simplifying assumption of $u_{cns}(t) = u_{nsc}(t) = u_{nsns}(t) = u_{nsnl}(t) = 0$ for $s, l = y, z,$ and $l \neq s$, consider the following specification:

$$u(c_t, n_{yt}, n_{zt}) = \ln(c_t) + [1 - n_{yt} - n_{zt}] \qquad (12.1)$$

which implies $\frac{u_{cc}}{u_c} c = -1$[6].

The set of parameters for the model is (a, n, s, k, b, d). These parameters are pinned down to match the steady state characteristics identified from the US data for time period 1960-2001. This gives the baseline values for the set of parameters. The baseline values are used to calibrate the multiplier Φ and then the Ramsey tax rates and the first best tax rates. Given the main purpose of the paper, the parameter indexing the degree of monopoly power, s, is of prime interest. Once the model has been calibrated, sensitivity of the key results is tested by varying s within a reasonable range. Note that the parameters b, a, n, d and k are the structural parameters which are calibrated directly from data, and hence do not require recalibration. Varying s for the current setting is tantamount to varying the profit ratio for given values of the structural parameters, and requires recalibration of the multiplier indexing for utility cost of distorting taxes, Φ. A reasonable range of values for the parameter k, that describes government's fiscal treatment of distributed profits, is also considered. Varying k requires recalibration of the multiplier Φ.

5.1 Parameterization.

Annual data of the US economy's real output, government consumption and corporate profits for the period 1960-2001 are taken from the *Federal Reserve Bank of St. Louis Economic Data*-FRED II. This data gives average government consumption to output ratio

[6] Specification *(12.1)* ignores the possibility of having different marginal disutility of work across sectors --- an abstraction which may be empirically questionable. The *Bureau of Labor Statistics* survey reports suggest that injury related incidence per 100 workers varies greatly across different industrial sectors of the US economy, and incidence rates are relatively higher in goods producing sector as compared to the service producing sector. Considering this observation, one can specify $u(c_t, n_{yt}, n_{zt}) = \ln(c_t) + [1 - n_{yt} - \Lambda n_{zt}]$ with $\Lambda > 0$. For the current purpose, however, the implicit assumption of unitary marginal rate of substitutions of labor across sectors is innocuous because the optimal labor income tax rates as in *(10.3)* are not at all sensitive to this assumption. Moreover, the calibration was verified by adding another parameter in *(12.1)* to account for the relative marginal disutility of work, which did not produce any remarkable changes in the key results.

equal to 0.23, and profit to output ratio equal to 0.11. Annual data for the US economy's capital stock and investment for the period 1960-1996 are collected from the US Department of Commerce's *Revised Fixed Reproducible Tangible Wealth in the United States*. The series for capital and investment include business equipment and structures, residential components and consumer durables, and give steady state capital to output ratio equal to 3.31, and investment to output ratio equal to 0.22. Table 1 summarizes the target statistics.

The baseline parameter values are presented in table 2. The parameter b is chosen such that it is consistent with annual real interest rate of 4%. This pins down $b = 0.9615$. The value of the parameter k stands for the fiscal treatment of profits and is the ratio between tax on distributed profit and tax on capital income. The tax on distributed profits for the US economy, from McGrattan & Prescott (2005)'s period average estimate for 1990-2000, is 17.4%. For the average effective tax rate on capital income for the US economy, I use 27.3% as in Carrey & Tchilinguirian (2000). This pins down $k = 0.6373$.

Capital's share of final output is set equal to 0.36, an approximation consistent with long run US data, and also frequently used in relevant literature[7]. This is consistent with $n = 0.7351$, $s = 0.1496$, and $a = 0.5759$. The calibrated value for the parameter s yields the price mark up ratio equal to 1.175, which is a reasonable approximation of the range of values typically used in established literature, such as the ones presented in Martins *et al.* (1996), Basu & Fernald (1997) and Bayoumi *et al.* (2004). With $k/y = 3.31$ and $i/y = 0.22$, the steady state version of *(8d)* pins down $d = 0.0664$, and consequently $c/y = 0.55$. In order to calibrate the utility cost of distorting taxes, Φ, note first that with baseline parameters $r = 0.1087$, which from *(11.4)* yields $\frac{V_k}{V_c} = -0.0213$. Using this in *(10.2)* pins down $\Phi = 0.9890$.

5.2 Quantitative Findings.

The quantitative findings are summarized in table 3 and figures *b-g*. Table 3 summarizes the calibrated Ramsey policy and the first best policy for baseline parameter values. The calibration with baseline parameter values suggests that the long run optimal policy for the

[7] In the current setting, the three income shares add up to $1-ns$, which is simply one minus the profit ratio.

government involves tax on all income and no subsidy. The calibrated Ramsey tax rates are approximately equal to 2%, 32% and 42% for capital income, labor income from intermediate goods sector, and labor income from final goods sector, respectively. Given the baseline value of the parameter k, the calibrated tax rate on distributed corporate profits is 1.3%. The first best policy would involve 0% tax on labor income from final goods sector, a uniform subsidy of approximately 18% on capital income and labor income from intermediate goods sector, and a lump sum tax such that the ratio of lump sum tax to output is equal to 0.3522.

The figures are constructed to show the sensitivity of the key results for changes in parameters s and k. Figure *b* and *c* examine the efficiency of the Ramsey policy for a range of values for the parameters s and k. Figure *b* suggests that economic agents prefer the Ramsey policy than the first best policy for high price mark up ratio. This is fairly obvious by now, since the Ramsey taxes compensate for monopoly distortion and induces lesser welfare cost than a heavy lump sum tax. Higher degrees of monopoly power results in higher losses of output and drives a larger wedge between social and private returns to factors, which in turn distorts the work and investment incentives. Although a first best subsidy can be used to compensate the wedge, a heavy lump sum tax in addition reduces disposable income. The Ramsey policy for high degrees of monopoly power diversifies the tax burdens through different tax instruments, which imply that the social cost of distorting taxes becomes relatively lower. With remarkably high degrees of monopoly power, the utility cost of distorting taxes are lower, implying that the households are willing to pay lesser amount in terms of consumption goods to replace one unit of distorting tax by one unit of lump sum tax.

Not surprisingly, this is also true for higher values of the parameter k, as in figure c. The more the tax (or subsidy) on distributed profits, the less is the government's reliance on factor income tax instruments. Consequently, for high values of the parameter k, the welfare cost of Ramsey taxes is low, and Ramsey taxes are preferred over lump sum tax. Figure g for instance demonstrates that different fiscal treatments of distributed corporate profits such that $k \in [0,1]$ does not affect the optimal choice of capital income tax at all, and affect only the optimal labor income tax policy. More specifically, higher values of the parameter k for a given monopoly distortion level are associated with lower values of labor income tax rates, implying that the Ramsey policy becomes more desirable for higher taxes (or subsidies) on distributed profits.

Figure *d*, *e* and *f* present the calibrated Ramsey and the first best taxes for $s \in [0, 0.35]$. Consider first the calibrated optimal capital income tax. For $s \in (0, 0.17)$, the relative effect of investment dominates the distortion effect of monopoly power which motivates an optimal tax on capital income. The peak of capital income tax is 13% which is for $s = 0.055$. For any $s \in (0.17, 0.35)$, the converse happens, and the optimal policy involves a capital income subsidy. For different values of s, the sensitivity of the relative effect of investment is much less than the sensitivity of the distortion effect of monopoly power, implying that the relative effect of investment dominates the monopoly distortion effect over a much smaller range of s [8]. Although high degrees of monopoly power are associated with high profits, they are also associated with larger wedges between social and private returns to factors and consequent larger loss in output. For high degrees of monopoly power, the rate of increase in the wedge between social and private marginal return to capital is much larger than the rate of increase in welfare effect of investment. For remarkably high degrees of monopoly distortions economic agents therefore set investment at a very low level. Investment in the range of $s \in (0.17, 0.35)$ can be encouraged only by setting a capital income subsidy.

Does this imply for $s \in (0.17, 0.35)$ the optimal policy involves heavy subsidies to both capital income and profits? For remarkably high degrees of monopoly power profits are high, and subsidizing both capital income and high profits requires raising heavy revenues which may be infeasible, especially in an economy without government bonds and low levels of labor income tax rates. In fact, for $s \in (0,1)$ the optimal tax/subsidy on capital income can be accompanied by little or no tax/subsidy on distributed profits. As in figure *g*, the optimal tax rate on capital income is completely insensitive for different values of the parameter k within a reasonable range. What the parameter k affects are the optimal labor income taxes. This implies that the government can pursue the optimal policy of subsidizing capital income with little or no subsidy on distributed profits, and hence make the revenue requirement feasible. This is also clear from figure *g*, since for low values of k both optimal labor income taxes are higher than their baseline calibrated estimates. Hence, for high degrees of monopoly power, the government's optimal policy may be one that attaches a low weight on profit taxation and finances the capital subsidy by heavily taxing labor income.

Figure *e* presents the calibrated optimal labor income taxes for $s \in [0, 0.35]$. Figure *f* presents the calibrated Ramsey taxes and the first best taxes for the same range of s. For any

[8] The optimal capital subsidy result actually holds for $s \in (0.17,1)$. The only permissible range of values for s for which it is optimal to tax capital income is therefore $(0, 0.17)$.

$s \in (0, 0.35]$, the optimal labor income tax for intermediate goods sector is lower than the optimal labor income tax in competitive sector. Higher degrees of monopoly power are associated with lower optimal taxes on labor income in both sectors. For $s = 0.25$ the optimal labor income tax in intermediate goods sector becomes zero, implying that it is optimal to subsidize labor income in the intermediate goods sector for any $s > 0.25$. Moreover, for any $s \in (0, 0.35]$, neither the optimal capital income subsidy nor the optimal labor income subsidy for the intermediate goods sector converges to the first best subsidy, i.e. both Ramsey subsidies are smaller in magnitude than the first best subsidy. These results were verified for $s \in (0,1)$ which suggests that the optimal labor income tax for the final goods sector never converges to zero. Figure *g* presents that since both the profit taxes and the labor income taxes create uniform distortion, an increase (decrease) in profit tax rate is accompanied by a decrease (increase) in labor income tax rates and no change in capital income tax rate.

6.0 Conclusion.

This paper examines the optimal capital income tax policy in a simple two-sector general equilibrium model where firms in the intermediate goods sector practice monopoly power in pricing of differentiated intermediate goods. It shows that with the introduction of monopoly power in a standard neoclassical optimal taxation model, the choice of optimal capital income tax policy becomes somewhat analytically ambiguous. Resolving the ambiguity requires correct assessment of the degree of monopoly distortion. The sign of the optimal capital income tax is determined by two opposing effects, which are the distortion effect of monopoly power and the welfare effect of investment. The distortion effect motivates the use of a capital income subsidy, while the relative effect of investment on welfare supports the use of a positive tax on capital income. For an empirically plausible set of parameters which are consistent with long run characteristics of the US economy, the paper finds that the welfare effect of investment dominates the distortion effect for very low degrees of monopoly power which supports the optimal policy of a capital income tax. For high degrees of monopoly power, it is optimal to subsidize capital income. This result therefore specifies Judd's (2002) prescription of optimal capital income subsidy for a range of high degrees of monopoly power.

The paper also shows that optimal tax on labor income in the imperfectly competitive sector is lower than the optimal tax on labor income in the perfectly competitive sector, and for all permissible degrees of monopoly power Ramsey taxes are higher than the first best income taxes. However for high degrees of monopoly power Ramsey taxes induce lesser welfare cost since they neutralize the distortions created by monopoly pricing. The optimal labor income tax policy is sensitive to government's fiscal treatment of distributed profits, but the optimal capital income tax policy is not. This implies that for excessively high degrees of monopoly power, the optimal policy *may* involve capital income subsidy, no subsidy for distributed profits, and taxes on labor income.

Both monopoly power and income taxes induce distortions in allocations and are associated with significant welfare costs. In a recent paper, Jonsson (2004) presents a quantitative analysis of the US economy's welfare costs due to monopoly power and taxation. One of the major findings of his work is that the welfare cost of taxation depends on the level of competition. As reported in Jonsson (2004), the long run welfare cost of imperfect competition in product market and distorting taxes are 48.26% and 12.79%, respectively. Moreover, based on the computed welfare cost approximations, Jonsson (2004) establishes that in an economy with imperfectly (perfectly) competitive markets labor income taxes are more (less) distorting than capital income taxes. From this point of view, the current paper's key finding of a nonzero limiting tax/subsidy on capital income in principle is less distorting than what it would have been if markets were perfectly competitive.

Bibliography.

Auerbach, A. J. & Hines, J. R. Jr. (2001). 'Perfect Taxation with Imperfect Competition', *NBER Working Paper, No. 8138.*

Basu, S. & Fernald, J. G. (1997). 'Returns to Scale in U.S. Production: Estimates and Implications', *Journal of Political Economy*, Vol. 105, pp. 249-283.

Bayoumi, T., Laxton, D., & Pesenti, P. (2004). 'Benefits and Spillovers of Greater Competition in Europe: A Macroeconomic Assessment', *NBER Working Paper, No. 10416*.

Carey, D. & Tchilinguirian, H. (2000). 'Average Effective Tax Rates on Capital, Labor and Consumption', *OECD Economics Department Working Papers No. 258.*

Diamond, P. & Mirrlees, J. (1971). 'Optimal Taxation and Public Production, II: Tax Rules', *The American Economic Review*, Vol. 61, pp. 261-278.

Dixit, A. & Stiglitz, J. E. (1977). 'Monopolistic Competition and Optimum Product Diversity', *The American Economic Review*, Vol. 67, pp. 297-308.

Golosov, M., Kocherlakota, N. & Tsyvinski, A. (2003). 'Optimal Indirect and Capital Taxation', *The Review of Economic Studies*, Vol. 70, pp 569-587.

Guo, J-T. & Lansing, K. J. (1999). 'Optimal Taxation of Capital Income with Imperfectly Competitive Product Markets', *Journal of Economic Dynamics and Control*, Vol. 23, pp. 967-995.

Jonsson, M. (2004). 'The Welfare Cost of Imperfect Competition and Distortionary Taxation', *Sveriges Riksbank Working Paper Series 170*.

Judd, K. L. (1999). 'Optimal Taxation and Spending in General Competitive Growth Models', *Journal of Public Economics*, Vol. 71, pp. 1-26.

Judd, K. L. (2002). 'Capital Income Taxation with Imperfect Competition', *The American Economic Review*, Vol. 92, pp. 417-421.

Judd, K. L. (2003). 'The Optimal Tax on Capital Income is Negative', *NBER Working Paper No. 6004 (1997)*, Hoover Institute Version 2003.

Martins, J. O., Scarpetta, S. & Pilat, D. (1996). 'Mark-up Pricing, Market Structure, and the Business Cycle', *OECD Economic Studies, No. 27*, 1996/11.

McGrattan, E. R. & Prescott, E. C. (2005). 'Taxes, Regulations, and the Value of U.S. and U.K. Corporations', *The Review of Economic Studies*, Vol. 72, pp. 767-796.

Selim, S. T. (2005a). 'Optimal Taxation with Commitment in a Two-sector Neoclassical Economy', *Royal Economic Society Annual Conference, 2005, Nottingham*.

Selim, S. T. (2005b). 'Monopoly Power and Optimal Taxation of Labor Income', *Mimeo*, Cardiff Business School.

Stiglitz, J. E. & Dasgupta, P. (1971). 'Differential Taxation, Public Goods, and Economic Efficiency' *The Review of Economic Studies*, Vol. 38, pp. 151-174.

Table 1: **Steady state ratios for the US economy, 1960-2001.**

Ratio	Description	Value
g/y	Government consumption to output ratio.	0.23
p/y	Profit to output ratio.	0.11
k/y	Capital to output ratio.	3.31[a]
i/y	Investment to output ratio.	0.22[a]

a: These estimates are for 1960-1996, collected from Revised Fixed Reproducible Tangible Wealth in the United States, US Department of Commerce.

Source: Federal Reserve Bank of St. Louis Economic Data-FRED II, and Revised Fixed Reproducible Tangible Wealth in the United States, US Department of Commerce.

Table 2: **Baseline parameter values.**

Parameter	Description	Value
b	Subjective discount rate.	0.9615
d	Capital depreciation rate.	0.0664
a	Share parameter for capital in intermediate goods sector.	0.5759
n	Share parameter for intermediate goods in final goods sector.	0.7351
s	Inverse of the elasticity of substitution between intermediate goods.	0.1496
k	Fiscal treatment of distributed profits.	0.6373

Table 3: **Calibrated optimal tax rates.**

	Capital income tax (q)	Sector z labor income tax (t_z)	Sector y labor income tax (t_y)
Ramsey Policy	0.0206	0.3167	0.4189
First Best Policy	-0.1759	-0.1759	0

Fig a: Optimal tax on labor income for sigma = 0.186

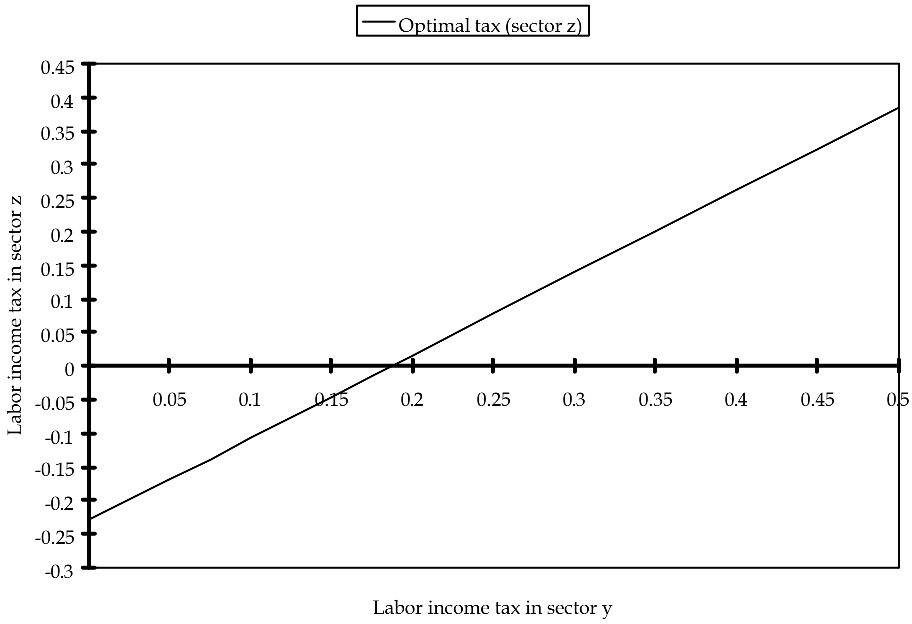

Fig b: Utility cost of taxation (F) vs. sigma.

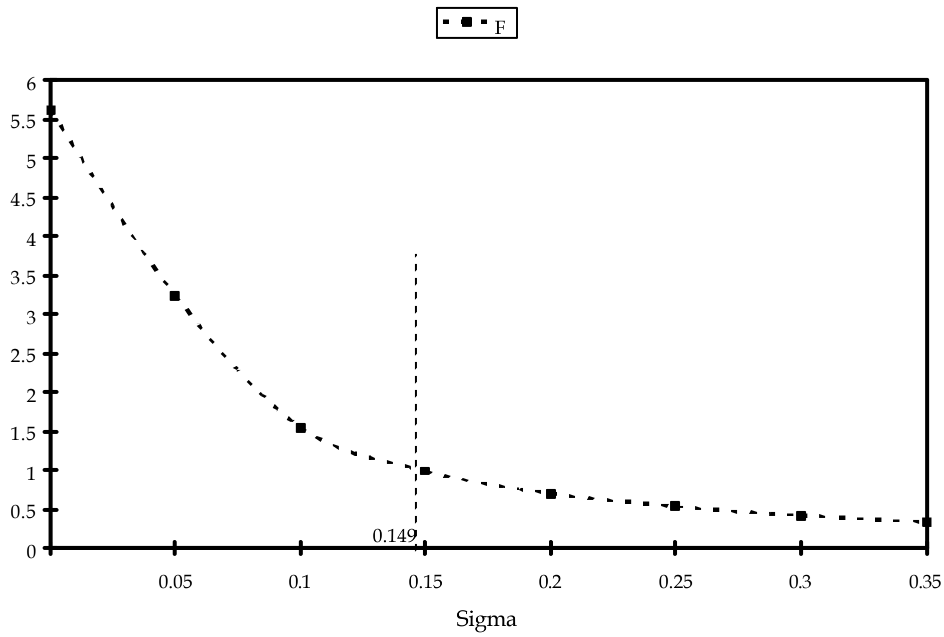

Fig c: Utility cost of taxation (F) vs. kappa

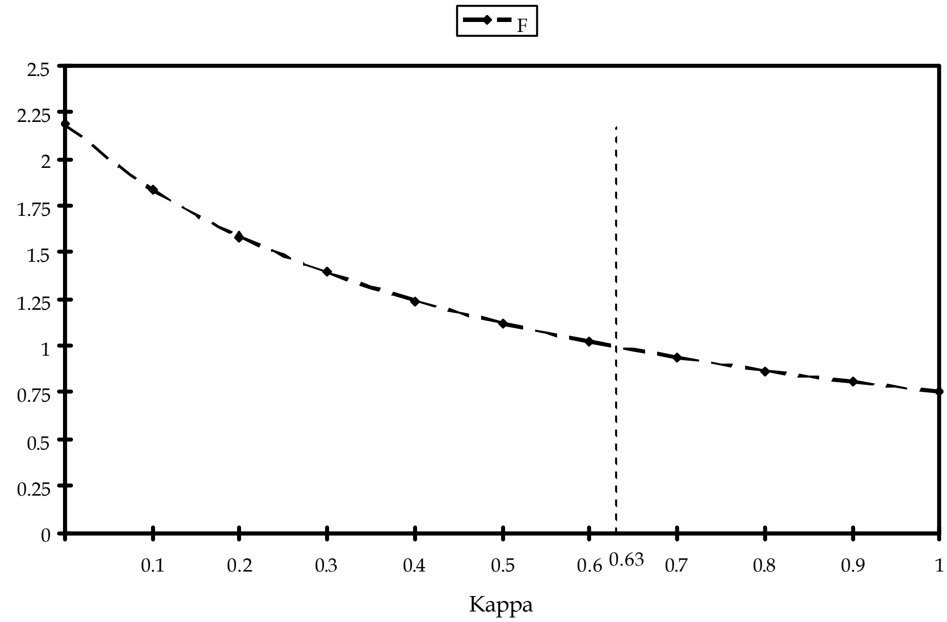

Fig d: Optimal capital tax vs. sigma

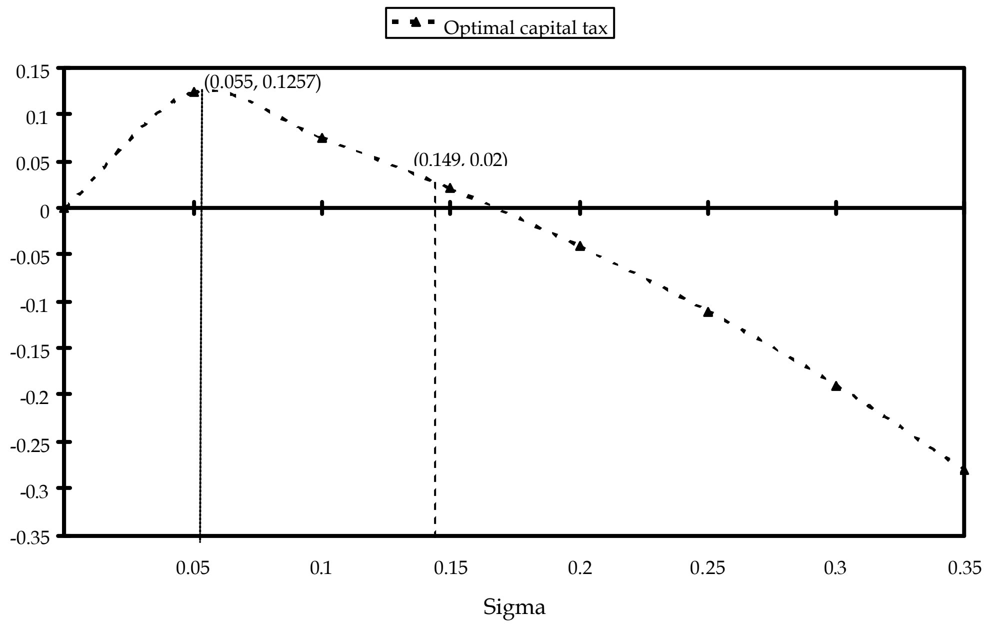

Fig e: Optimal labor income tax vs. sigma

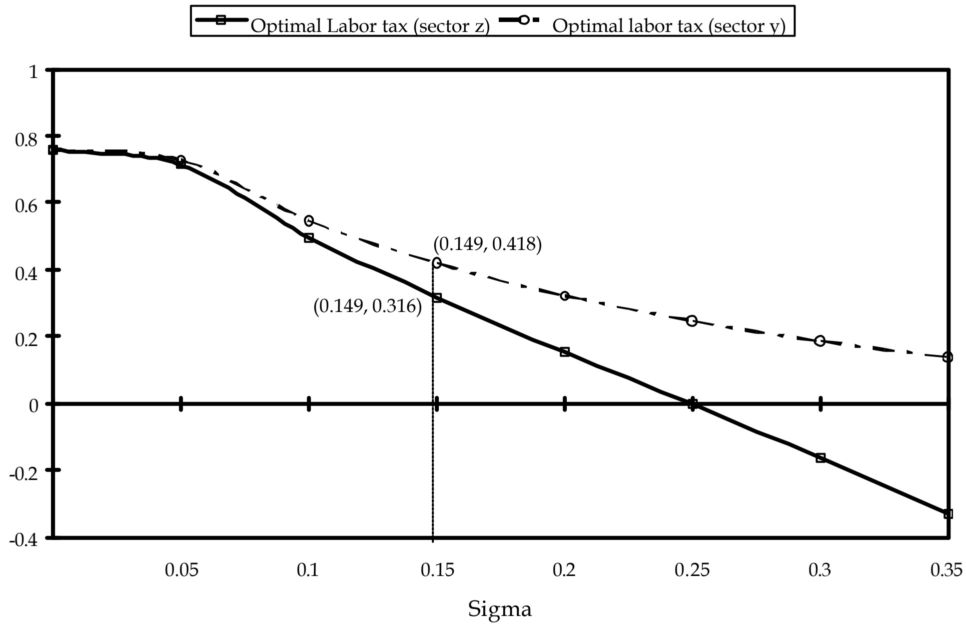

Fig f: Ramsey and first best taxes vs. sigma

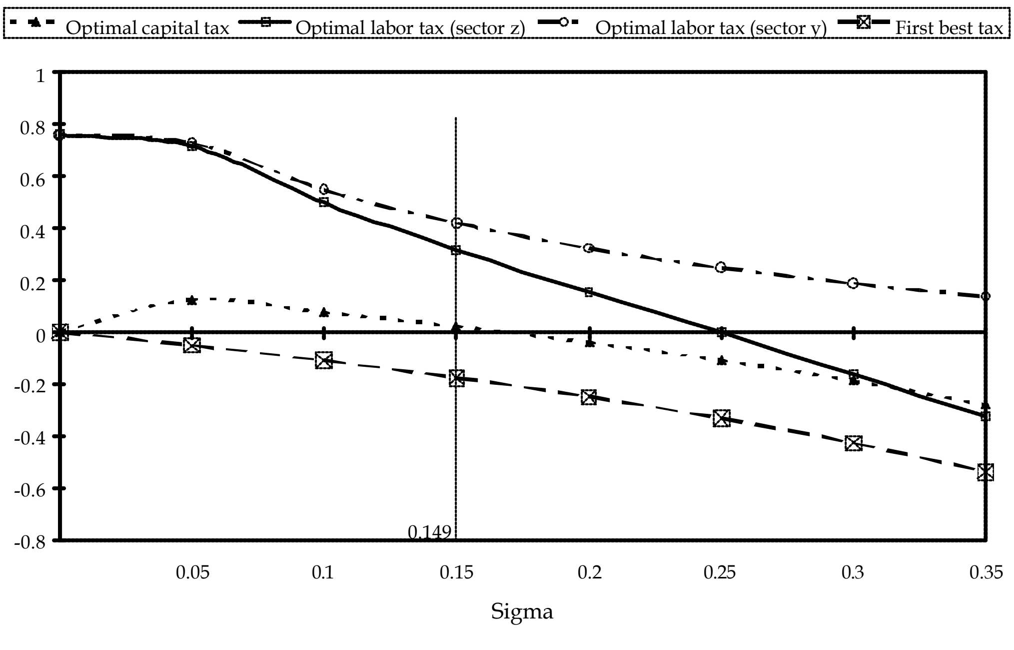

Fig g: Ramsey taxes vs. kappa