Monopoly Power and Optimal Taxation of Labor Income

Sheikh Tareq Selim

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

First version: October, 2004. Current version: October, 2005.
Cardiff Economics Working Paper Series.

Abstract:

This paper studies the Ramsey problem of optimal labor income taxation in a simple model economy which deviates from a first best representative agent economy in three important aspects, namely, flat rate second best tax, monopoly power in intermediate product market, and monopolistic wage setting. There are three key findings: (1) In order to correct for monopoly distortion the Ramsey tax prescription is to set the labor income tax rate lower than its competitive market analogue; (2) Government's optimal tax policy is independent of its fiscal treatment of distributed pure profits; and (3) For higher levels of monopoly distortions Ramsey policy is more desirable than the first best policy. The key analytical results are verified by a calibration which fits the model to the stylized facts of the US economy.

Keywords: Optimal taxation, Monopoly power, Ramsey policy.

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

Monopoly Power and Optimal Taxation of Labor Income

1.0 Introduction.

Until very recently, the dynamic general equilibrium tradition of optimal taxation seemed more or less silent about the departure from the simplifying assumption of economy-wide competitive markets. To my knowledge, apart from the recent attempts by Judd (1997), Guo & Lansing (1999), Judd (2002), Koskela & Thadden (2002), Schmitt-Grohe & Uribe (2004a) and Selim (2005), most general equilibrium models of Ramsey taxation with representative agent established in literature that deal specifically with optimal income taxation typically consider environments without imperfections in private markets. Modern economies are, however, characterized by distortions from imperfect competition in private market, which implies that economic welfare is lower than what it could have been if markets were fully competitive[1]. Relaxing the economy-wide competitive markets assumption therefore is likely to identify stronger descriptions of the incentive structure underlying an optimal tax policy.

This paper first develops a model of a two-sector neoclassical production economy with tax distortions and distortions arising from monopoly power in pricing of intermediate goods. In the relevant literature, it is a well-known finding that with private market distortions optimal taxes perform a corrective function that assists in minimizing productive inefficiency. The main focus of this paper is the optimal labor income tax policy and its corrective role in the presence of private market imperfections. The paper develops a basic model of optimal labor income taxation in an environment where firms in the intermediate goods sector create distortions by manipulating prices through the exploitation of a downward sloping demand curve for their output. This formulation of monopoly power is drawn primarily from the work of Dixit & Stiglitz (1977). The basic model is then extended with the introduction of monopolistic wage setting. With imperfectly competitive labor market, the source of non-tax distortions diversifies and a natural intuition is that the Ramsey policies tend to be more corrective in nature.

The framework developed in this paper is simple but useful and insightful since its economy-wide perfect competition analogue is embedded for a particular value of the parameter that indexes the degree of monopoly power. The government's quest is to find the

[1] Jonsson (2004) presents the recent empirical evidence of this fact for the US economy.

optimal level of a single tax, which in this setting is the labor income tax. This simple setting allows one to exclusively examine the temporal pattern of a corrective tax and the particular characteristics of its period by period effects. With the basic framework and its extension to imperfectly competitive labor market, the paper derives the first best tax rules and the Ramsey tax rules, and discusses, both analytically and quantitatively, how these are designed to offset the distortions due to monopoly power.

Three main results emerge from this paper --- (1) government's optimal choice of labor income tax rate with monopoly distortions is completely independent of how government treats taxes on distributed profits; (2) the optimal tax rate with monopoly distortions is lower than its competitive market analogue, which holds irrespective of how the government treats distributed profits fiscally; and (3) for remarkably high degrees of monopoly power, economic agents prefer distorting Ramsey taxes than first best taxes.

The corrective function of optimal taxes in economies with private market distortions has been through an exciting process of intellectual investigations. The main concentration --- perhaps due to its political sensitivity --- has been the optimal capital income tax policy. Judd (1999) in a competitive market model shows that a positive tax on asset income generates exponentially growing MRS/MRT distortions among goods over time. Since such explosive distortions are inconsistent with commodity taxation, the long run tax on capital income must be zero. This is however not the long run optimal policy when private market distortions violate the productive efficiency condition, as may be found in Guo & Lansing (1999), Koskela & Thadden (2002), Golosov *et al.* (2003) and Judd (2002 & 2003). In the presence of private market distortions where the efficiency condition is already violated, optimal fiscal policy can be designed to alleviate the distortion, or more precisely, as a corrective device for the distortions.

The corrective function of optimal *labor* income taxes has been partly emphasized in the literature by using models that involve both labor and capital taxes. But as mentioned earlier, the capital income tax policy has dominated the intellectual discussions. The paper by Koskela & Thadden (2002) is an exception, which for instance shows that with imperfectly competitive labor market the wage tax policy faces two conflicting demands when capital tax is set at zero. Due to such conflict, Koskela & Thadden (2002) argue that both instruments should be used, which in turn invalidates the zero capital income tax result. In referring to optimal labor income tax policy, Guo & Lansing (1999) argue that when distributed profits can be fully taxed, the entire revenue raising tax burden falls on labor, while capital income receives a subsidy as a corrective device. This result is also one of the key findings in Judd (2002).

With a much greater emphasis on optimal capital taxation, the relevant literature allows some scope to contribute in resolving the specific concerns related to optimal labor income taxation with private market imperfections. This is exactly where the current paper is intended to contribute. The three main results of this paper are based on strong intuitions and therefore provide some very useful insights into these policy issues. The first result may not be surprising but its underlying intuition is subtle. In the model economy considered here, profits actually represent the income to a fixed factor, namely, monopoly power. It is trivial that with this formulation the Ramsey planner would like to tax profits at a rate of 100% and reduce other distorting taxes. In reality, however, governments cannot implement a complete confiscation of this type of income. This may be due to the situation where the government is unable to distinguish profits from other income (or firms *somehow* hiding profits). The political viability and the consequential practicality of such a policy are also of considerable reservation. If the government cannot tax distributed profits separately, in an economy without capital a single tax rate applied to labor income must also function as a profit tax.

In order to consider a range of non-confiscatory profit tax solutions, this paper introduces a non-negative parameter that linearly characterizes the government's fiscal treatment of profits. Different values of this parameter characterize the different relative weight attached to profit taxation. It is shown that for all plausible values of this parameter, both the first best labor income tax rule and the Ramsey tax rule remain unaffected. This is because distributed pure economic profit is not one of the choice variables for the households' optimization problem (unless otherwise specified) implying that profits and profit taxes do not influence households' allocation decisions at the margin. The household's equilibrium allocation decisions are sensitive to labor income tax rate which has both income and welfare effects at the margin. In the Ramsey equilibrium, the government's optimal choice of labor income tax rate is therefore independent of how the government treats profit for taxation.

The second result is the normative benchmark of optimal taxation with monopoly distortions. The popular intuition of making a welfare maximizing distorting tax a curative device for monopoly distortions can effectively be attributed to this result. This result is driven by the fact that distortions interact, and cost of one distortion depends on the level of another. Since monopoly distortions drive a wedge between social and private returns to factors, setting the optimal tax rate lower than its competitive market analogue can compensate for the loss in output in the economy. Put differently, a relatively lower labor income tax than its competitive market analogue is optimal since it compensates for the monopoly induced distorted margin between social and private returns to labor. The first best tax policy in the presence of monopoly power is to subsidize labor income and impose a heavy lump sum tax which finances both the inevitable government expenditure and the subsidy. In the Ramsey equilibrium, for some degrees of monopoly power there is an optimal labor income tax, and after a threshold level of monopoly power it becomes optimal to subsidize labor income. The threshold level depends on the number of non-tax distortions. Hence starting from the competitive market analogue, higher degrees of monopoly power are associated with lower levels of Ramsey taxes, and after the threshold level higher levels of Ramsey subsidies. This result holds irrespective of how the government treats profit taxes.

For higher degree of monopoly power, there are more than proportionate increments in the wedge between social and private marginal returns to factors. This is because an elastically demanded good (or factor) sold with a price mark up possess a multiplier like demand shock effect. Since this effect induces more than proportionate increase in the wedge, its curative device must also be equivalently responsive. For remarkably high levels of price mark up (or wage mark up), the first best subsidy is higher but so is the lump sum tax. Economic agents facing such a situation will therefore be less willing to replace distorting Ramsey taxes with lump sum taxes. For high degrees of monopoly power, the utility cost of Ramsey taxes are therefore relatively lower, which explains the third important result of this chapter.

The idea that monopoly power and pure profits are important in determining the function and optimal choice of tax rates has a long history, however. In a well known paper, Stiglitz & Dasgupta (1971) show that the optimal commodity tax policy for a monopolistic industry with a bound on profit taxation generally includes both differential taxes and subsidies. In a dynamic general equilibrium, differential commodity taxation is accomplished by introducing a distortion of the savings decision so that present and future consumption goods are taxed at different rates. This intuition is most commonly held for the interpretation of an optimal nonzero capital tax in models where firms in a particular sector practices monopoly power (see for instance, Guo & Lansing (1999), Judd (2002 & 2003), and Selim (2005)). Moreover, 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. This important finding is ignored in Myles (1989), who examine Ramsey taxation with imperfect competition but abstracts from general equilibrium with both intermediate and final goods.

This paper contributes by extending the relevant literature with the introduction of a model which perhaps is the simplest in its family but is capable of imitating the labor income tax policy process in the real world. The policy issue and the key results presented in this paper are of extreme importance. Many macroeconomic policies aimed towards outlawing monopolies and price agreements are actually targeted to enhance competition. There is a popular debate between the proponents of direct regulations and advocates of fiscal policy about the choice of an appropriate policy that effectively enhances competition. This paper does not pretend to examine the details of this debate, but does attempt to establish the usefulness of labor income tax policy in compensating the distorted margins of allocations due to private market imperfection[2]. In the next section, a model of a simple economy where firms in the intermediate goods sector possess some degree of monopoly power and government taxes labor income and distributed profits to finance preset revenue target, is developed. The optimal taxation problem is presented in section 3.0. Section 4.0 introduces monopolistic wage setting in the model economy. Section 5.0 calibrates the model for the post war US economy and presents some intuitive quantitative results. Section 6.0 concludes.

2.0 The Model Economy.

Consider a simple model economy without physical capital that consists of households, firms, and the government. Time t is discrete and runs forever. The production environment has two sectors: one producing intermediate goods and the other producing final goods. In the remainder of this paper, I will hold the final good as the numeraire. The final goods sector of the economy is characterized by perfectly competitive markets. Producers of intermediate goods may possess a degree of monopoly power and hence can earn positive economic profits. All firms are owned by households who receive profits in the form of dividends. The closest (and perhaps wealthier) relatives of this model are the ones used in Guo & Lansing

[2] It is often argued in the literature that taxation is relatively more effective as a policy device in enhancing competition. The basic idea behind this argument is that since imperfect competition creates a marginal distortion in the productive efficiency condition of an economy, tax policy must be designed in a manner such that it minimizes the inequality between marginal rate of substitution and marginal rate of transformation among goods. With no concerns of redistribution, the Ramsey taxes in such settings become more of a corrective nature rather than revenue-raising nature.

Auerbach & Hines Jr. (2001b), on the other hand, argue that other policy instruments, such as enforcement of antitrust, may be more cost-effective at correcting the distortions of private market imperfections. In line with Judd (2003), I agree that this view has limited scope both intuitively and empirically, since there is no (or insignificant) evidence that pricing above marginal cost is related to violations of antitrust law. It is therefore difficult to think of any policy instrument other than taxation which could counterbalance the distortions due to imperfect competition, when *say*, a firm is pricing its innovated output above marginal cost since it owns a copyright that legally entitles it to do so. In a separate paper, Auerbach & Hines Jr. (2001a) however admit that when it is possible to identify imperfectly competitive market structure, an appropriate set of taxes and subsidies as a curative device is more attractive to policymakers than regulatory devices.

(1999) and Selim (2005). This model is later extended in section 4.0 where the labor market is subject to imperfect competition due to monopolistic wage setting.

More specifically, there is a continua of measure one of identical infinitely-lived households, each of whom are endowed with one unit of time at each instant and ownership of firms. The one unit of time can be allocated to a combination of work and leisure. In the final goods sector there is a continua of measure one of identical firms that own a technology with which a perishable final good, y_t, can be produced combining a continuum of intermediate goods z_{jt}, with $j \in [0,1]$. The final good can be used for private consumption (c_t) and exogenously determined government consumption (g_t). The final good is produced using the following constant returns to scale technology:

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

where $s \in [0,1)$ indexes the degree of monopoly power exercised by suppliers of the intermediate good z_{jt}. With this specification, s^{-1} is the elasticity of substitution between intermediate goods, and for $s = 0$ intermediate goods are perfect substitutes in the production of final goods making the intermediate goods market perfectly competitive. On the other hand, $s \to 1$ represents very low elasticity of substitution between intermediate goods giving higher market power to firms in the intermediate goods sector.

The intermediate goods sector comprises of j firms who own a technology with which a continuum of intermediate goods (z_{jt}) can be produced using labor service (n_{jt}) as the only input. The technology is defined as:

$$z_{jt} = n_{jt}^{a} \qquad (1.2)$$

where $a \in (0,1]$.

The representative household supplies labor service to firms in the intermediate goods sector. Since all households are identical, they have identical preferences over consumption of final good and labor supply. At each period, the representative household derives utility from consumption (c_t) and disutility from labor service (n_t). Preferences for the representative household are given by:

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

where $b \in (0,1)$ is the subjective discount rate. The utility function $u: \mathbf{R}_+^2 \to \mathbf{R}$ is continuously differentiable, strictly increasing in consumption, decreasing in labor, strictly concave, and satisfies standard Inada conditions, namely $\lim_{c_t \to 0} [u_n(t)]^{-1} u_c(t) = \infty$, and $\lim_{c_t \to \infty} [u_n(t)]^{-1} u_c(t) = 0$ for any $n > 0$.

The government consumes exogenous g_t of the final good each period and has, at its disposal, taxation of labor income and pure distributed profits as the *fiscal* instruments to finance the predetermined revenue target. The proportional tax rate is denoted by t_t. Since profits influence household's decisions only through an income effect, a trivial solution for the government would be to confiscate profits by taxing it at a rate of 100% and reduce other distorting taxes. In order to consider other optimal solutions, consider the situation where government taxes profits at a rate kt_t, where k is a parameter and $t_t^{-1} \geq k \geq 0$. In the Ramsey equilibrium, different values of the parameter k will illustrate the government's fiscal treatment of distributed profits. For instance, $k = 0$ implies profits escape all direct taxation, and $k = 1$ implies profits and labor income are taxed at the same rate[3].

The government also trades one period bonds to households, and b_{t+1} denotes real government bonds carried into period $t+1$, which pay interest at the rate r_{bt}. Interest earning from bonds are assumed to be tax-exempt. The government's period t budget constraint is given by:

$$g_t + b_t(1 + r_{bt}) = t_t \left[\int_0^1 w_{jt} n_{jt} dj + k \int_0^1 p_{jt} dj \right] + b_{t+1} \tag{3}$$

[3] For $k = t_t^{-1}$ profits are taxed at the rate of 100%, although in most parts of the analysis this obvious case is ignored.

where w_{jt} denotes real wage, and p_{jt} denotes pure profits. The government is benevolent, i.e. it maximizes welfare of the economy. The government bonds in this environment perform the role of a policy instrument that is orthogonal to the labor income tax policy, i.e. with fixed government spending any tax reform can be supported by an increase or decrease in the level of government's indebtness to the private sector.

2.1 Firms' Problems.

Let p_j denote the relative price of intermediate good z_j. The representative firm in the final goods sector competitively maximizes profits. It faces the following sequence of problems:

$$\max_{z_{jt}} \left[\left(\int_0^1 z_{jt}^{1-s} \, dj \right)^{\frac{1}{1-s}} - \int_0^1 p_{jt} z_{jt} \, dj \right] \qquad (4.1)$$

The first order condition with respect to a change in z_{jt} yields the inverse demand function of the j th intermediate good:

$$p_{jt} = y_t^{s} z_{jt}^{-s} \qquad (4.2)$$

Firms in the intermediate goods sector possess monopoly power in pricing and face the demand function *(4.2)* for j th intermediate good. The firms take the wage rate and prices of other firms as given when choosing price and labor to maximize profits. The decision problem of the representative firm in the intermediate goods sectors is:

$$\max_{p_{jt}, n_{jt}} \; [p_{jt} z_{jt} - w_{jt} n_{jt}] \qquad (4.3)$$

$$s.t. \quad z_{jt} = n_{jt}^{a}$$

$$p_{jt} = y_t^{s} z_{jt}^{-s}$$

The first order condition for maximum profits is:

$$w_{jt} n_{jt} = a(1-s) p_{jt} z_{jt} \qquad (4.4)$$

I will restrict my attention to a symmetric equilibrium where all firms in the intermediate goods sector produce at the same level, employ the same labor and charge the same relative price. It is important to make this assumption here, although a much detailed illustration of the equilibrium is presented later. The symmetry assumption simplifies $n_{jt} = n_t$ and $p_{jt} = p_t$ for all j. Moreover, *(1.1)* and *(1.2)* imply that the aggregate production technology is given by:

$$y_t = n_t^{a} \qquad (4.5)$$

Since the final goods sector is characterized by perfectly competitive markets, firms producing final goods earn zero profits in equilibrium, i.e. $\left[y_t - \int_0^1 p_{jt} z_{jt}\right] = 0$. Using *(4.2)* in the zero profit condition and imposing symmetry yields $p_{jt} = p_t = 1$ for all j. Moreover, the symmetric equilibrium imposed on *(4.4)* together with $p_{jt} = p_t = 1$ gives the equilibrium wage rate:

$$w_t = a(1-s)z_t(n_t)^{-1} \qquad (4.6)$$

Using *(4.6)*, the equilibrium profits for the intermediate goods sector is given by:

$$p_t = z_t[1-a(1-s)] \qquad (4.7)$$

Since the parameter s controls the degree of monopoly power, it is also associated with the equilibrium profit to output ratio. The equilibrium profit to output ratio for this model is linked to the degree of returns to scale in intermediate goods sector and the parameter s. It is convenient to express the relationship between equilibrium profit to output ratio and the price mark up ratio as:

$$n_t^{1-a} = m\left[1-\frac{p_t}{y_y}\right] \qquad (4.8)$$

where m denotes the price mark up ratio. If for instance the profit ratio is 5% and degree of returns to scale in the intermediate goods sector is 1, equation *(4.8)* gives $m = 1.05$. With $a = 1$, the profit ratio is simply equal to s. According to Basu & Fernald's (1997) estimates on typical US industry profit ratio, the value of the price mark up ratio assuming constant returns to scale technology in manufacturing industry is 1.03. More recent empirical estimates of price mark up ratio from a study by Bayoumi, Laxton & Pesenti (2004) are equal to 1.23 for the overall US economy and 1.35 for the Euro area. The estimate for the US for instance, assuming that $a = 1$ in the current setting amounts to an estimate of s equal to 0.186 (for the Euro area it is 0.259). The other estimates established in literature also indicate lack of competition in the Euro area as compared to the US economy (see Martins, Scarpetta & Pilat (1996) for details).

To get an idea of how the distortion created by monopoly power affects factor return, consider the social marginal product of labor given by $a\,[z_t\,(n_t)^{-1}]$. For $s > 0$ implying practice of monopoly power, the equilibrium wage rate given by *(4.6)* is less than its social marginal product by an amount $a\,s\,[z_t\,(n_t)^{-1}]$.

2.2 Household's Problem.

Each of the continua of measure one of infinitely-lived households intertemporally chooses allocations to maximize a stream of discounted utilities over consumption and labor. The decision problem of the representative household is defined by the following program:

$$\max_{c_t, n_t, b_{t+1}} \sum_{t=0}^{\infty} b^t u(c_t, n_t) \qquad (5.1)$$

$s.t.$

$$c_t + b_{t+1} \le (1 - t_t) w_t n_t + (1 + r_{bt}) b_t + (1 - k t_t) p_t \qquad (5.2)$$

where b_0 is given, and standard non-negativity restrictions apply. The representative household views w_t, r_{bt}, p_t and the government's tax policy as determined outside of their control. In addition, it is also assumed that there is no intra-household trading of bonds. This is assumed simply to avoid the complexities of having a private market for bonds. It is, however, acknowledged that relaxing this assumption may be interesting for future research. Given the main purpose of this paper, holding this assumption is fairly understandable.

The first order conditions for this problem, with $R_{bt} \equiv (1 + r_{bt})$, are the period budget constraint *(5.2)* itself and the followings:

$$-u_n(t) = u_c(t)(1 - t_t)w_t \qquad (5.3a)$$

$$u_c(t) = u_c(t+1)bR_{bt+1} \qquad (5.3b)$$

$$\lim_{t \to \infty} b^t u_c(t) b_{t+1} = 0 \qquad (5.3c)$$

Equation *(5.3a)* states that the representative household's utility is at its maximum when the marginal rate of substitution between labor and consumption is equal to the price ratio of labor to consumption. Equation *(5.3b)* is the standard Euler equation which makes the household indifferent between consuming today and saving for a later date at the optimum. Equation *(5.3c)* is the transversality condition that states that the discounted utility is maximum when the present discounted value of government bonds in terms of consumption is zero as time goes to infinity.

2.3 Equilibrium.

For the following definition symbols without time subscripts represent one-sided infinite sequence of the corresponding variable.

Definition 2.3 (Equilibrium). An equilibrium is an allocation (c, n, z, y), a price system (w, p, r_b), and a government policy (t, b), 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 equilibrium as defined above is characterized by the following system *(6.1)* for the set of endogenous variables $\{c_t, n_t, b_t, w_t, p_t, p_t, z_t, y_t, t_t\}$:

$$0 < n_t \leq 1 \qquad (a)$$

$$y_t = c_t + g_t \qquad (b)$$

$$y_t = z_t \qquad (c)$$

$$z_t = n_t^{a} \qquad (d)$$

$$-u_n(t) = u_c(t)(1-t_t)w_t \qquad (e)$$

$$u_c(t) = u_c(t+1) b R_{bt+1} \qquad (f)$$

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

$$w_t = a(1-s)z_t(n_t)^{-1} \qquad (h)$$

$$p_t = z_t[1-a(1-s)] \qquad (i)$$

$$p_t = y_t^{s} z_t^{-s} \qquad (j)$$

With *(6.1b, c & d)*, the model economy's aggregate resource constraint in terms of allocations is simply:

$$c_t + g_t = n_t^{a} \qquad (6.2)$$

3.0 Optimal Taxation.

With r_{b0} and g_t specified exogenously, the optimal taxation problem for the government is to choose an implementable allocation $\{c_t, n_t\}_{t=0}^{\infty}$ to maximize household's utility defined by *(2)*. The notion of implementable allocations deserves further explanation in the current context. For each arbitrarily chosen fiscal policy of the government, there is a unique equilibrium allocation and prices from system *(6.1)*. This can be verified by solving *(6.1)* for any fixed policy. Thus the set of allocations that are consistent with *(6.1)* is implementable as equilibrium. If a particular tax policy that maximizes welfare is consistent with the implementable allocations, it is consistent with equilibrium feedback of the taxpayers. Given the preset revenue target of the government, the optimal taxation problem for the government is to choose from the set of implementable allocations an allocation that maximizes welfare, such that the resulting taxes and prices along with allocations are consistent with the equilibrium. This approach is the primal approach to optimal taxation problem.

Put more technically, the optimal taxation problem for the government in this model economy is simply a programming problem of choosing $\{c_t, n_t\}_{t=0}^{\infty}$ to maximize household's utility defined by *(2)* subject to *(a)* the resource constraint defined by *(6.2)*, and *(b)* an implementability constraint that ensures the resulting taxes and prices along with allocations are consistent with the equilibrium system *(6.1)*. Since g_t is specified exogenously, this approach to the optimal taxation problem is in fact one characterization of the underlying Ramsey problem. The implementability constraint is an intertemporal constraint involving only allocations and initial conditions, and is typically derived by using equilibrium conditions to recursively substitute out prices and taxes in the household's present-value budget constraint. The implementability constraint for the current model is:

$$\sum_{t=0}^{\infty} b^t [u_c(t)c_t + u_n(t)n_t - u_c(t)(1-kt_t)p_t] - u_c(0)R_{b0}b_0 = 0 \qquad (7.1a)$$

where

$$(1-kt_t)p_t = \left[\frac{1-a(1-s)}{a(1-s)}\right]\left[a(1-s)(1-k)n_t^a - k\frac{u_n(t)n_t}{u_c(t)}\right] \qquad (7.1b)$$

3.1 The Ramsey Problem.

The Ramsey problem for the government is to choose a policy 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 feedback of taxpayers. According to the primal approach, this problem can be characterized as one where the government chooses $\{c_t, n_t\}_{t=0}^{\infty}$ to maximize household's utility defined by *(2)* subject to *(6.2)*, *(7.1a & b)*. Let $\Phi \geq 0$ be the Lagrange multiplier associated with the implementability constraint, and define the Pseudo objective function as:

$$V(c_t, n_t, \Phi) \equiv u(c_t, n_t) + \Phi[u_c(t)c_t + u_n(t)n_t - u_c(t)(1-kt_t)p_t] \qquad (8.1)$$

where $(1-kt_t)p_t = \left[\frac{1-a(1-s)}{a(1-s)}\right]\left[a(1-s)(1-k)n_t^a - k\frac{u_n(t)n_t}{u_c(t)}\right]$.

With $\{c_t\}_{t=0}^{\infty}$ as the sequence of Lagrange multipliers on the resource constraint *(6.2)*, the Ramsey problem's Lagrangian is:

$$J = \sum_{t=0}^{\infty} b^{t} \{V(c_t, n_t, \Phi) + c_t (n_t^{a} - c_t - g_t)\} - \Phi u_c(0) R_{b0} b_0 \qquad (8.2)$$

For exogenously determined g_t, R_{b0} and b_0, the Ramsey problem amounts to maximizing *(8.2)* with respect to $\{c_t, n_t\}_{t=0}^{\infty}$. The consolidated first order conditions for an optimum for this problem due to changes in allocations are:

$$V_n(t) = -a V_c(t) n_t^{a-1} \qquad \forall t \geq 1 \qquad (8.3a)$$

$$V_n(0) = [u_{cc}(0) \Phi R_{b0} b_0 - V_c(0)] a n_0^{a-1} + \Phi R_{b0} b_0 u_{cn}(0) \qquad (8.3b)$$

The Ramsey equilibrium is therefore characterized by a system of equations comprising *(8.3)*, *(7.1)*, and *(6.2)*.

Note first that the Lagrange multiplier Φ represents the utility cost of raising revenue through distorting taxes. In other words, Φ is the amount in units of time 0 consumption that households would be willing to pay in order to replace one unit of distorting tax revenue by one unit of lump sum tax revenue. To solve the system for Ramsey allocations and Ramsey taxes, one can fix Φ and solve *(8.3)* and *(6.2)* for an allocation. Then one can substitute these allocations in the implementability constraint *(7.1)*, and depending on whether the implementability constraint is binding or slack, one can increase or decrease the value of Φ. Once the resulting allocations satisfy the implementability constraint, a unique value of Φ is obtained, and allocations and prices constitute equilibrium as defined in 2.3.

In the next section it is shown that a unique steady state Ramsey tax rule exists for a unique value of the multiplier Φ. Furthermore, in section 5.0 it is formally demonstrated that for a unique steady state allocation there exists a unique value of the multiplier Φ. In general, for a $T \geq 0$ for which fluctuations in government expenditure is arbitrarily small for all $t \geq T$, the solution to *(8.3)* can be characterized by a set of stationary allocation rules $c_t(c_{t-1}, n_{t-1}, \Phi)$ and $n_t(c_{t-1}, n_{t-1}, \Phi)$. Given these allocation rules, one can use *(4.6)*, *(5.3)*, and *(6.1d)* to compute a set of stationary rules for the factor price and tax rate: $w_t(c_{t-1}, n_{t-1}, \Phi)$ and $t_t(c_{t-1}, n_{t-1}, \Phi)$ for $t \geq T$. A stationary allocation rule for government bonds can be computed by recursively solving the household's budget constraint *(5.2)* by substituting out prices and taxes for allocations. The optimal allocations for $t \leq T$ can be computed by solving *(8.3)* 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, together with the initial conditions, determines the multiplier Φ such that the implementability constraint *(7.1)* is satisfied.

3.2 Fiscal Policy.

If the government had an access to a lump sum tax $(\equiv \ell_t)$ and could take up the first best tax policy, the equilibrium allocations would coincide with those chosen by a benevolent social planner who maximizes utility as defined by *(2)* subject to the resource constraint *(6.2)*. To find the first best policy, add the term ℓ_t to the right hand side of the symmetric version of the government's budget constraint *(3)*. In this problem government bond do not affect the equilibrium allocations, and hence it is convenient to set $b_t = 0$ for all t.

Proposition 1: The first best fiscal policy corresponding to equilibrium *(6.1)* is to subsidize labor income, and generate all revenues by a lump sum tax. In particular, the first best fiscal policy implies:

$$t_t^1 = \frac{-s}{1-s} \qquad \text{and} \qquad \ell_t = g_t + \frac{s}{1-s}[y_t\{a(1-s)(1-k)+k\}]$$

Proof: Let $b^t l_t^1$ be the Lagrange multiplier associated with the resource constraint *(6.2)*. The necessary conditions for the optimum of the planner's problem for changes in allocations are:

$$c_t: \quad u_c(t) = l_t^1 \qquad (8.4a)$$

$$n_t: \quad u_n(t) = -a\, l_t^1 y_t (n_t)^{-1} \qquad (8.4b)$$

Comparing *(8.4)* with household's optimizing conditions *(5.3)* yields $t_t^1 = \dfrac{-s}{1-s}$ which is strictly negative for $s \in (0,1)$. The government's budget constraint with lump sum tax then yields $\ell_t = g_t + \dfrac{s}{1-s}[y_t\{a(1-s)(1-k)+k\}]$ after substituting for $w_t n_t, t_t^1$ and p_t. •

A welfare maximizing social planner would seek to implement an allocation which is characterized by the optimality condition *(8.4).* To replicate these conditions in an (imperfectly) competitive equilibrium, as is inferred from the first order conditions of the representative household's maximization problem, taxes have to be set according to $t_t^1 = \dfrac{-s}{1-s}$. The first best policy therefore involves subsidizing labor income for inefficiency due to the monopoly power and generating all revenues by a heavy lump sum tax.

The competitive market analogue of this result, which is derived by setting $s = 0$, is zero distorting tax and $\ell_t = g_t$. Moreover, for $s \in (0,1)$ the lump sum tax is strictly greater than government's planned expenditures when profits are taxed at the same rate as labor income (i.e. $k = 1$), and when profits are not taxed at all (i.e. $k = 0$). Understandably, the case of 100% profit tax for the first best fiscal policy is ignored. Note also that for higher degrees of monopoly power, both the amount of subsidy and lump sum tax increases, and the rate of increase in lump sum tax is higher than that of the first best labor income subsidy.

Now consider the Ramsey policy where government do not have an access to lump sum tax. At this point, consider some standard simplifications in the utility function only for the sake of analytical tractability. Let $u : \mathbf{R}_+^2 \to \mathbf{R}$ be separable in consumption and labor, and linear in labor, as supported by Hansen (1985), among others. Imposing these restrictions is tantamount to assuming $u_{cn}(t) = u_{nc}(t) = u_{nn}(t) = 0$. Furthermore, assume that there is a steady state where fluctuations in government expenditure become arbitrarily small. From *(8.3a)* and *(5.3b)*, the steady state level of the optimal tax rate is given by the following equation:

$$1 - t = \frac{u_c\{1 + \Phi[k + a - a s - a k + a s k]\} + \Phi u_{cc}[c - (1-k)p]}{u_c\{1 - s + \Phi[1 - s + k(a)^{-1} - k + s k]\}} \qquad (8.5)$$

Consider the competitive equilibrium version of *(8.5)* and denote the corresponding steady state tax rate by t^p. This is obtained simply by setting $s = 0$ in *(8.6)*, which results in the following equation:

$$1 - t^p = \frac{u_c\{1 + \Phi[k + a(1-k)]\} + \Phi u_{cc}[c - (1-k)p]}{u_c\{1 + \Phi[1 + k(a)^{-1} - k]\}} \qquad (8.6)$$

Since the sign and relative magnitudes of t and t^p are rather inconclusive from *(8.5)* and *(8.6)*, I will resort to calibration and numerical results to analyze the key findings. Nevertheless, one analytical result is quite insightful and comes right out of the above two expressions.

Proposition 2: If profits are taxed at the same rate as labor income is taxed (i.e. $k = 1$), equation *(8.5)* from the Ramsey equilibrium implies that optimal tax rate is lower than its competitive market analogue.

Proof: If profits and labor income are taxed at the same rate, the government cannot set $t \geq 1$, since it violates transversality condition *(5.3c)*. Hence *(8.5)* with $k = 1$ implies $[u_c(1+\Phi) + \Phi u_{cc} c] > 0$. Comparing *(8.5)* with $k = 1$ and *(8.6)* with $k = 1$, it is straightforward to show that $(t - t^p) < 0$. •

The intuition for this result is clear. In the presence of monopoly power, a lower tax rate relative to its competitive market analogue is optimal since it offsets the distortions created by the monopoly power. As will be shown later, proposition 2 actually holds for all permissible values of the parameter k .

4.0 Monopolistic Wage Setting.

Consider now the simplest form of monopolistic wage setting behaviour of workers in the model. This is in the spirit of Koskela & Thadden (2002). The optimal income taxation problem now deviates from a first best representative agent economy in three aspects: first, to raise revenue the government must use distorting second best tax; second, the intermediate product market is imperfectly competitive; and third, the labor market is imperfectly competitive and subject to monopolistic wage setting by workers, i.e. wages are set with a mark up compared to a fully competitive outcome leading to a socially suboptimal level of working hours.

Assume that households collectively organize in a trade union which acts as a monopolistic wage setter. Wages are set for one period, and the wage setting behaviour takes into account the static constraint imposed by the labor demand schedule $n_{jt} = n(w_{jt})$. Since firms are small relative to the economy, they are unable to behave in a strategic manner towards the wage setting behaviour. This assumption abstracts the model from the hold-up problem which typically arises under firm specific bargaining. Assume further that the behaviour of the union is myopic in the sense that intertemporal feedback effects of wage setting are not taken into account. The union is also assumed not to influence profits which are distributed back to its members. Assume further that the institutional set up which generates the market inefficiency is taken as given by the government when designing the tax policy, implying that corrective taxes or subsidies are the only channels to address the labor and intermediate product market distortion. The proportional tax rate on wage is denoted by t_t^m.

Recall the profit maximization problem of the representative firm in intermediate goods sector. Imposing symmetry, the first order condition to this problem yields the following wage function which is the wage setting constraint for the trade union's maximization problem:

$$w_t = a(1-s)n_t^{a-1} \qquad \textit{(9.1a)}$$

The wage elasticity of labor demand therefore is

$$h_w = (-1)\frac{1}{[1-a(1-s)]} \qquad \textit{(9.1b)}$$

Acting on behalf of its members, the trade union maximizes utility defined by *(2)* subject to constraints *(5.2)* and *(9.1a)*. The first order condition for variation in labor supply is:

$$u_n(t) = -u_c(t)a(1-s)(1-t_t^m)w_t \qquad \textit{(9.1c)}$$

The mark up of net wages over the marginal rate of substitution between labor and consumption is therefore $\frac{1}{a(1-s)}$, which is equal to $\frac{|h_w|}{|h_w|-1}$. Comparing *(9.1c)* with social planner's equilibrium, the first best policy (in steady state) for this model is $t^{m1} = 1 - \frac{1}{a(1-s)^2} < 0$.

The implementability constraint for the corresponding Ramsey problem is:

$$\sum_{t=0}^{\infty} b^t \left[u_c(t)c_t + \frac{u_n(t)n_t}{a(1-s)} - u_c(t)(1-kt_t^m)p_t \right] - u_c(0)R_{b0}b_0 = 0 \qquad (9.2)$$

where $(1-kt_t^m)p_t = \left[\frac{1-a(1-s)}{a(1-s)}\right]\left[a(1-s)(1-k)n_t^a - k\frac{u_n(t)n_t}{a(1-s)u_c(t)}\right]$.

Define the Pseudo objective function associated with the Ramsey problem as:

$$V^m(c_t, n_t, \Phi^m) \equiv u(c_t, n_t) + \Phi^m[u_c(t)c_t + \frac{u_n(t)n_t}{a(1-s)} - u_c(t)(1-kt_t^m)p_t] \qquad (9.3)$$

where $\Phi^m \geq 0$ is the multiplier associated with the implementability constraint, and represents the utility cost of raising revenue by distorting taxes. The Lagrangian for the Ramsey problem is:

$$J^m = \sum_{t=0}^{\infty} b^t \left\{ V^m(c_t, n_t, \Phi^m) + c_t^m(n_t^a - c_t - g_t) \right\} - \Phi^m u_c(0)R_{b0}b_0 \qquad (9.4)$$

The first order condition with respect to variation in labor supply for $t \geq 1$ is:

$$V_n^m(t) = -a V_c^m(t) n_t^{a-1} \qquad \forall t \geq 1 \qquad (9.5)$$

where, imposing $u_{cn}(t) = u_{nc}(t) = u_{nn}(t) = 0$,

$$V_n^m(t) = u_n(t)\left\{1 + \frac{\Phi^m}{a(1-s)} + \frac{\Phi^m[1-a(1-s)]k}{[a(1-s)]^2}\right\} - \Phi^m u_c(t)(1-k)[1-a(1-s)]a\, n_t^{a-1}$$

(9.6a)

$$V_c^m(t) = u_c(t)(1+\Phi^m) + \Phi^m u_{cc}(t)\{c_t - (1-k)n_t^a[1-a(1-s)]\} \qquad (9.6b)$$

Assume solution to the Ramsey equilibrium converges to a time-invariant allocation. Combining steady state versions of *(9.5)* and *(9.6)* with *(9.1c & a)*, one can derive the following expression for the steady state optimal tax rule:

$$1 - t^m = \frac{u_c\{1+\Phi^m[k + a - a s - a k + a s k]\} + \Phi^m u_{cc}[c - (1-k)p]}{u_c\{a(1-s)^2 + \Phi^m[1 - s + k(a)^{-1} - k + s k]\}} \qquad (9.7)$$

Note first that the denominator of the right hand side of expression *(9.7)* has the term $a(1-s)^2$, which in expression *(8.5)* is $(1-s)$. Although both *(9.7)* and *(8.6)* include mostly the same structural parameters of the model, analytical comparison of these two is not conclusive since the multipliers associated with the implementability constraints of these two problems are not same. Since the main function of the optimal distorting taxes are corrective, and since the sources and levels of market distortions are different in the two models, it is reasonable to conjecture that Ramsey taxes will have different social costs.

5.0 Calibration and Numerical Results.

I will use US economy's data to calibrate the model in order to focus on a subset of interesting numerical results, which in turns will highlight the key policy findings of this paper. In line with the basic assumptions underlying the period utility function given in *(2)* and the assumption $u_{cn}(t) = u_{nc}(t) = u_{nn}(t) = 0$, consider the following specification:

$$u(c_t, n_t) = \ln(c_t) + [1 - \Lambda n_t] \qquad (10.1)$$

where $\Lambda > 0$ is a constant associated with marginal disutility of work. For the model with monopolistic wage setting, I will denote this parameter by Λ^m.

First, consider the model with perfectly competitive labor market. With *(10.1)*, and dropping time subscripts, the Ramsey equilibrium condition *(8.3a)* can be written as:

$$\frac{c}{y}\left\{\frac{\Lambda n[1+\Phi+\frac{\Phi}{a(1-s)}k\{1-a(1-s)\}]}{a[1+\Phi(1-k)\frac{p}{c}]}\right\}+\frac{\Phi(1-k)\{1-a(1-s)\}}{[1+\Phi(1-k)\frac{p}{c}]}=1 \qquad (10.2a)$$

Now consider the model with monopolistic wage setting. The analogous condition is:

$$\frac{c}{y}\left\{\frac{\Lambda^m n[1+\frac{\Phi^m}{a(1-s)}+\frac{\Phi^m}{\{a(1-s)\}^2}k\{1-a(1-s)\}]}{a[1+\Phi^m(1-k)\frac{p}{c}]}\right\}+\frac{\Phi^m(1-k)\{1-a(1-s)\}}{[1+\Phi^m(1-k)\frac{p}{c}]}=1 \qquad (10.2b)$$

The idea of the calibration is as follows. The set of parameters for the model is $(b,a,s,k,\Lambda,\Lambda^m)$. First, these parameters are pinned down to fit the stylized facts of the US economy for data period 1960-2001. The time period considered is one year which is consistent with the frequency of fiscal policy revision. In particular, I will parameterize the model for $(b,a,s,k,\Lambda,\Lambda^m)$ to fit the facts of the US economy for the approximate data period of 1960-2001. Some estimates are also used from the literature. Using these pinned down values in *(10.2)* will give estimates of the multipliers Φ and Φ^m. Then, the set of calibrated parameter values and the calibrated multiplier values are used to derive an estimate of the optimal tax rate. The two key parameters of the model for which variations may be of interest are the profit tax treatment parameter, k, and the parameter associated with market power, s. Once the model has been calibrated, I will vary these two parameters within reasonable range to derive insights regarding the sensitivity of the key results with respect to these.

5.1 Data and Parameterization.

Annual data of the US economy for the period 1960-2001 are taken from the *Federal Reserve Bank of St. Louis Economic Data*-FRED II. According to this data, in seasonally adjusted real terms average government consumption to output ratio is equal to 0.23, profit to output ratio is equal to 0.11, and government bond to output ratio is equal to 0.51. Since the model is without capital, the only interest rate is the interest rate on government bonds. I use an interest rate value of 6% which is a reasonable approximation of the series of interest rate on US government securities[4]. This is consistent with an estimate of $b = 0.9434$. Working hours estimate is set at 0.3 which implies that the average time an individual spends in employment is about $1/3$ of total time. This approximation is frequently used as a benchmark that reflects the average time people between 18-64 years in the US spend in employment. The calibration, however, was verified for working hours range of 0.2 to 0.3, following Cooley & Prescott (1995). The key findings are consistent within this range. The target statistics are summarized in table 1.

The parameter k stands for the fiscal treatment of profits and is the ratio between profit tax and labor tax. The profit tax in this model is the tax that households pay on distributed profits. McGrattan & Prescott (2005) estimate a tax rate on corporate distributions for the US and the UK economy, which is the personal income tax rate on dividend income if corporations make distributions to households by paying dividends. I use their period average estimate of 17.4% for 1990-2000 for the US economy. For the average effective tax rate on labor income for the US economy, I use a value of 22.6% from Carey & Tchilinguirian (2000). This pins down $k = 0.76991$.

There are two convenient ways one can pin down the parameter s. First, one can simply *assume* $a = 1$, which pins down s equal to the profit to output ratio. The second way is to use price mark up estimates from the literature and derive an estimate of s that is consistent with the mark up value. This in turn will pin down a which is consistent with both profit ratio and the mark up value. Here I follow the latter. There is, however, some difficulty associated with choosing the appropriate value for price mark up. An interesting observation in the relevant literature is the range of estimates for the price mark up ratio (denoted m for the current setting). The estimates for price mark up ratio for the US economy ranges from as low as 1.03 in Basu & Fernald (1997) to as high as 1.23 in Bayoumi *et al.* (2004). There are even higher estimates of this ratio for particular industries of the US, as may be found in detail in Martins *et al.* (1996). For the current model, I choose $m = 1.12$ as the price mark up ratio, which is the Martins *et al.* (1996)'s 1970-1992 average estimate for US industries producing differentiated goods. Given the range of available estimates, this is a reasonable approximation. This pins down $a = 0.99734$ and $s = 0.10763$. For the model with monopolistic wage setting, the baseline wage mark up estimate is therefore equal to 1.12,

[4] Interest rate sensitivity of the key numerical results is not noteworthy. The model was calibrated with interest rate values of 4%, 5% and 6%, which yielded insignificant changes in the main numerical results.

which is very close to the recent estimate of 1.16 for the US economy, as in Bayoumi *et al.* (2004).

With average government consumption to output ratio equal to 0.23, the steady state version of *(6.1b)* gives private consumption to output ratio equal to 0.77. The baseline estimate for Λ and Λ^m are then 2.8075 and 2.4987, respectively. Using these parameter values in *(10.2)* gives $\Phi = 0.4963$ and $\Phi^m = 0.5978$. The parameters, their brief description and their baseline values are presented in table 2. For comparison and sensitivity of the calibrated optimal tax rate for changes in k and s, a range of values such that $k \in [0,1]$ with 0.1 difference and $s \in [0, 0.4]$ with 0.05 difference between two consecutive values, is considered. Note that varying the value for k and s requires recalibration of the multipliers Φ and Φ^m. This implies that the utility cost of raising revenue through distorting taxes varies for changes in fiscal treatment of profits and the parameter controlling the degree of monopoly power.

5.2 Quantitative Findings.

The main quantitative findings are summarized in table 3 and figures *a-e*. In constructing the figures, a single parameter was varied while simultaneously recalibrating the other parameters and the multipliers to match the long run characteristics of US data. Consider first calibration of the model with perfectly competitive labor market. The calibrated optimal tax rate is equal to 27.13%, which is reasonably close to the estimated average effective labor income tax rate of 26.7% and 22.6% for the US economy for data period 1991-1997, as reported in Carey & Tchilinguirian (2000), using Mendoza *et al.* (1994) and Carey & Tchilinguirian (2000)'s methodology, respectively. Even without capital, the model therefore presents is a sensible imitation of the US economy. For the model with monopolistic wage setting, the baseline parameter values gives optimal tax rate equal to 28.21% --- a slightly higher estimate than the one for competitive labor market model. The calibrated tax estimates for both models are preserved for all permissible values of k, implying that the government's optimal choice of tax rate is completely insensitive to its fiscal treatment of profits. This is not surprising, since profit tax as modelled here distorts the welfare margin only through an income effect. More intuitively, household's allocation decisions are not affected at the margin by k which enables the government to choose optimal tax rate without any concern of its fiscal treatment of profits.

Table 3 presents the competitive market analogue of optimal tax rate (t^p) with recalibrated parameters and multipliers, the baseline calibrated Ramsey tax rate (t), and the first best tax rate (t^1) with baseline parameters, for both competitive labor market and monopolistic wage setting specialization of the model. For $s = 0$, the optimal tax rates for the model with competitive labor market and monopolistic wage setting are equal to 34.97% and 40.11%, respectively. Not surprisingly, these estimates (for $s = 0$) are also insensitive to changes in the parameter k. Combining these findings imply that proposition 2 holds for all permissible values of k; more generally, the optimal tax rate with monopoly distortions is lower than its competitive market analogue irrespective of how the government treats taxes on distributed profits.

Figure *a* and *b* present how the utility cost of distorting taxes varies with different values of the parameters s and k. Figure *a* shows that a higher degree of monopoly power is associated with a relatively lower utility cost of distorting taxes, which holds for both models. Higher s is associated with households' willingness to pay lesser amount of time 0 consumption goods to replace a unit of distorting tax by a unit of lump sum tax, implying that households facing higher monopoly distortions would be more willing to accept a distorting tax as a corrective device. Note that in figures *a* and *b*, the rate of decline in Φ^m is much sharper than that of Φ, implying that introducing an additional distortion in the model makes corrective Ramsey taxes relatively more desirable from social cost of taxation point of view.

Figure *c* presents the Ramsey tax rates for both models for a range of values of the parameter s. Figures *d* and *e* compare the Ramsey taxes with the first best taxes for the competitive labor market model and the monopolistic wage setting model, respectively, for a range of values of the parameter s. For higher values of the parameter s, the optimal tax rate continues to be lower. For the competitive labor market model, it reaches the zero level at approximately $s = 0.34$, and for any s higher than this level it becomes optimal to subsidize labor income. For the monopolistic wage setting model, the optimal tax reaches zero level for $s = 0.24$ and continues to be subsidy thereafter. Since the optimal choice of tax rate is influenced by both the wedge between social and private marginal returns to labor and the diminishing utility cost of distorting taxes for higher values of the parameter s, the decline in t^m is much sharper than the decline in t.

The sharp decline in optimal tax rate for extremely high values of s indicates that with elastic demand for intermediate goods (and elastic demand for labor in the wage setting model), monopoly distortions create compounding effect in the wedge between social and private returns to labor, and it becomes optimal to cure its more than proportionate distortions with more than proportionate decrease in tax rates. For the monopolistic wage setting model, the multiplier effect is much larger, since there are multiple sources of market distortions.

6.0 Conclusion.

In order to address the issue of optimal choice of labor income tax in the presence of monopoly power in private market, this paper presents a simple dynamic optimal taxation model of an economy without capital. In the model with competitive labor market, firms in the intermediate goods sector exert monopoly power in pricing and hence distort the productive efficiency condition of the economy. In the model with monopolistic wage setting, monopoly power distorts productive efficiency from two sources: intermediate goods market and labor market. The main purpose of this study is to derive the optimal policy for labor income taxation, and to examine whether and how these optimal choices act as corrective policy. Both analytical and quantitative investigations are undertaken, which cohere to the same set of findings.

The study finds that optimal choice of labor income tax rate is independent of how the government treats distributed profits fiscally. This holds for both models. This is primarily because as long as households treat distributed profits as exogenous, profits and profit taxes do not affect their equilibrium allocation decisions. The only tax that affects household's decisions both through an income and incentive effect is the labor income tax. Optimal choice of this tax is independent of how profits are taxed. Stiglitz & Dasgupta (1971) in this regard argue that with an exogenous upper bound on profit taxes (i.e. no confiscation), productive efficiency is no longer desirable. The current analysis is consistent with an extended version of this interpretation. More precisely, since the optimal choice of labor income tax rate is insensitive to how the government treats distributed profits fiscally, any level of profit taxation (including zero taxation) *may* indicate violation of the productive efficiency. This finding motivates the second result of the current study, i.e. optimal tax rate with monopoly distortions is lower than its competitive market analogue.

The first best intuition of a relatively lower optimal labor income tax due to monopoly distortion is obvious: a lower optimal tax rate at least partly compensates for the loss of output due to mark up pricing (or wages). In particular, for all levels of monopoly distortion the Ramsey tax rate is lower than its competitive market analogue and higher than its first best counter part. The first best policy with any nonzero monopoly distortion is a subsidy, but the Ramsey policy for certain levels of monopoly power is a tax, and after a threshold it is a subsidy. Another important finding is that for remarkably high levels of monopoly distortions, economic agents are less willing to replace Ramsey taxes with lump sum taxes. This is a striking result, since in a sense it establishes that with monopoly distortion second best taxes are more desirable as curative devices than first best taxes. This finding also implies that the Ramsey taxes are more desirable as corrective policy rather than revenue-raising policy.

A relevant intuition behind these two results can be drawn from Solow (1998, ch. 2 & 3). In the presence of some degree of monopoly power in private market, a demand shock typically has multiplier like effect. Since the intermediate good's demand (and the labor demand in monopolistic wage setting model) is elastic in addition, a small increase in its price will reduce its demand more than proportionately, which in turn will reduce the production of final good. Since the only factor of production of intermediate goods is labor, employment demand in next period will decrease making intermediate sector firms increase wages in offer. But with a relatively low labor input, production of intermediate goods will fall further, which makes the intermediate goods firms increase its price further. Hence the distorted margins of social and private returns to labor will continue to grow more than proportionately. The only way the government can compensate for this effect is to introduce a lower income tax, which for remarkably high levels of monopoly distortion can be a subsidy. The compounding wedge between social and private returns to labor makes economic agents prefer distorting taxes rather than lump sum tax, since high degrees of monopoly power in the pricing of an elastically demanded good is associated with high equilibrium profits making the first best lump sum tax heavier. In the model with monopolistic wage setting, the source of private market distortion diversifies that induces a sharper decline in Ramsey tax rate for higher degrees of monopoly power.

Obviously, high level of market power is not a desirable situation, and a long run optimal steady state subsidy to both labor income and profits is also not consistent with the Transversality condition. However, for high degrees of monopoly power there is no need to tax or subsidize profits, since the optimal policy is insensitive to fiscal treatment of distributed profits. The optimal subsidy in the steady state therefore can be financed by bond earnings, which is mainly why tax exempt real government bonds play an essentially important role in the model.

The lower optimal tax result may well be empirically (and policy wise) disputable when one considers the aggregate levels of competition and labor income tax rates in the Euro zone and in the US. The average effective tax rates on labor income in the Euro zone is much higher than in the US, although level of competition in the US is higher than that in the Euro zone. But deciding the equivalence of this result from these statistics ignores the inherent features of tax rules and tax administration systems.

References.

[1] Auerbach, A. J. & Hines, J. R. Jr. (2001b). 'Taxation and Economic Efficiency', *NBER Working Paper, No. 8181*.

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

[3] 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.

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

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

[6] Cooley, T. F. & Prescott, E. C. (1995). 'Economic Growth and Business Cycles', in T. F. Cooley and E. C. Prescott, eds., *Frontiers of Business Cycle Research,* Princeton University Press.

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

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

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

[10] 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.

[11] Hansen, G. D. (1985). 'Indivisible Labor and the Business Cycle', *Journal of Monetary Economics*, Vol. 16, pp. 309-328.

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

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

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

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

[16] Koskela, E. & Thadden, L. (2002). ‘Optimal Factor Taxation Under Wage Bargaining - A Dynamic Perspective’, *Discussion Paper 31/02, Economic Research Centre of the Deutsche Bundesbank*.

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

[18] 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.

[19] Myles, G. D. (1989). ‘Ramsey Tax Rules for Economies with Imperfect Competition’ *Journal of Public Economics*, Vol. 38, pp. 95-115.

[20] Schmitt-Grohe, S. & Uribe, M. (2004). ‘Optimal Fiscal and Monetary Policy under Imperfect Competition’, *Journal of Macroeconomics*, Vol. 26, pp. 183-209.

[21] Selim, S. T. (2005). ‘Monopoly Power and Optimal Taxation of Capital Income’, *Mimeo*, Cardiff Business School.

[22] Solow, R. M. (1998). *Monopolistic Competition and Macroeconomic Theory*, Federico Caffe Lectures, Cambridge: Cambridge University Press, 1998.

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

Tables & Figures.

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
b/y	Government bond to output ratio.	0.51

Source: Federal Reserve Bank of St. Louis Economic Data-FRED II.

Table 2: Baseline parameter values.

Parameter	Description	Value
b	Subjective discount rate.	0.9434
a	Degree of returns to scale in intermediate goods sector.	0.9973
s	Inverse of the elasticity of substitution between intermediate goods.	0.1076
k	Fiscal treatment of profits.	0.7699
Λ	Value of marginal disutility of labor (competitive labor market).	2.8075
Λ^m	Value of marginal disutility of labor (monopolistic wage setting).	2.4987

Table 3: Calibrated optimal tax rates.

	t^{p} (Ramsey, $s = 0$)	t (Ramsey, $s = 0.1076$)	t^{1} (First Best, $s = 0.1076$)
Competitive Labor Market	0.3497	0.2713	-0.1206
Monopolistic Wage Setting	0.4011	0.2821	-0.2591

Fig a: Utility cost of taxation vs. sigma.

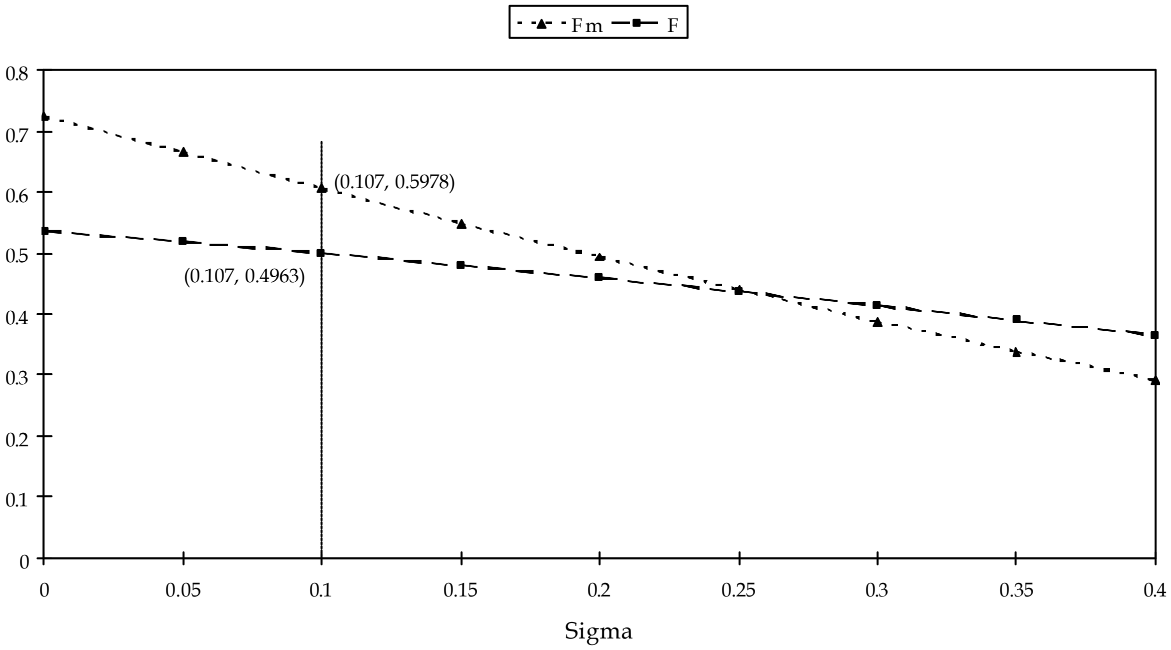

Fig b: Utility cost of taxation vs. kappa.

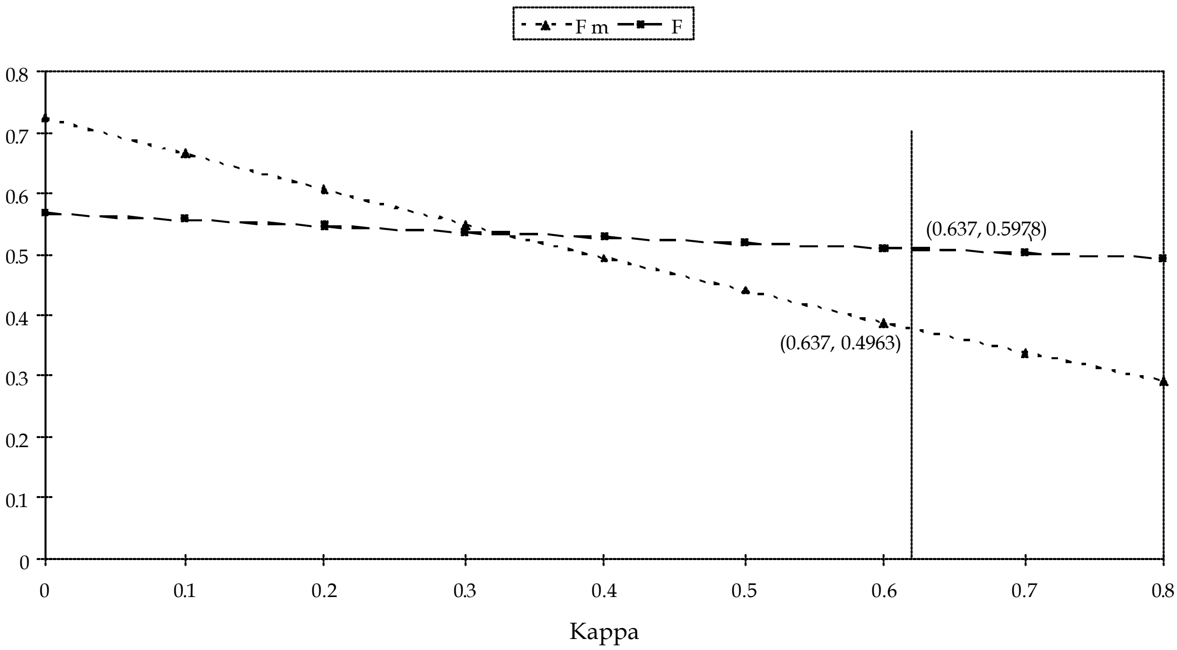

Fig c: Ramsey tax rates vs. sigma.

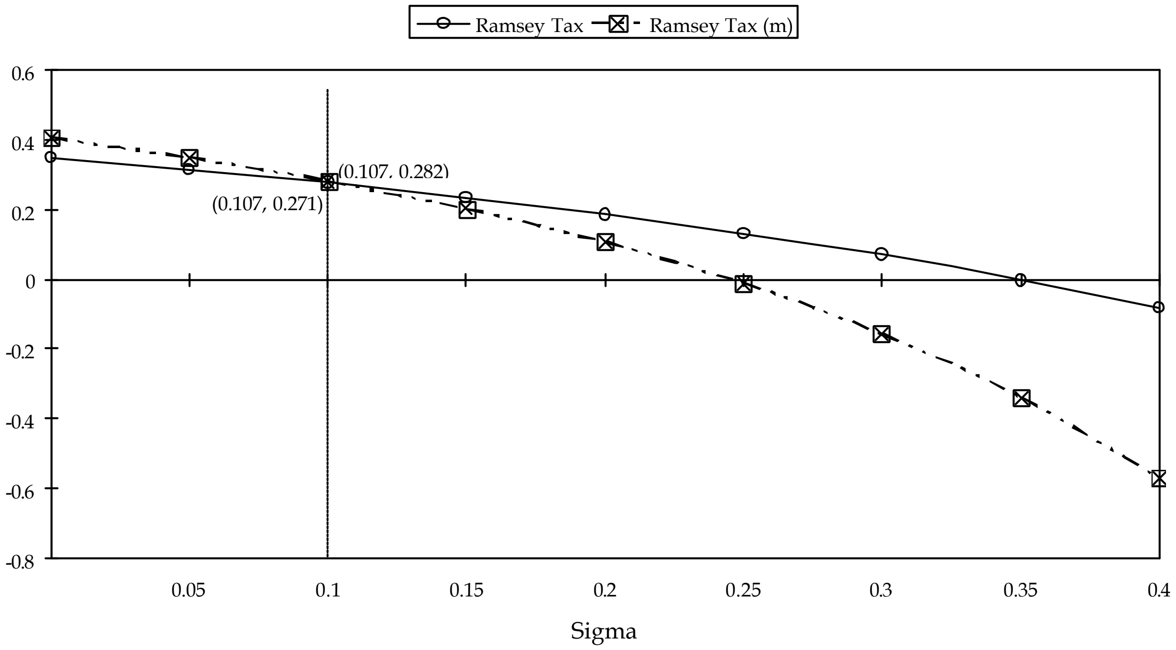

Fig d: Ramsey and first best tax (competitive labor market) vs. sigma.

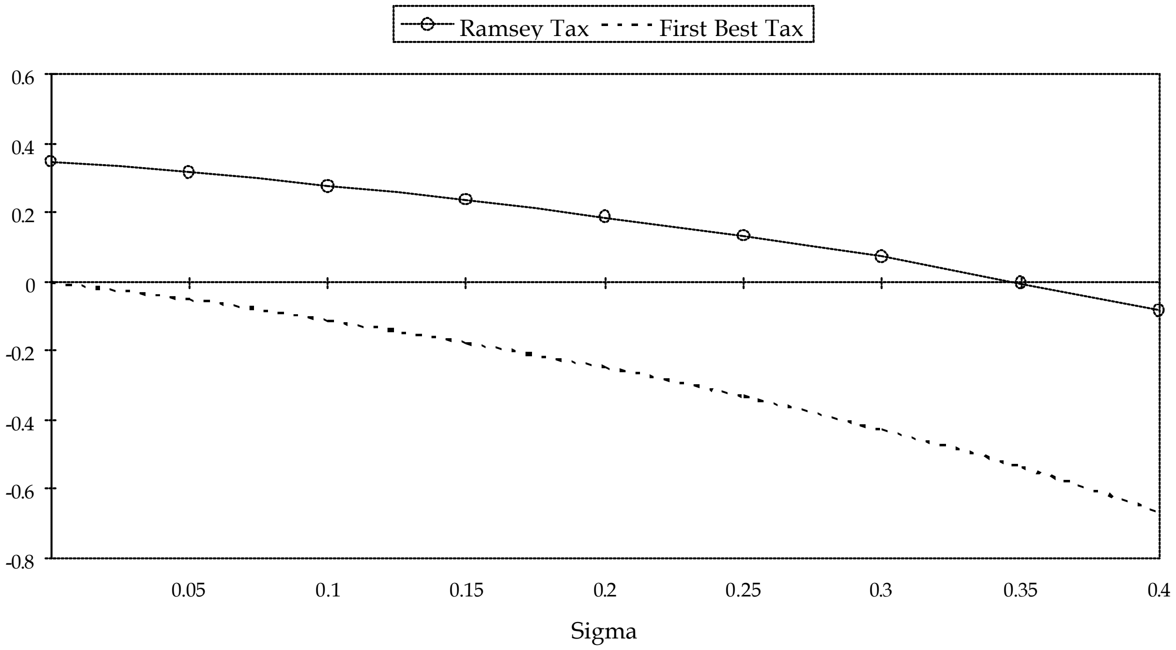

Fig e: Ramsey and first best tax (monopolistic wage setting) vs. sigma.