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Organizational Capital and Optimal Ramsey Taxation ✩

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Abstract

Many recent studies have argued that it is useful to introduce a third input into the neo-classical production technology which encapsulates the productivity enhancing knowledge created in the process of production. This input, often called organizational capital, has been shown to improve the predictions of dynamic general equilibrium models, especially at the business cycle frequency. In this paper, we study the impact of organizational capital on optimal capital taxation in the Ramsey tradition and find that the planner would choose to tax capital income in the presence of organizational capital even in environments where earlier models predicted zero taxes or even subsidies.

JEL Classification: E6
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1. Introduction

A number of economists have argued that it is helpful to expand the production technology available to firms beyond one that takes only two conventional inputs, labour and physical capital, to a third input which incorporates production relevant knowledge. This input is often referred to as organizational capital. Organizational capital (OC) may be thought

of as a kind of knowledge capital linked to ideas about the process of production that help determine how much output results from the application of conventional inputs in the context of a particular technology. We think of OC as being a determinant of the endogenous component of productivity, something that is co-produced by firms in the process of creating output. The idea that firms are store-houses of OC can be found in Prescott and Visscher (1980) and more recently in Atkeson and Kehoe (2005) who report that payments to owners of organizational capital are 37 percent of the net payments to owners of physical capital in the US economy. The idea is also implicitly contained in the sizeable empirical industrial organization literature on estimating learning curves at the industry or firm level.

A recent literature has begun to explore the macroeconomic implications of organizational capital and especially its ability to resolve discrepancies between existing models and data. For example, Gunn and Johri (2011) show that the presence of OC can help explain why firm equity values co-move with output and lead productivity in the context of expectation driven cycles. Johri (2009) shows that the presence of OC creates an incentive for price-setting firms to lower markups in times of monetary expansion which in turn leads to endogenous inertia in the price level and inflation. In an open-economy context, Johri and Lahiri (2008)show that the presence of OC can help explain the observed persistence of real exchange rate movements in the presence of monetary shocks while Johri et al. (2011) use a model with OC to explain why investment in physical capital is positively correlated across countries. Despite these and other studies, potential macroeconomic implications of organizational capital remain largely unexplored. In this paper we explore how the presence of OC changes standard conclusions in the optimal tax literature.

Standard economic theory using the Ramsey approach usually finds that the optimal tax rate on capital income should be zero in the long run. Early work by Chamley (1986), and Judd (1985) established this result in the context of basic infinite horizon

growth models while Atkeson et al. (1999) extends the settings in which the result holds. Judd (2002) shows that the presence of imperfectly competitive product markets leads to a desire to subsidize capital income in an effort to overcome the additional distortion associated with market power- a tendency towards an under-accumulation of capital. With monopoly power, Judd (2002) shows, an optimal policy should promote efficiency along the capital accumulation margin. Providing a capital subsidy can boost capital accumulation and achieve this optimality goal.This negative tax on capital income result continues to hold when a rich array of real and nominal rigidities are added to the model in Chugh (2007) and Schmitt-Grohe and Uribe (2005). In contrast to these theoretical results, most governments tend to charge positive tax rates on capital income. Previous work on optimal taxation in the Ramsey tradition has tended to abandon either the assumption of infinite lives or the assumption of perfect financial markets in order to generate theoretical results that justify these policy choices.[1]

In this paper we add OC to the production environment in which monopolistically competitive firms operate and ask if it is possible to generate positive tax rates on capital income in an economy with infinite lives and perfect financial markets.[2] We find that the optimal steady-state capital income tax rate is significantly positive in the long run as is the tax rate on labor income when the contribution of OC to production is close to the aggregate estimates available in the literature. As OC becomes less and less valuable to firms as an input, the capital income tax rate falls first towards zero, and then turns negative as the production technology approaches the standard case with no contribution from OC. In order to explore the source of this result it is helpful to review why the

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[1]See Alvarez et al. (1992), Erosa and Gervais (2002) and Garriga (2003) for life cycle models where the tax code cannot be explicitly conditioned on the age of the household and Hubbard and Judd (1987), Aiyagari (1995) and Imrohoroglu (1998) for the latter. Using Bewley (1986) class of models, Aiyagari (1995) shows that if households face tight borrowing constraints and are subject to uninsurable idiosyncratic income risk, then the optimal tax system will in general include a positive capital income tax.

[2]We use a model with imperfect competition in goods markets both because this is a natural environment for firms with OC previously analyzed in the literature and also because it raises the bar on finding positive capital taxes.

standard growth model implies a positive tax on labor income but no taxes on capital income. One way to understand this result is through the fact that capital is a stock while labor is a pure flow[3]. A tax on labor income distorts only the static trade-off between consumption and leisure whereas a tax on capital income distorts the intertemporal trade-off between current and future consumption. Atkeson et al. (1999) shows that a constant capital income tax is equivalent to an increasing sequence of consumption taxes. In other words, taxes on capital income cause cumulative distortions over an infinite time period while taxes on wages cause distortions only for a single period. As a result, it is not optimal to tax the stock when a tax on a flow is available.

If firms accumulate OC using labour as an input, then it is easy to see why the classic result might be overturned. A tax on wages reduces the incentive of the firm to hire labor. This reduction in hours will lead to a smaller future stock of OC, which in turn will imply that existing labor and capital can produce less output in the future. In other words, the firm will be less productive and this will have long term adverse effects on consumption as was the case with capital income taxes discussed above. Moreover, organizational capital also interacts with market power which not only induces under-accumulation of physical capital, but also under-accumulation of organizational capital. As a result, the Ramsey planner has no reason to shield capital income over labor income from taxation in our OC model.

Having established the optimal tax rate to charge in the long run, we turn to explore the role of OC in influencing the behaviour of optimal tax policy out of steady state in an economy that is hit with shocks to total factor productivity and to government spending. In keeping with the literature, we find that the planner chooses to smooth the tax rate on labor income but allows sizeable variation in the capital income tax rate.

Our model shares some features with the human capital model of Jones et al. (1997). These authors show that the zero capital income tax result can carry over to labor income

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[3]See Jones et al. (1997) for details on this point.

in a model with human capital. The result holds so long as the technology for accumulating human capital displays constant returns to scale in the stock of human capital and goods used (not including raw labor). Our paper complements their work in a number of ways. First, we introduce imperfect competition in the product market which is a key feature of modern dynamic economies. Second, we model the accumulation of organizational capital as a function of current knowledge and hours worked. Finally we study the cyclical properties of optimal tax policy.

The remainder of the paper is organized as follows. Section 2 describes the model while section 3 discusses parameterizations and computation technique. Section 4 presents numerical solution results and section 5 concludes.

2. The model

The model economy involves households, firms, and the government. The structure of the economy is a standard growth model augmented with three features - monopolistic competition in the product market, OC in the technological environment, and distortionary taxation. The firms possess a degree of monopoly power and hence, can earn positive economic profits. As owners of all the firms, households receive profits as dividends. However, the crucial feature of the model economy that serves as the basis of our results is the introduction of firm-level OC.

2.1. Households

We suppose that the economy is populated by a continuum of identical, infinitely lived households. The households' preferences are defined over consumption, c_t, and labor effort, n_t and are described by the standard time separable utility function

$$\sum_{t=0}^{\infty} \beta^t U(c_t, n_t), \tag{1}$$

where $\beta \in (0, 1)$ represents a subjective discount factor, c_t is consumption and n_t is hours worked in period t.

The representative household faces the following period-by-period budget constraint:

$$c_t + i_t + b_t \leq (1 - \tau_t^n)w_t n_t + (1 - \tau_t^k)r_t k_t + b_{t-1}R_{t-1} + \pi_t, \qquad (2)$$

where i_t denotes investment, b_t represents one-period real government bonds carried into period $t+1$, k_t denotes capital. Households derive income by supplying labor and capital services to firms at rates w_t and r_t, earning interest on their government bond holdings, and receiving profits π_t, in the form of dividends as owners of the firms. τ_t^n and τ_t^k are the tax rates imposed on labor and capital income, respectively. The capital stock depreciates at the rate δ, so that it evolves according to

$$k_{t+1} = (1 - \delta)k_t + i_t, \qquad (3)$$

We normalize the number of total hours available to households to 1. That is,

$$n_t + l_t \leq 1, \qquad (4)$$

where, l_t denotes leisure.

Households are also constrained by the transversality conditions that prevent them from engaging in Ponzi schemes. A representative household's problem is to maximize the utility function (1) subject to (2), (3), (4) and the no-Ponzi-game borrowing limit. Let λ_t denote the Lagrange multiplier on the households' flow budget constraint. Then the first-order conditions of the household's maximization problem are (2) holding with equality and

$$c_t: \qquad U_{ct} = \lambda_t, \tag{5}$$

$$n_t: \qquad -U_{nt} = \lambda_t(1 - \tau_t^n)w_t, \tag{6}$$

$$k_{t+1}: \qquad \lambda_t = \beta E_t \lambda_{t+1}\left[(1 - \tau_{t+1}^k)r_{t+1} + 1 - \delta\right], \tag{7}$$

$$b_t: \qquad \lambda_t = \beta E_t \lambda_{t+1}R_t, \tag{8}$$

$$tvc: \qquad \lim_{t\to\infty} \beta^t \lambda_t k_{t+1} = 0, \tag{9}$$

$$tvc: \qquad \lim_{t\to\infty} \beta^t \lambda_t b_{t+1} = 0. \tag{10}$$

Here U_{ct} and U_{nt} are the partial derivatives of $U(c_t, n_t)$ with respect to c_t and n_t. The interpretation of these first order conditions is quite standard. Equation (7) is the consumption-savings optimality condition. It states that marginal rates of substitution between present and future consumption equals after-tax return on savings. Equation (7) implies that capital income tax creates a dynamic distortion in the consumption-savings margin. Equation (8) determines the gross return on bond holdings. Equations (7) and (8) imply that after-tax returns on capital and bonds to be equalized each period. Combining (5) and (6) gives

$$\frac{U_{lt}}{U_{ct}} = (1 - \tau_t^n)w_t \tag{11}$$

Equation (11) gives the optimal labor-leisure choice which is distorted by the tax, τ^n. This distortion is purely static in a standard monopolistically competitive model. But, as will be clear in the next section, in our model the labor income tax also creates a dynamic distortion.

2.2. The Government

The government faces an exogenous stream of real expenditures that it must finance through the labor income tax, the capital income tax, and the issuance of real risk-free one-period debt. Its period-by-period budget constraint is given by

$$g_t + R_{t-1}b_{t-1} = b_t + \tau_t^n w_t n_t + \tau_t^k r_t k_t \tag{12}$$

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R_t denotes the gross one-period, risk-free, real interest rate in period t. g_t denotes per capita government spending on the final good.

2.3. Production

The production side of the economy builds on earlier work on organizational capital in a DGE model with monopolistic competition. Following Clarke and Johri (2009) it features two sectors: an intermediate goods sector that produces differentiated goods using labor, physical capital and organizational capital, and a final goods sector that uses intermediate goods to produce a unique final good.

2.3.1. Final Goods Producers

Government consumption goods, private consumption goods and investments are physically indistinguishable. There are a large number of producers who produce this unique final good in a perfectly-competitive environment. Final goods producers require only the differentiated intermediate goods as inputs and use the following CES technology for converting intermediate goods into final goods.

$$y_t = \left[\int_0^1 y_{it}^{\frac{\eta-1}{\eta}} \, di \right]^{\frac{\eta}{\eta-1}}, \tag{13}$$

where $\eta(>1)$ denotes the intratemporal elasticity of substitution across different varieties of intermediate goods. The differentiated intermediate goods are indexed by $i \in [0,1]$.

Each period final goods firms choose inputs y_{it} for all $i \in [0,1]$ and output y_t to maximize profits given by

$$y_t - \int_0^1 p_{it} y_{it} di \tag{14}$$

subject to (13) where p_{it} is the relative price of the ith intermediate good[4]. The solution to this problem gives us the input demand functions:

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[4]We normalize the final good's price, p_t, to 1

$$y_{it} = p_{it}^{-\eta}(y_t). \tag{15}$$

The zero profit condition can be used to infer the relationship between the final good price and the intermediate goods prices:

$$p_t(=1) \equiv \left[\int_0^1 p_{it}^{1-\eta} di \right]^{\frac{1}{1-\eta}}. \tag{16}$$

2.3.2. Intermediate Goods Producers

There are a large number of intermediate goods producers, indexed by the letter i who operate in a Dixit-Stiglitz style imperfectly competitive economy. Each of these firms produces a single variety i using three factor inputs - physical capital, k_{it}, organizational capital, h_{it}, and labor services, n_{it}. Following Cooper and Johri (2002), the production technology facing each firm is given by

$$y_{it} = z_t k_{it}^{\alpha} n_{it}^{1-\alpha} h_{it}^{\theta} \tag{17}$$

where y_{it} is the intermediate good variety produced by firm i. The function is assumed to be concave, and strictly increasing in all three arguments.

The technology differs from a standard neo-classical production function because the firm carries a stock of OC which is an input in the production technology. Organizational capital refers to the information accumulated by the firm, through the process of past production, regarding how best to organize its production activities and deploy its inputs. As a result, the higher the level of OC, the more productive the firm is. The accumulation of OC builds on the specification used in Gunn and Johri (2011) and is similar to Chang et al. (2002), but in addition, we allow for linear depreciation of OC in order to impose symmetry in the way the two stocks of capital are specified in the model.[5]

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[5]This symmetry is also a reason why we model OC as accumulating using labor as an input rather

We assume that new OC is built using two inputs: labor and old OC. The current amount of labor used interacts with the existing stock of OC to produce new ideas regarding how best to produce goods and this adds to the undepreciated stock of ideas so that we can write the accumulation equation as:

$$h_{i,t+1} = (1 - \delta^h)h_{it} + h_{it}^\gamma n_{it}^{1-\gamma}, \tag{18}$$

where δ^h is the depreciation rate of organizational capital and $0 < \delta^h, \gamma < 1$.[6] All producers begin life with a positive and identical endowment of organizational capital. The restriction $0 < \delta^h < 1$ is consistent with the empirical evidence supporting the hypothesis of organizational forgetting. Argote et al. (1990) provide empirical evidence for this hypothesis of organizational forgetting associated with the construction of Liberty Ships during World War II. Similarly, Darr et al. (1995) provide evidence for this hypothesis for pizza franchises and Benkard (2000) provides evidence for organizational forgetting associated with the production of commercial aircraft.

While learning-by-doing is often associated with workers and modeled as the accumulation of human capital, a number of economists have argued that firms are also store-houses of knowledge. Atkeson and Kehoe (2005) note "At least as far back as Marshall (1930, bk. iv, chap. 13.I), economists have argued that organizations store and accumulate knowledge that affects their technology of production. This accumulated knowledge is a type of unmeasured capital distinct from the concepts of physical or human capital in the standard growth model". Similarly Lev and Radhakrishnan (2005) write, "Organizational capital is thus an agglomeration of technologies, business practices, processes and designs, including incentive and compensation systems that enable some firms to consistently extract out of a given level of resources a higher level of product and at lower cost than

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than output as in Clarke and Johri (2009).

[6]Note that physical capital accumulation has a symmetric structure. Next period capital is the sum of the undepreciated stock of physical capital and the new capital produced this period which is a fraction of output, itself produced by a combination of labor and the current stock of physical capital.

other firms". There are at least two ways to think about what constitutes organizational capital. Some, like Rosen (1972), think of it as a firm specific capital good while others focus on specific knowledge embodied in the matches between workers and tasks within the firm. In modeling organizational capital here we follow the second line of thinking. We assume that the firm must satisfy demand at the posted price. The decision problem of the firm is to choose plans for n_{it}, k_{it}, h_{it+1}, and p_{it} so as to maximize discounted life-time profits[7]:

$$\sum_{t=0}^{\infty} Q_t \left\{ p_{it} y_{it} - w_t n_{it} - r_t k_{it} \right\}$$

subject to (17), (18), and (15), where Q_t is the appropriate discount factor to use to price revenue and costs in adjoining periods which is determined in the household problem[8].

The first-order conditions associated with the firm's problem are then:

$$n_{it}: \quad w_t = mc_{it}(1-\alpha)\frac{y_{it}}{n_{it}} + \Psi_{it}(1-\gamma)n_{it}^{-\gamma}h_{it}^{\gamma} \tag{19}$$

$$k_{it}: \quad r_t = mc_{it}\alpha\frac{y_{it}}{k_{it}} \tag{20}$$

$$h_{i,t+1}: \quad \Psi_{it} = Q_{t+1}E_t\left[mc_{i,t+1}\theta\frac{y_{i,t+1}}{h_{i,t+1}} + \Psi_{i,t+1}\left\{(1-\delta^h)\right.\right.$$
$$\left.\left. +\gamma h_{i,t+1}^{\gamma-1}n_{i,t+1}^{1-\gamma}\right\}\right] \tag{21}$$

$$p_{it}: \quad mc_{it} = \frac{\eta-1}{\eta}p_{it}, \tag{22}$$

where Ψ_{it} and mc_{it} are the Lagrange multipliers associated with the organizational capital

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[7]All input payments are assumed to be made in units of the final good.

[8]Combining (5) and (8) we get the pricing formula for a one-period risk-free real bond $1 = R_t \frac{\beta u_{c,t+1}}{u_{ct}}$, which implies the following real pricing kernel between period t and $t+1$:

$$Q_{t+1} = \frac{\beta u_{c,t+1}}{u_{ct}}$$

Consumers discount factor is appropriate to discount period $t+1$ profit because they own all intermediate firms and thus receive all the profits.

accumulation equation and production function respectively. Equations (20) and (22) are standard. Equation (21) determines the optimal use of organizational capital by the firm. One additional unit of organizational capital has a (marginal) value, in terms of profits, of Ψ_{it} to the producer in the current period. The right hand side of (21) measures the value of having available an additional unit of organizational capital for use by the firm in the following period. First, the additional organizational capital directly contributes to the production in the following period as captured by the first term on the right hand side. Second, the additional organizational capital today has a positive effect on the future stock of organizational capital which is captured by the two terms inside the curly bracket. First term is the un-depreciated additional stock and the second term is the new organizational capital stock generated by this additional stock. In the next period this higher stock of organizational capital has a marginal value of $\Psi_{i,t+1}$ to the producer. All this must be discounted by the factor Q_{t+1}. The condition (21) implies that organizational capital will be accumulated up to the point where the value of an additional unit of organizational capital today is equal to the discounted value of this organizational capital next period. The presence of organizational capital dramatically changes a firm's demand for labor. Combining (19) and (21) we get:

$$
\begin{aligned}
w_t = mc_{it}(1-\alpha)\frac{y_{it}}{n_{it}} + Q_{t+1}\left[mc_{i,t+1}\theta\frac{y_{i,t+1}}{h_{i,t+1}} + \Psi_{i,t+1}\left\{ (1-\delta^h) + \gamma h_{i,t+1}^{\gamma-1}n_{i,t+1}^{1-\gamma}\right\}\right] \\
\times(1-\gamma)n_{it}^{-\gamma}h_{it}^{\gamma}
\end{aligned}
\tag{23}
$$

The second term on the right hand side of (23) does not appear in a standard model of monopolistic competition without LBD. In a standard model, a firm's labor hiring decision is solely based on the marginal product of labor in the current period. But in our model, in addition to that basic contribution firms also take into account the positive effect of an additional unit of labor in accumulating organizational capital in the following period. One additional unit of labor can generate $(1-\gamma)n_{it}^{-\gamma}h_{it}^{\gamma}$ units of organizational

capital in the following period. Each of these additional units of organizational capital has a value of Ψ_{it} to the firm. So, the right hand side of (23) gives the total marginal benefit of having available an additional unit of labor input.

We restrict our attention to a symmetric equilibrium in which all firms make the same decisions. We thus drop all the subscripts i. That is, in equilibrium $y_{it} = y_t$, $c_{it} = c_t$, $p_{it} = p_t = 1$, $k_{it} = k_t$, $n_{it} = n_t$, $h_{it} = h_t$ and the aggregate production technology and organizational capital accumulation are given by

$$y_t = z_t k_t^\alpha n_t^{1-\alpha} h_t^\theta \tag{24}$$

$$h_{t+1} = (1 - \delta^h) h_t + h_t^\gamma n_t^{1-\gamma} \tag{25}$$

We can also aggregate the firm's optimality conditions, equations (19)- (22), as

$$w_t = mc_t (1 - \alpha) \frac{y_t}{n_t} + \Psi_t (1 - \gamma) n_t^{-\gamma} h_t^\gamma \tag{26}$$

$$r_t = mc_t \alpha \frac{y_t}{k_t} \tag{27}$$

$$\Psi_t = Q_{t+1} \left[mc_{t+1} \theta \frac{y_{t+1}}{h_{t+1}} + \Psi_{t+1} \left\{ (1 - \delta^h) + \gamma h_{t+1}^{\gamma-1} n_{t+1}^{1-\gamma} \right\} \right] \tag{28}$$

$$mc_t = \frac{\eta - 1}{\eta} \tag{29}$$

2.4. Equilibrium

In the presence of government policy there are many competitive symmetric equilibria, indexed by different government policies. This multiplicity motivates the Ramsey problem. In our model competitive and Ramsey equilibria are defined as follows:

2.4.1. Competitive Equilibrium

A competitive equilibrium is a set of plans { c_t, n_t, k_{t+1}, h_{t+1}, i_t, w_t, r_t, b_t, mc_t, λ_t, Ψ_t, and R_t}, such that the household maximizes expected lifetime utility taking as given prices and policies; the firms maximize profit taking as given the wage rate, capital rental rate, and the demand function; the labor market clears, the capital market clears, the bond

market clears, the government budget constraint and the aggregate resource constraint are satisfied. In other words, all the processes above satisfy conditions (3), (5)-(10), (12), (24)-(29) and the aggregate resource constraint

$$c_t + g_t + i_t = z_t k_t^\alpha n_t^{1-\alpha} h_t^\theta \tag{30}$$

given policies $\{\tau_t^n, \tau_t^k\}$, exogenous processes $\{z_t, g_t\}$, and the initial conditions k_{-1}, h_{-1}, z_0, g_0.

2.4.2. The Ramsey Equilibrium

The Ramsey equilibrium is the unique competitive equilibrium that maximizes the household's expected lifetime utility. Following Schmitt-Grohé and Uribe (2007), we assume that the benevolent Ramsey planner has been operating for an infinite number of periods and it honors the commitments made in the past. This form of policy commitment is known as 'optimal from the timeless perspective' Woodford (2003). The Ramsey Equilibrium is defined as a set of processes c_t, n_t, k_{t+1}, h_{t+1}, i_t, w_t, r_t, τ_t^n, τ_t^k, b_t, mc_t, λ_t, Ψ_t for $t \geq 0$ that maximize:

$$E_0 \sum_{t=0}^{\infty} \beta^t U(c_t, n_t)$$

subject to the conditions (3), (5)-(10), (12), (24)-(29) and (30), for $t > -\infty$, given exogenous processes g_t and z_t, values of all the variables dated $t < 0$, the values of the Lagrange multipliers associated with the constraints listed above dated $t < 0$. Under traditional Ramsey equilibrium concept, the equilibrium conditions in the initial periods are different from those applied to later periods. But under Woodford's timeless definition, the optimality conditions associated with Ramsey equilibrium are time invariant.

3. Parameterization and Solution Method

In order to numerically solve the model, parameter values need to be assigned. We choose standard values for the parameters used in the business cycle literature and explore how the optimal tax rates change as the organizational capital parameters vary. The time unit in our model is one quarter. We set $\beta = .9902$ so that the discount rate is 4 percent (Prescott (1986)) per year. We assume that the period utility function takes the log - log specification

$$U(c_t, n_t) = \ln c_t + \upsilon \ln(1 - n_t)$$

The value for υ is set so that the steady state labor supply is 20% in the model without OC. The exogenous processes for government spending, g_t, and productivity, z_t, are assumed to follow independent AR(1) in their logarithms,

$$\ln(g_t/\bar{g}) = \rho_g \ln(g_{t-1}/\bar{g}) + \epsilon_t^g$$

$$\ln z_t = \rho_z \ln z_{t-1} + \epsilon_t^z$$

with $\epsilon_t^z \sim iidN(0, \sigma_z^2)$ and $\epsilon_t^g \sim iidN(0, \sigma_g^2)$. $\bar{g}$ is the steady-state level of government spending and we calibrate this value so that government spending constitutes 17 percent of steady-state output. We choose the first-order autocorrelation parameters $\rho_z = 0.95$ and $\rho_g = 0.85$, the standard deviation parameters $\sigma_z = 0.007$ and $\sigma_g = 0.02$ in line with Chugh (2007) and the RBC literature. Table 2.1 presents the structural parameters used in the baseline model.

We assign a value of 0.3 to the cost share of capital, α. This is consistent with the empirical regularity that in developed countries wages represent about 70 percent of total cost. This brings us to the new parameters associated with organizational capital. Initial values around which our numerical exercises occur are obtained from the literature. We set $\theta = 0.15$, γ equal to 0.55. and $\delta = .025$. This value of θ corresponds to a "learning

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Table 1: Baseline parameter values

Parameters	Value	Description
β	.9902	Subjective discount rate
υ	1.913	Labor supply elasticity parameter
α	0.3	Share of capital in the production technology
δ	0.025	Depreciation of physical capital
θ	0.15	Elasticity of output with respect to organizational capital
δ^h	0.025	Depreciation rate of organizational capital
γ	0.55	Org. capital production parameter, $h_{t+1} = (1 - \delta^h)h_t + h_t^\gamma n_t^{1-\gamma}$
$\bar{g}$	calibrated	steady-state level of govt. spending
ρ_g	0.85	persistence in log govt. spending
$\sigma^{\epsilon_t^g}$	0.02	standard deviation of log govt. spending
ρ_z	0.95	persistence in log productivity
$\sigma^{\epsilon_t^z}$	0.007	standard deviation of log productivity

rate"of just under twelve percent and is taken from the lower end of production function estimates for US manufacturing industries provided in Cooper and Johri (2002). We studied the response of varying these parameters and found that the results were only sensitive to θ. These are reported in the next section. To maintain symmetry with the physical capital we set δ^h equal to .025[9].

We characterize the Ramsey steady-state numerically using the methodology outlined in Schmitt-Grohé, and Uribe (2005). Their publicly available numerical tools allow the computation of Ramsey policy in a general class of stochastic dynamic general equilibrium models.

4. Results

We focus our attention in this section on the long run Ramsey equilibrium without any uncertainty. After obtaining the dynamic first-order conditions of the Ramsey problem, we impose the steady state and numerically solve the resulting non-linear system using the Schmitt-Grohé, and Uribe (2005) algorithm. This gives us the exact numerical solution

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[9]McGrattan and Prescott (2005) use an estimate of 11% (annual rate) for the depreciation rate of intangible capital which is approximately equivalent to our quarterly value.

of the Ramsey problem. After discussing these results we also report the behaviour of the economy out of steady state as it is hit by shocks to technology and to government spending.

4.1. Optimal Taxes in the OC Economy

In a standard neoclassical model a capital income tax is worse than a labour income tax because the former distorts the intertemporal trade-off between current and future consumption while the latter distorts the static trade-off between consumption and leisure. A tax on capital income reduces the return to saving and thus affects future consumption while a tax on current labor income does not have any effect on future consumption, households work and consume less in the current period.

The presence of organizational capital fundamentally changes this line of reasoning. Recall that firms combine hours worked with the existing stock of OC to produce additional OC which in turn raises the productivity of the firm, giving it the ability to produce more output without hiring additional physical capital or labor. From the planners point of view, the additional productivity in the future implies that workers can earn higher wages and enjoy additional consumption in the future. Anything that reduces the incentive of the firm to hire labor, in effect, leads to lower accumulation of OC, lower productivity and therefore lower future consumption. As a result, labor income taxes affect future consumption in much the same way as capital income taxes do so the planner is faced with juggling two dynamic distortions in order to achieve the best possible allocation, which, in general implies positive rates for both taxes.

The relative magnitude of the two tax rates depends on how strongly OC influence productivity of labor and capital in the production function. This is controlled by the parameter, θ. Figure 1 plots the value of the optimal tax rates on labor and capital income chosen by the Ramsey planner as θ is varied from a value of zero to a value of .15 (which is close to estimates found in the dynamic general equilibrium literature). For this baseline value of θ, the planner chooses a capital tax rate of 18 percent and a labor

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Figure 1: OC and optimal tax rates
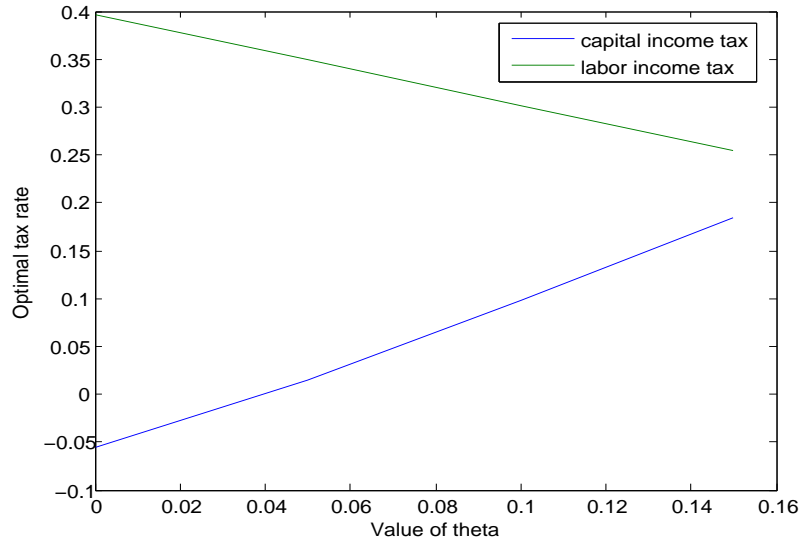
tax rate of 26 percent. As the contribution of OC in output falls (θ is lowered), the tax rate on labor income rises while that on capital income falls. When OC is no longer part of the production technology, ($\theta = 0$), the planner opts for a capital subsidy, in keeping with earlier results in the literature. We have also explored the impact of varying other parameters governing the accumulation of organizational capital but the results are barely sensitive to these parameters so we do not report them here. They are available from the authors.

Since the OC economy involves increasing returns in the three inputs into production, a natural question arises: is the positive tax on capital due to increasing returns? We address this question by solving an economy without OC but with the same degree of increasing returns in labor and capital as displayed by our baseline OC economy. The production technology is assumed to be

$$y_{it} = z_t k_{it}^{\alpha} n_{it}^{1.15-\alpha}. \tag{31}$$

We use (1.15-α) as the labor share so that this model and the OC model have the same increasing returns in production technology. The representative firm's problem is to maximize profit given by

$$p_{it}y_{it} - w_t n_{it} - r_t k_{it} \tag{32}$$

subject to (31) and (15). The first order conditions associated with this problem are then:

$$n_{it} : \qquad w_t = mc_{it}(1.15 - \alpha)\frac{y_{it}}{n_{it}} \tag{33}$$

$$k_{it} : \qquad r_t = mc_{it}\alpha\frac{y_{it}}{k_{it}} \tag{34}$$

$$p_{it} : \qquad mc_{it} = \frac{\eta - 1}{\eta}p_{it}, \tag{35}$$

We impose symmetry in the production sector and solve the Ramsey problem for this economy using the same baseline parameter values described in section 2.3. The resulting solution gives us the following optimal tax rates:

$$\tau^k = -0.3, \qquad \tau^n = 0.42$$

Clearly then, merely introducing increasing returns in production cannot account for positive taxation of capital income.

4.2. Ramsey Dynamics

Having discussed the steady state properties of the model with OC we turn to the response of the planner to technology and government spending shocks. We compute the numerical solution to the Ramsey problem based on a second-order approximation of the Ramsey planner's decision rules. We approximate the model in levels around the non-stochastic steady-state based on the perturbation algorithm described in Schmitt-Grohé and Uribe (2004a). As in Schmitt-Grohé and Uribe (2004b), we first generate simulated time series of length 100 for the variables of interest and then compute the first and second moments. We repeat the procedure 500 times and report the averages of the moments.

Table 2 displays the usual moments reported in the Ramsey taxation literature. While the presence of OC leads to amplification of shocks so that output varies more than in a corresponding model without OC, much of the basic features of taxation carry through to this economy. Supporting results in Chari et al. (1994); Chugh (2007), the tax rate on labor income fluctuates very little but capital income tax is relatively volatile. Since these are already discussed in the literature, we keep our discussion short. The planner chooses to smooth the labor income tax while using the capital income tax for consumption smoothing purposes. As a result the capital tax varies considerably around its mean value of .18.

Table 2: Dynamic properties of Ramsey allocation

Variable	Mean	Std. Dev.	Auto. corr.	Corr(x,y)	Corr(x,g)	Corr(x,z)
Ramsey model with OC						
τ^n	0.2552	0.0061	0.9091	-0.9994	-0.0737	-0.9876
τ^k	0.1855	0.1686	-0.0070	0.1098	0.5137	0.0584
$R-1$	4.0019	0.0007	0.8712	0.5912	0.2568	0.6472
y	4.5332	0.0884	0.9066	1.0000	0.0919	0.9876
n	0.2792	0.0035	0.8624	0.8490	0.4022	0.8473
i	0.6632	0.0600	0.8545	0.7874	-0.3928	0.8713
c	2.9615	0.0465	0.9650	0.7530	-0.3326	0.7389
Ramsey model without OC						
τ^n	0.4325	0.0007	0.8477	-0.2182	-0.8863	0.0472
τ^k	-0.1377	0.2000	-0.0121	-0.1303	0.3816	-0.2480
$R-1$	4.0007	0.0007	0.9287	-0.0796	0.5034	-0.2537
y	0.3625	0.0073	0.8850	1.0000	0.2784	0.9513
n	0.1987	0.0020	0.8477	0.2182	0.8863	-0.0472
i	0.0369	0.0024	0.8053	0.7073	-0.2376	0.8099
c	0.2530	0.0053	0.9340	0.8329	-0.2121	0.9489

Note: The net real interest rate, $R-1$, is expressed in percent per year.

5. Conclusion

We introduce organizational capital and imperfect competition into an otherwise standard infinite horizon dynamic general equilibrium model in order to study the properties

of optimal taxation in the Ramsey tax framework. Our numerical solutions suggest that while the introduction of monopoly power calls for a capital income subsidy, the introduction of organizational capital creates a stronger incentive to tax capital income. In our model, both capital and labor income tax distort the dynamic trade-off between current consumption and future consumption. Consequently, it is optimal for the Ramsey planner to tax both capital income and labor income. The relative magnitudes of the tax rates depend crucially on the contribution of organizational capital to output, in firms production technology.

References

Aiyagari, S.R., 1995. Optimal capital income taxation with incomplete markets, borrowing constraints, and constant discounting. Journal of Political Economy 103, 1158–75.

Alvarez, Y., Burbidge, J., Farrell, T., Palmer, L., 1992. Optimal taxation in a life-cycle model. The Canadian Journal of Economics / Revue canadienne d'Economique 25, 111–122.

Argote, L., Beckman, S.L., Epple, D., 1990. The persistence and transfer of learning in industrial settings. Management Science 36, 140–154.

Atkeson, A., Chari, V., Kehoe, P.J., 1999. Taxing capital income: a bad idea. Quarterly Review , 3–17.

Atkeson, A., Kehoe, P.J., 2005. Modeling and measuring organization capital. Journal of Political Economy 113, 1026–1053.

Benkard, C.L., 2000. Learning and forgetting: The dynamics of aircraft production. American Economic Review 90, 1034–1054.

Bewley, T.F., 1986. Stationary monetary equilibrium with a continuum of independently fluctuating consumers, in: Hildenbrand, W., Mas-Colell, A. (Eds.), Contributions to Mathematical Economics in Honor of Gerard Debreu. Amsterdam: North-Holland.

Chamley, C., 1986. Optimal taxation of capital income in general equilibrium with infinite lives. Econometrica 54, 607–22.

Chang, Y., Gomes, J.F., Schorfheide, F., 2002. Learning-by-doing as a propagation mechanism. American Economic Review 92, 1498–1520.

Chari, V.V., Christiano, L.J., Kehoe, P.J., 1994. Optimal fiscal policy in a business cycle model. Journal of Political Economy 102, pp. 617–652.

Chugh, S.K., 2007. Optimal inflation persistence: Ramsey taxation with capital and habits. Journal of Monetary Economics 54, 1809–1836.

Clarke, A.J., Johri, A., 2009. Procyclical solow residuals without technology shocks. Macroeconomic Dynamics 13, 366–389.

Cooper, R., Johri, A., 2002. Learning-by-doing and aggregate fluctuations. Journal of Monetary Economics 49, 1539–1566.

Darr, E.D., Argote, L., Epple, D., 1995. The acquisition, transfer, and depreciation of knowledge in service organizations: productivity in franchises. Management Science 41, 1750–1762.

Erosa, A., Gervais, M., 2002. Optimal taxation in life-cycle economies. Journal of Economic Theory 105, 338–369.

Gunn, C., Johri, A., 2011. News and knowledge capital. Review of Economic Dynamics 14, 92–101.

Hubbard, R.G., Judd, K.L., 1987. Social security and individual welfare: Precautionary saving, borrowing constraints, and the payroll tax. American Economic Review 77, 630–46.

Johri, A., 2009. Delivering endogenous inertia in prices and output. Review of Economic Dynamics 12, 736–754.

Johri, A., Lahiri, A., 2008. Persistent real exchange rates. Journal of International Economics 76, 223–236.

Johri, A., Letendre, M.A., Luo, D., 2011. Organizational capital and the international co-movement of investment. Journal of Macroeconomics 33, 511 – 523.

Jones, L.E., Manuelli, R.E., Rossi, P.E., 1997. On the optimal taxation of capital income. Journal of Economic Theory 73, 93–117.

Judd, K.L., 1985. Redistributive taxation in a simple perfect foresight model. Journal of Public Economics 28, 59–83.

Judd, K.L., 2002. Capital-income taxation with imperfect competition. American Economic Review 92, 417–421.

Lev, B., Radhakrishnan, S., 2005. The valuation of organization capital, in: Measuring Capital in the New Economy. National Bureau of Economic Research, Inc. NBER Chapters, pp. 73–110.

Marshall, A., 1930. Princeples of Economics: An Introductory Volume. London: Macmillan.

McGrattan, E.R., Prescott, E.C., 2005. Taxes, regulations, and the value of u.s. and u.k. corporations. Review of Economic Studies 72, 767–796.

Prescott, E.C., 1986. Theory ahead of business cycle measurement. Technical Report.

Prescott, E.C., Visscher, M., 1980. Organization capital. The Journal of Political Economy 88, 446–461.

Rosen, S., 1972. Learning by experience as joint production. The Quarterly Journal of Economics 86, 366–82.

Schmitt-Grohé, S., Uribe, M., 2004a. Optimal fiscal and monetary policy under imperfect competition. Journal of Macroeconomics 26, 183 – 209.

Schmitt-Grohé, S., Uribe, M., 2004b. Solving dynamic general equilibrium models using a second-order approximation to the policy function. Journal of Economic Dynamics and Control 28, 755 – 775.

Schmitt-Grohe, S., Uribe, M., 2005. Optimal fiscal and monetary policy in a medium-scale macroeconomic model. NBER Macroeconomics Annual 20, 383–425.

Schmitt-Grohé, S., Uribe, M., 2007. Optimal simple and implementable monetary and fiscal rules. Journal of Monetary Economics 54, 1702 – 1725.

Woodford, M.D., 2003. Interest and Prices. Princeton University Press: Princeton, New Jersey.