Capital Income Taxation Revisited: The Role of Information Asymmetry in the Credit Market

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Abstract

This paper reexamines the issue of optimal capital income taxation in an endogenous growth model with overlapping generations. By assuming costly state verification for capital producing projects, we show that the presence of the information asymmetry creates inefficiency in the credit market by driving a wedge between the rate of interest and the rate of transformation. In this context, we further show that capital income taxation worsens the credit market distortions and, subsequently, induces greater adverse effects on growth and welfare. Taken together, our analysis suggests that the presence of informational frictions in the credit market introduces a rationale for more conservative taxation on capital income from both growth and welfare perspectives.

JEL Classification: D82, H21, O41

Keywords: Capital income taxation; Asymmetric information; Economic growth

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I. Introduction

The issue of optimal capital income taxation has long been a focal point of the public finance literature. Despite the extensive studies by many authors, the final verdict on this issue appears to still remain elusive. In the context of economic growth, on the one hand, a preponderant body of work has emerged in support of a zero or low taxation on capital income. For example, Chamley (1986) and Judd (1985) provide some pioneering studies in which the optimal tax on capital income is shown to be zero in the standard Ramsey-type growth model, thus shifting any burden of taxation towards labor.[1] However, others have argued in overlapping generations models that taxation on capital income can potentially result in higher amounts of savings and investment (see, for example, Uhlig and Yanagawa 1996 and Caballé 1998).[2] These almost diametrically opposing results on capital income taxation seem to have arrived from the different modeling assumptions regarding the life-cycle considerations of agents in different models.

Within the overlapping-generations framework with finitely-lived agents, individuals need to save when they are young for their retirement consumption when they are old. This life-cycle consideration is, however, absent in the infinitely-lived agents framework of the Ramsey-type, where individuals are effectively always young since they live forever. In a standard overlapping-generations model, there are two competing effects of capital taxation on growth via savings. First, an increase in capital income taxation alleviates the need for labor income taxation and thus shifts income from the second period towards the first period in an individual's life-time (after-tax) income profile, resulting in more savings by the young for retirement purposes. Second, higher capital income taxation leads to lower returns on investment, and thus dampens agents' incentives to save. Provided that the interest elasticity of savings (or equivalently, the elasticity of intertemporal substitution) is sufficiently low – an assumption that accords well with many empirical estimates in the literature – raising capital income taxation will result in higher savings and hence faster growth. Therefore, the growth-maximizing taxation policy in this case is to set the tax rate on capital be as high as possible. In contrast, the absence of life-cycle considerations of

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[1] When this line of enquiry is extended to the context of endogenous growth where both physical capital and human capital (labor) are reproducible factors, the literature shows that in general taxation on both capital and labor income reduces long-run growth (see, for instance, Lucas 1990; Rebelo 1991; Pecorino 1993; Jones et al. 1997; and Milesi-Ferretti and Roubini 1998).

[2] These studies consider an overlapping-generations model in which government taxes both capital and labor income to support a constant public spending share of output, show that increasing the tax rate on capital income leads to higher economic growth under plausible parameterizations. In line with this result, Jones and Manuelli (1992) also find that a policy of income redistribution from the old to the young, which is akin to raising tax on capital, can increase growth.

saving for retirement when agents are young, as in the infinitely-lived-agents framework, renders the first positive effect of capital taxation inoperative and hence implies that capital taxation only discourages savings, investment and growth.

In a recent paper, Ho and Wang (2007) consider an overlapping-generations model in which capital accumulation is subject to the adverse selection problem in the credit market. It was shown that, when the risk types of borrowers for capital-producing projects are unknown to lenders, capital taxation worsens the adverse selection problem and introduces an additional negative effect on growth. Consequently, it was found that the growth rate is not monotonically increasing with the tax rate on capital income, even under the assumption of zero interest-rate elasticity of savings. This suggests that, comparing to the results established in Uhlig and Yanagawa (1996) and Caballé (1998), the optimal taxation on capital is not to set it as high as possible.

The primary objective in the present paper is to reexamine the issue of optimal taxation on capital (versus taxation on labor) when physical capital is produced by risky projects which are partially financed externally through a credit market with asymmetric information between borrowers and lenders. Unlike in Ho and Wang (2007), where the adverse selection type of asymmetric information is considered, in the present model the source of information asymmetry stems from the privately observed project returns and the costly state verification by others. Since many different kinds of informational frictions are likely to be present in the real-life credit market, the relevance of the previous study would be rather limited unless its implications are proved to be robust to different specifications of informational structure. In the current setup, the costly state verification by lenders drives a wedge between the (expected) interest rates on loans and the opportunity cost of funds, as the equilibrium loan contracts require a positive probability of verification by lenders in order to maintain the incentive compatibility condition. This credit market inefficiency creates an adverse effect on capital formation, growth, and welfare, that is absent in the benchmark economy with full information. Furthermore, in contrast with Ho and Wang (2007) where the working population is comprised of only lenders, the present paper assumes that both lenders and borrowers are endowed with labor. In such a case, while borrowers can use their own wage income as internal funds for their investment projects, they also borrow externally from lenders (their wage income) through the credit market, at a higher cost due to informational frictions. As the co-existence of internal and external finance is a rather common feature of loan markets, the current setup thus brings an additional dimension of realism to the model.[3]

Our main findings are as follows. First of all, we show that higher capital income taxation leads to a higher probability of verification in equilibrium. This result arises because increasing tax on capital income skews the incentives of a borrower toward "under reporting," rendering more frequent verification necessary to keep the borrowers' incentive compatibility constraint binding. Thus, since verification is costly, capital income taxation generates an extra adverse effect on capital accumulation and growth. Assuming that government collects tax revenues from both capital and labor incomes, the credit market distortions induced by capital income taxation will tilt the optimal taxation policy in favor of a lower (higher) tax rate on capital (labor) income in the growth maximization calculus. Specifically, we find that both the optimal tax rate on capital income and the optimal growth rate in the economy are negatively related to the severity of asymmetric information in the credit market. Furthermore, the relationship between the optimal auditing probability and the severity of asymmetric information is also negative. Finally, our welfare analysis reveals that the welfare-maximizing tax rate on capital is even smaller than its growth-maximizing counterpart, and is also deceasing in the severity of the credit market friction.

The current paper is also related to the following studies. Contrary to many standard results, Yakita (2003) argues in an endogenous growth model with overlapping generations that the inability of accumulating human capital in the last period of an individual's life renders a positive relationship between labor income taxation and growth.[4] In a partial equilibrium analysis, Jacobs and Bovenberg (2004) examines factor income taxation in an overlapping generations model with endogenous human capital and shows that positive (possibly significant) taxation on capital will be optimal in order to alleviate the distortionary effect of wage taxation on human capital formation. In a Ramsey model with formal and informal sectors, Penalosa and Turnovsky (2005) shows that capital should be

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3 We follow Bernake and Gerter (1989) modeling borrowers' wage income as the source of internal funds. In Joydeep (1998), however, internal funds take the form of bequests transferred from old borrowers to their off-springs.

4 When the cost of human capital investment takes the form of foregone wages as in Yakita (2003), a typical result in the infinite horizon framework is that labor income taxation does not affect long-run growth as it affects both the benefit and cost of human capital formation by the same proportion (see, e.g., Milesi-Ferretti and Roubini 1998). In the framework with overlapping generations, the positive growth effect of wage tax obtained in this paper also runs contrary to those established in Uhlig and Yanagawa (1996) and Caballé (1998). The difference arises because the wage tax here also serves as a means of redistributing labor income from the old to the young, so that labor income taxation in this paper in fact works in favor of, instead of against, the young generation and hence leads to more savings (physical capital) as well as more time spent in accumulating human capital by the young.

taxed at least as heavily as labor to minimize the distortion in allocation of factors across sectors. By considering an infinite-horizon growth model with public capital and elastic labor supply, Chen (2007) finds that, while the growth effect of capital income taxation is ambiguous, labor income taxation is likely to lower growth.

In what follows, we first describe the model economy in Section II. We then derive the equilibrium loan contracts in the credit market under asymmetric information in Section III. The growth implications of the credit market equilibrium and the optimal tax policy are discussed in Section IV. We then conduct the welfare analysis of the taxation policy in Section V. Finally, Section VI contains some concluding remarks.

II. The Model Economy

The model economy is composed of overlapping generations of two-period-lived agents. Each generation consists of a continuum of agents whose measure is normalized to one and it is divided into lenders and borrowers with equal size. While both a young lender and a young borrower are endowed with one unit of labor each, only the latter owns and runs a risky capital producing project. To maintain simplicity and clarity, it is assumed that both borrowers and lenders are risk neutral and consume only when they are old.[5]

A (young) lender supplies his endowed labor inelastically to earn wage income, which is then lent to a borrower in exchange for consumption goods in the next period. Alternatively, a lender has access to a default, inferior technology that converts one unit of his time t wage into ε units of time t+1 consumption goods with probability one. This alternative use of funds thus defines the opportunity cost of lending. Each (young) borrower first supplies his endowed labor inelastically to earn wage income for internal investment use; then next he operates an *ex ante* identical project, with both internal and external financing, that yields an uncertain amount of physical capital in the following period. For illustration purpose, we assume that these risky projects have the simplest return structure: they fail to produce anything with a probability π and produce a positive amount of capital, κ, per unit of investment with a probability $1-\pi$.[6] Borrowers with successful

[5] Assuming agents only enjoy old-age consumption automatically implies that intertemporal elasticity of substitution, as well as interest elasticity of savings, is equal to zero, and hence that the argument in Uhlig and Yanagawa (1996) and Caballé (1998) would apply. Thus, this assumption allows us to make the comparion between our result and theirs most transparent. Our analysis, however, can be extended to the case where lenders consume in both periods and their preferences are characterized by CRRA utility functions with a sufficiently low intertemporal elasticity of substitution.

[6] Our analysis can be easily carried over to the more general case where a project yields two different *positive* amounts of capital with complementary probabilities.

projects will supply produced capital at the market rate, and hence derive capital income, when they are old. To introduce asymmetric information into the model, we assume that the realized project returns can be costlessly observed only by the borrower who operates the project and the auditing effort by the lender would cost him δ (in terms of capital goods) per unit of loan.

The government in our model collects both capital income and wage income taxes at the flat rates of τ_ρ and τ_w, respectively, to finance a public spending that is equal to a constant fraction, α, of the aggregate output. The wages of the young lenders and young borrowers are taxed at the rate of τ_w, while the returns from produced capital, net of interest repayments, of the old borrowers and the interest income of old lenders are taxed at the rate of τ_ρ.

Finally, the output in period t is produced according to a Cobb-Douglas technology:

$$Y_t = AK_t^\gamma (H_t L_t)^{1-\gamma}, \qquad 0 < \gamma < 1 \tag{1}$$

where K_t and L_t are the aggregate capital and labor, respectively and H_t represents the stock of knowledge which acts as an Harrod-neutral technology progress parameter. Following the endogenous growth literature, we postulate that $H_t = K_t$ so that the economy exhibits increasing returns to scale and sustainable growth in the long run. Since both young lenders and young borrowers are endowed with labor supply and the total population size is normalized to a unity measure (i.e., L_t =1), the aggregate output becomes $Y_t = AK_t$, and the competitive rental rate of capital and wage rate of labor are equal to, respectively:

$$w_t = (1-\gamma)AK_t, \tag{2}$$

$$\rho_t = \gamma A. \tag{3}$$

To simplify the equilibrium dynamics path later on, it is also assumed that capital depreciates completely after one period of use.

III. The Equilibrium Loan Contract

Since a young borrower's expected payoff is strictly increasing with the size of the investment project, he will approach a lender for extra investment funds. The credit market in this model operates as follows. In each period, funds (wages of young lenders) flow from lenders to borrowers (within the same cohort) in the form of standard loan contracts, through either direct or intermediated lending.[7] Since a borrower's project returns zero when it fails, the borrower in such a state will have to default on the loan previously borrowed. Given the asymmetric information pertaining to a project's return realizations, *ex post* monitoring/auditing by the lender is necessary to prevent a borrower from claiming default regardless of his project's actual outcome. Therefore, the loan contract offered to a borrower at time t can be characterized by $C_t = (R_t, q_t, \phi_t)$, where R_t (>0) is the (gross) loan rate, q_t (>0) is the loan size, and ϕ_t (>0) is the probability of monitoring when default is claimed. In the event of monitoring, a borrower will be penalized by forfeiting all his income if he is caught of under reporting. As is customary in the literature, we will focus on the equilibrium contract that induces truthful revelation of their projects' returns by borrowers.

In each period, the large number of lenders competes to offer the most favorable loan contracts to borrowers, subject to the standard constraints. Given the loan contract of $C_t = (R_t, q_t, \phi_t)$ and the tax rate on capital income of τ_ρ and the tax rate on labor income τ_w, a representative borrower's expected payoff (under truthful revelation) can be written as

$$(1-\pi)(1-\tau_\rho)(\kappa\rho_{t+1}Q_t - R_t q_t) \tag{4}$$

where Q_t is the total amount of project investment by the borrower, consisting of both internal funds (his after-tax wage income) and external loans, that is, $Q_t = (1-\tau_w)w_t + q_t$. A number of constraints needs be satisfied in the credit market equilibrium. First, to induce truthful revelation, an incentive compatibility condition should hold. Since R_t >0, a borrower with failed project will obviously not have any incentive to report otherwise. Thus, we only need the following constraint that ensures the truthful revelation for borrowers with successful projects:

$$(\kappa\rho_{t+1}Q_t - R_t q_t) \geq (1-\phi_t)\kappa\rho_{t+1}Q_t \tag{5}$$

This constraint says that the payoffs, net of interest payments, from truthful reporting to a borrower with successful project are greater than or equal to the payoffs if he lies about his

[7] Whether the loans are resulted from one-to-one lender-borrower relationships as in Bencivenga and Smith (1993) and Ho and Wang (2007) or intermediated as in Gale and Hellwig (1985) and Williamson (1986) does not affect the aggregate dynamics we study later. However, at the individual level, direct lending will lead to state-dependent old age consumption for lenders, while intermediated lending would allow lenders to achieve complete insurance against such state-dependency in old age consumption since there is no aggregate uncertainty.

project outcome *and* successfully evades the *ex post* monitoring by the lender. Second, the competition among lenders will drive the economic profit of a lender to zero. Given the opportunity cost of his funds and the monitoring cost, the lender's zero profit condition is given by

$$(1-\tau_\rho)\left[(1-\pi)R_t - \pi\phi_t\delta\rho_{t+1}\right]q_t = \varepsilon q_t\,, \tag{6}$$

where the left-hand-side is the expected net (after tax) income from the loan and the right-hand-side is the opportunity cost of the loan. Third, the inequality below is required to ensure the participation by borrowers in the credit market:

$$\kappa\rho_{t+1} \geq R_t\,. \tag{7}$$

Finally, the following feasibility constraint on loan size should be satisfied:

$$q_t \leq (1-\tau_w)w_t\,. \tag{8}$$

We can thus define the equilibrium loan contract at time t as determined by selecting $C_t = (R_t, q_t, \phi_t)$ to maximize (4), subject to (5) – (8), for given tax rates of τ_ρ and τ_w and factor prices of w_t and ρ_{t+1}. Such an equilibrium contract can be readily solved, under the following additional technical assumptions,

$$(1-\pi)\kappa - \pi\delta > 0 \tag{9}$$

and

$$\gamma^2 A\left[2(1-\pi)\kappa - \pi\delta\right](1-\tau_\rho) > 2\varepsilon \tag{10}$$

which are satisfied with a large enough κ, a small enough ε.

To solve for the equilibrium contract, we first note that the incentive compatibility constraint (5) will be binding in equilibrium, as has been well recognized in this type of problems. One can then easily derive the equilibrium loan rate and monitoring probability from the binding constraint of (5), the zero-profit condition of (6), and a binding feasibility constraint of (8) as, respectively,

$$R_t \equiv R = \frac{2\varepsilon\kappa}{\left[2(1-\pi)\kappa - \pi\delta\right](1-\tau_\rho)}\,, \tag{11}$$

$$\phi_t \equiv \phi = \frac{\varepsilon}{\gamma A\left[2(1-\pi)\kappa - \pi\delta\right](1-\tau_\rho)}\,. \tag{12}$$

The technical conditions of (9) and (10) ensure that $R > 0$ and $0 < \phi < 1$. In addition, since the participation constraint (7) holds with strict inequality under (9) and (10), a borrower would like to borrow as much as possible; implying that the feasibility constraint (8) indeed binds. Thus, for the given parameter values, the equilibrium loan contract at time

t, $C_t = (R_t, q_t, \phi_t)$, is given by (8) with equality, (11), and (12).

We can then obtain from (12) an interesting and important result that the equilibrium monitoring probability ϕ increases with the tax rate on capital income. This result arises from the fact that increasing capital income taxation will lead to greater incentives for borrowers with successful projects to report project failures instead, as they would have to pay a higher loan rate required by lenders to compensate for the loss of revenue due to the higher taxation. Consequently, more frequent monitoring is required to keep the incentive compatibility constraint binding. To the extent that the *ex post* monitoring represents a form of credit market inefficiency, our result suggests that capital income taxation worsens the credit market distortions by inducing a greater deadweight loss associated with wasteful monitoring activities.

IV. Optimal Taxation: Growth Maximizing

We now explore in this section the impact of capital income taxation, via the credit market channel, on capital accumulation and growth. To this end, we first derive the equilibrium dynamics of aggregate capital stock.

Under the given return structure of the capital-producing projects and the equilibrium contracts described in the previous sections, the aggregate capital stock in the economy evolves according to the following equation:

$$K_{t+1} = \left[2(1-\pi)\kappa - \pi\phi\delta\right](1-\tau_w)w_t . \tag{13}$$

Making use of (2), we can obtain the following constant growth rate of capital stock:

$$g \equiv \frac{K_{t+1}}{K_t} = A(1-\gamma)\left[2(1-\pi)\kappa - \pi\phi\delta\right](1-\tau_w) . \tag{14}$$

Such simplified economic dynamics in the model economy is largely due to the AK-type of production function, which makes the wage rate proportional to the capital stock, and the linear return structure of the capital-producing projects in the model.

On the other hand, under the equilibrium loan contract, the government's budget constraint in period t can be written as

$$\begin{aligned} \alpha Y_t &= \tau_w w_t + 0.5\tau_\rho(1-\pi)\{\kappa\rho_t[(1-\tau_w)w_{t-1} + q_{t-1}] - R_{t-1}q_{t-1}\} + 0.5\tau_\rho\left[(1-\pi)R_{t-1} - \pi\phi\delta\rho_t\right]q_{t-1} \\ &= \tau_w w_t + 0.5\tau_\rho\rho_t\left[2(1-\pi)\kappa - \pi\phi\delta\right](1-\tau_w)w_{t-1}. \end{aligned}$$

Substituting the factor prices in (2) and (3), as well as (13), into the above equation, the government budget constraint can be rewritten as

$$\alpha = (1-\gamma)\tau_w + 0.5\gamma\tau_\rho . \tag{15}$$

This way of writing the government budget constraint is quite revealing with regard to the intuition pointed out in the previous studies of similar models that capital income taxation is growth promoting. This is because, from (15), it is clear that an increase in the tax rate on capital income, τ_ρ, will be accompanied by a decrease in the tax rate on labor income, τ_w. This results in higher after-tax labor income out of which young individuals can (and will) save, which in turn translates into faster capital accumulation and growth.

Substituting (15) into (14), we have

$$g = A(1-\gamma)[2(1-\pi)\kappa - \pi\phi\delta](1 - \frac{\alpha - 0.5\gamma\tau_\rho}{1-\gamma}), \tag{16}$$

or, equivalently,

$$\ln g = \ln(1 + \frac{0.5\gamma\tau_\rho - \alpha}{1-\gamma}) + \ln[2(1-\pi)\kappa - \pi\phi\delta] + \ln A(1-\gamma). \tag{17}$$

Therefore, increasing capital income taxation generates two opposing effects on growth. The first term on the right-hand-side of (17) reflects the beneficial effect through increasing loan supply that has been previously argued. More importantly, recalling (12), the second term on the right-hand-side of (17) captures the role of asymmetric information: a higher taxation on capital income introduces a negative effect on growth by worsening credit market distortions as it induces more frequent costly auditing.

It is worth to note that, if there is no information asymmetry in this model ($\delta = 0$), the second term on the right-hand-side of (17) will become a constant and hence the previous result that the growth rate is monotonically increasing in the capital income tax, as in Uhlig and Yanagawa (1996) and Caballé (1998), will be restored.[8] However, in the presence of asymmetric information, i.e., $\delta > 0$, it follows from (17) that the relationship between capital income taxation and growth in the economy is non-monotonic. In fact, it can be shown that this relationship is hump shaped: the growth rate rises initially with the capital income taxation but eventually declines when the tax rate on capital income, and consequently the induced credit market distortions, becomes too high.

To explicitly solve for the tax rate on capital income that maximizes growth, one can obtain the following first order condition from (17):

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[8] In this case, the optimal policy is to set the capital income tax as high as possible. Since the technical condition (10) is needed to ensure borrowers' participation in the loan market, the highest possible tax rate on capital when δ=0 is given by $1 - [\varepsilon / 2\gamma^2 A(1-\pi)\kappa]$ (< 1).

$$\frac{\partial \ln g}{\partial \tau_\rho} = \frac{0.5\gamma/(1-\gamma)}{1+(0.5\gamma\tau_\rho - \alpha)/(1-\gamma)} - \frac{\pi\delta}{2(1-\pi)\kappa - \pi\phi\delta} \cdot \frac{\partial \phi}{\partial \tau_\rho} = 0 .$$

Recalling the determination of ϕ from (12), we can solve the optimal τ_ρ as

$$\tau_\rho^* = 1 - \frac{1}{\gamma}\sqrt{\frac{(1-\alpha-0.5\gamma)\pi\delta\varepsilon}{A(1-\pi)\kappa[2(1-\pi)\kappa - \pi\delta]}} . \tag{18}$$

Furthermore, to ensure (18) is indeed a maximum solution, one can readily verify that the following second order condition holds:

$$\frac{\partial^2 \ln g}{\partial \tau_\rho^2} = -\frac{0.25\gamma^2}{(1-\gamma+0.5\gamma\tau_\rho - \alpha)^2} - \frac{\delta^2\pi^2}{[2(1-\pi)\kappa - \delta\pi\phi]^2}\left(\frac{\partial \phi}{\partial \tau_\rho}\right)^2 - \frac{\delta\pi}{[2(1-\pi)\kappa - \delta\pi\phi]}\frac{\partial^2 \phi}{\partial \tau_\rho^2} < 0 .$$

It is clear from (18) that $\tau_\rho^* < 1$. Under the parameter configurations satisfying (9), (10) and a sufficiently small α to guarantee that $1-\alpha-0.5\gamma > 0$ holds, it is easy to show that

$$(1-\tau_\rho^*)^2 = \frac{(1-\alpha-0.5\gamma)\pi\delta\varepsilon}{\gamma^2 A(1-\pi)\kappa[2(1-\pi)\kappa - \pi\delta]} < 1-\tau_\rho^* ,$$

which implies that $\tau_\rho^* > 0$. Thus, the optimal tax rate on capital income in our model is well defined, satisfying $0 < \tau_\rho^* < 1$.

Thus, we can readily obtain from (18) the key implication of our analysis: the credit market friction lowers the optimal taxation on capital income. This can be seen in two ways. Firstly, in the presence of asymmetric information in the credit market ($\delta > 0$), the optimal tax rate on capital income is lower than its counterpart in the case with full information. Secondly, it is clear that the optimal tax rate on capital income is decreasing in the severity of asymmetric information in the credit market ($\partial \tau_\rho^* / \partial \delta < 0$). The intuition for these two observations is as follows. Since capital income taxation worsens the credit market distortions originated from the information asymmetry, one needs be more conservative in setting the tax rate on capital in order to avoid causing excessive credit market distortions, in addition to that caused by the information asymmetry directly, and the subsequent adverse effects on growth. From the policy perspective, our analysis suggests that countries with severe asymmetric information in their credit markets should tax relatively less on capital income.

It follows from substituting (18) into (12) that the optimal auditing probability is given by

$$\phi^* = \sqrt{\frac{(1-\pi)\kappa\varepsilon}{A(1-\alpha-0.5\gamma)\pi\delta[2(1-\pi)\kappa - \pi\delta]}} , \tag{19}$$

which can be easily shown to be decreasing with the informational cost of δ when $0<\delta<(1-\pi)\kappa/\pi$, which is satisfied under condition (9). This negative relationship implies that, as the credit market frictions worsen, economies should adopt more relaxed auditing policies (by lowering ϕ). Intuitively, on the one hand, the worsening of asymmetric information calls for a more stringent auditing policy in order to keep the incentive compatibility condition in check. On the other hand, as a greater credit market friction lowers the optimal tax rate on capital and hence lessens the incentive problem in the credit market, less auditing is required. The negative relationship arises since, for a small enough δ, the second consideration always dominates.

Furthermore, with the tax rate on capital and the auditing probability determined optimally as in (18) and (19), respectively, it follows from (16) that the optimal growth rate is given by

$$g^{*}=A(1-\gamma)\left[2(1-\pi)\kappa-\sqrt{\frac{(1-\pi)\kappa\varepsilon\pi\delta}{A(1-\alpha-0.5\gamma)[2(1-\pi)\kappa-\pi\delta]}}\right]\left(1-\frac{\alpha-0.5\gamma\tau_{\rho}^{*}}{1-\gamma}\right)$$

Since $\partial\tau_{\rho}^{*}/\partial\delta<0$, it is easy to see that $\partial g^{*}/\partial\delta<0$. Thus, not surprisingly, the optimal growth rate in the model economy decreases with the extent of the credit market friction.

While beyond the scope of the present paper, the above implications can be potentially testable once appropriate proxies are available. Assuming governments are setting the taxation policy (and the auditing probability) optimally to maximize growth, one can expect to observe in cross-country data that the tax rate on capital, the growth rate and the intensity of auditing are negatively correlated with the extent of market friction.

V. Optimal Taxation: Welfare Maximizing

In this section, we examine the optimal taxation policy from the welfare point of view. Some studies in the literature have examined both on growth-maximizing and welfare-maximizing taxation policies, and have obtained different results. For example, while the growth-maximizing and welfare-maximizing tax rates are found to be the same in Barro (1990), there are divergences between the two in Futagami, Morita, and Shibata (1993), Lau (1995), and Penalosa and Turnovsky (2005). Thus, two questions are of particular interest here. One is whether or not the welfare-maximizing taxation policy in our model will be the same as one derived in the previous section that maximizes growth. The other is whether or not the presence of credit market friction will again lower the optimal taxation on capital in the case of welfare maximization.

Since agents in our model only consume when they are old, the welfare calculation for each generation needs only focus on the payoffs to the members of that generation when they are old. Let Π_t denotes the total payoffs to all members of generation *t*-1, in period *t* when they are old. Then the welfare of all generations can be expressed by

$$\Pi = \Pi_0 + \beta\Pi_1 + \beta^2\Pi_2 + ... = \sum_{t=0}^{+\infty}\beta^t\Pi_t \,,$$

where $0 < \beta < 1$ is the discount rate (of the social planner).

Recalling the population composition of generation *t*-1, the old in period *t* consists of a unit measure of lenders, a measure π of borrowers with failed projects, and a measure $1-\pi$ of borrowers whose projects succeeded. Hence, based on the equilibrium contracts, the payoff to all lenders of generation *t*-1 is equal to $\varepsilon(1-\tau_w)w_{t-1}$ from the zero-profit condition of (6) and the binding resource constraint of (8). Since borrowers with failed projects receive zero payoffs, from the law of large numbers, the payoff to all borrowers of generation *t*-1 is given by:

$$\begin{aligned}&(1-\pi)(1-\tau_\rho)\{\kappa\rho_t[(1-\tau_w)w_{t-1}+q_{t-1}]-R_{t-1}q_{t-1}\}\\&=(1-\pi)(1-\tau_\rho)(2\kappa\rho_t-R_{t-1})(1-\tau_w)w_{t-1}.\end{aligned}$$

Thus, recalling (2), (11), (12) and (13), the welfare of generation *t*-1 is equal to

$$\begin{aligned}\Pi_t &= 0.5\varepsilon(1-\tau_w)w_{t-1}+0.5(1-\pi)(1-\tau_\rho)(2\kappa\rho_t-R_{t-1})(1-\tau_w)w_{t-1}\\&=0.5\left[\varepsilon+(1-\pi)(1-\tau_\rho)\left(2\gamma A\kappa-\frac{2\varepsilon\kappa}{[2(1-\pi)\kappa-\pi\delta](1-\tau_\rho)}\right)\right](1-\tau_w)w_{t-1}\\&=0.5\left[2(1-\pi)(1-\tau_\rho)\gamma A\kappa-\frac{\varepsilon\pi\delta}{[2(1-\pi)\kappa-\pi\delta]}\right](1-\tau_w)w_{t-1}\\&=0.5(1-\tau_\rho)\gamma A\left[2(1-\pi)\kappa-\frac{\varepsilon\pi\delta}{\gamma A[2(1-\pi)\kappa-\pi\delta](1-\tau_\rho)}\right](1-\tau_w)w_{t-1}\\&=0.5(1-\tau_\rho)\gamma A[2(1-\pi)\kappa-\pi\phi\delta](1-\tau_w)w_{t-1}=0.5(1-\tau_\rho)\gamma AK_t.\end{aligned}$$

Since the economy reaches the balanced growth path right away, whereby the capital stock grows a constant rate of *g*, the aggregate social welfare for all generations is represented by

$$\Pi=\sum_{t=0}^{\infty}\beta^t 0.5(1-\tau_\rho)\gamma AK_t=0.5(1-\tau_\rho)\gamma AK_0\sum_{t=0}^{\infty}\beta^t g^t=\frac{0.5\gamma A(1-\tau_\rho)K_0}{1-\beta g}\,, \tag{20}$$

where K_0 is the initial aggregate capital stock. Taking the logarithmic transformation of (20), we obtain

$$\ln\Pi=\ln(0.5\gamma AK_0)+\ln(1-\tau_\rho)-\ln(1-\beta g)\,.$$

The welfare-maximizing tax rate on capital must satisfy the first order condition:

$$\frac{\partial \ln \Pi}{\partial \tau_\rho} = -\frac{1}{1-\tau_\rho} + \frac{\beta}{1-\beta g}\frac{\partial g}{\partial \tau_\rho} = 0$$

where g is the growth rate given by (16) in the previous section.

It follows then that the welfare-maximizing tax rate on capital income (call it τ_ρ^{**}) must be smaller than the growth-maximizing rate (call it τ_ρ^{*}), because $\left.\frac{\partial \ln \Pi}{\partial \tau_\rho}\right|_{\tau_\rho=\tau_\rho*} < 0$ and g is a concave function of τ_ρ.[9] In addition, utilizing the first order condition and the concavity of g, it is easy to check that the second order condition also holds at $\tau_\rho = \tau_\rho^{**}$:

$$\frac{\partial^2 \ln \Pi}{\partial \tau_\rho^2} = \frac{\beta}{1-\beta g}\frac{\partial^2 g}{\partial \tau_\rho^2} < 0 .$$

We can glean the intuition for the result of $\tau_\rho^{**} < \tau_\rho^{*}$ from examining (20). The effect of capital income tax on the social welfare can be decomposed into two components: one is the effect on the initial generation of the old and the other is on all future generations. It is obvious that capital income taxation reduces the welfare of the initial old, to whom the capital income accrues. It is also clear from (20) that capital income taxation affects the welfare of all future generations through its effect on the growth rate g. Thus, capital income taxation generates one additional negative effect on the welfare, comparing to those on the growth rate. Consequently, the welfare-maximizing tax rate on capital is lower than its counterpart in growth maximization.[10]

To see whether the presence of the credit market friction also lower the welfare-maximizing tax rate on capital, by differentiating the first order condition with respect to the informational cost δ, we can obtain the following:

$$\left[\frac{1}{(1-\tau_\rho^{**})^2} - \frac{\beta}{1-\beta g}\frac{\partial^2 g}{\partial {\tau_\rho}^2}\right]\frac{\partial \tau_\rho^{**}}{\partial \delta} = \frac{\beta^2}{(1-\beta g)^2}\left(\frac{\partial g}{\partial \delta}\right)\left(\left.\frac{\partial g}{\partial \tau_\rho}\right|_{\tau_\rho=\tau_\rho^{**}}\right) + \frac{\beta}{1-\beta g}\left(\frac{\partial^2 g}{\partial \delta \partial \tau_\rho}\right).$$

Since $\tau_\rho^{**} < \tau_\rho^{*}$, the concavity of g with respect to τ_ρ implies that $\left.\frac{\partial g}{\partial \tau_\rho}\right|_{\tau_\rho=\tau_\rho^{**}} > 0$. In addition, one can show from (12) and (14) that $\frac{\partial g}{\partial \delta} < 0$ and $\frac{\partial^2 g}{\partial \delta \partial \tau_\rho} < 0$. It then follows

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[9] The concavity of g *in* τ_ρ can be shown from (16) and noting that ϕ is given by (12).

[10] It is worth to point out that this result does not arise from the presence of asymmetric information in our model. It is rather easy to see that the same result holds when $\delta = 0$. Indeed, this result, and intuition of it, is similar to those in Futagami, Morita, and Shibata (1993) and Lau (1995).

that $\frac{\partial \tau_{\rho}^{**}}{\partial \delta} < 0$, i.e., the welfare-maximizing tax rate on capital indeed falls as the informational cost rises.

To summarize, though we cannot solve for the welfare-maximizing tax rate on capital analytically, we can conclude this section with the following two results based on the above analysis. First, the welfare-maximizing and the growth-maximizing tax rates on capital are different in our model, with the former being lower than the latter. Second, the argument that taxation on capital income should be reduced by the presence of information friction in the credit market also holds from the welfare point of view.

VI. Concluding Remarks

Instead of assuming a simple conversion process from consumption goods to capital goods as in typical macroeconomic models, we take a more serious approach with regard to the process of capital accumulation by assuming that capital is produced by risky projects that are financed internally by wage income and externally through a credit market with informational friction. Specifically, we have analyzed the growth and welfare implications of capital vs. labor taxation in a setting where borrowers have private information regarding the investment project realizations and state verifications by lenders are costly. Under this information structure, equilibrium loan contracts require a positive probability of *ex post* verification to induce truth-telling from borrowers, and hence give rise to credit market distortions as verification is costly. It is shown that the credit market distortions are worsened by increasing taxation on capital income, as it leads to greater monitoring efforts, and thus deadweight losses, to keep the incentive compatibility condition in check. It is because this added market inefficiency caused by capital income taxation, that we found it not optimal to set the tax rate on capital to be as high as possible, contrasting to the result established in previous studies of the similar models without informational frictions. Indeed, both the growth-maximizing and the welfare-maximizing tax rates on capital are found to be strictly less than one and decreasing with the extent of the credit market friction. From the policy perspective, our analysis yields the following cross-country implications: (i) economies with more severe problem of information asymmetry in marketplace should impose a smaller tax rate on capital income; and (ii) auditing requirements or, loosely speaking, contract enforcement should be made more lax as the market frictions worsen.

Comparing to Ho and Wang (2007), the present paper makes several new contributions.

First, we extend the former analysis to an environment in which capital-producing projects are financed by both internal and external funds, where the external funds are intermediated through a credit market that is plagued with costly state verification – a widely discussed form of credit market imperfection in the literature. Even though we find the same qualitative implication about the optimal taxation on capital, we think the current study is still important and useful as a formal robustness check with regard to different model specifications and different information structures. Second, not only that information asymmetry can be of different forms, these different varieties of informational frictions are likely to coexist in the marketplace at the same time. In such a likely event, our present analysis then can be interpreted as providing an additional channel through which informational frictions justify a low taxation on capital income. Third, while Ho and Wang (2007) only focuses on the optimal taxation from the standpoint of economic growth, the present paper includes a formal analysis on the optimal taxation policy from the welfare perspective as well. In this connection, our result here regarding the welfare-maximizing taxation policy further strengthens the previous call for a more conservative tax policy on capital income in the presence of credit market frictions.

When the credit market, through which capital-producing projects are financed, is plagued with asymmetric information, taxation on capital creates a distortion in borrowers' incentives insofar it leads to greater tendency to cheating behavior. To counter this increased likelihood for cheating, more stringent contract enforcement is then needed. Consequently, since enforcement is costly, capital income taxation generates additional deadweight losses in terms of economic resources, growth, and welfare. On the whole, our analysis here presents a robust argument for lowering capital income taxation in the presence of credit market frictions.

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