

**Capital Income Taxation Revisited:
The Roles of Information Friction and External Finance***

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August 2014

Abstract

This paper reexamines the classical issue of optimal taxation on capital income in an overlapping-generations growth model where the risky capital-producing projects are financed partially with external funds in the presence of costly state verification. In this context, we first show that the information friction creates standard credit market distortions that are exacerbated by both capital income taxation and external financing. We subsequently show from both growth and welfare perspectives that the optimal tax rate on capital income decreases with the severity of asymmetric information and the extent of external financing. Alternatively, our analysis suggests that the presence of informational friction in the credit market introduces a rationale for more conservative taxation on capital, especially when the reliance on external financing is high.

JEL Classification: D82, H21, O41

Keywords: Asymmetric information; Credit market; Capital income taxation; Economic growth

* We thank Ping Wang and seminar participants at Institute of Economics, Academia Sinica, World Finance Conference 2013, Hong Kong Economic Association Workshop on Tax Reform 2013, and Asian Meetings of Econometric Society 2014 for helpful comments. This research project was fully supported by a grant from the Research Grant Council of Hong Kong (Project No. 148309).

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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. In this respect, Chamley (1986) and Judd (1985) provided the pioneering studies in which the optimal tax on capital income is shown to be zero in the standard Ramsey-type growth model, thus shifting the 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 stem from the different modeling assumptions regarding the life-cycle considerations of agents in the 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

¹ This classical result has since been extended in a number of ways, including to the context of endogenous growth where both physical capital and human capital are reproducible factors (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, and show that increasing the tax rate on capital income leads to higher economic growth under plausible parameterizations. In a similar vein, Jones and Manuelli (1992) finds 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.

As a precursor of the present paper, Ho and Wang (2007) consider an overlapping-generations model in which financing the capital-producing projects is subject to the adverse selection problem. In particular, it was shown that, when the risk types of borrowers for capital-producing projects are unknown to lenders, capital taxation worsens the credit market distortions 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 with the results established in Uhlig and Yanagawa (1996) and Caballé (1998), the optimal tax rate on capital income will not be set as high as possible (though still be positive).

The present paper, however, differs from the analysis of Ho and Wang (2007) in two specific aspects. First, unlike the adverse selection type of asymmetric information considered in Ho and Wang (2007), the source of information asymmetry in the present model stems from the privately observed project returns and the costly state verification by lenders. Since different types of informational friction 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 the different specifications of the 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, which is absent in the benchmark economy with full information. Second, in contrast with Ho and Wang (2007) in which borrowers and lenders in each generation are of an equal size and paired into an one-to-one matching, we consider a more general environment here in which both borrowers and lenders work when they are young and their relative population size can take any value between zero and one. Viewing borrowers' own wages as internal fund and lenders' wages as external fund, the relative size of lenders to borrowers in each generation can be interpreted as a proxy for the degree of dependency on external financing in project

investment by borrowers.³ As such, the present model allows us to explore the implications of the interaction between asymmetric information and the extent of external financing on verification strategies, economic growth, and optimal tax policy.

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 obtains because increasing tax on capital income skews the incentives of borrowers 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. However, the relationship between the optimal auditing probability and the severity of asymmetric information is non-monotonic. Finally, our welfare analysis reveals that the welfare-maximizing tax rate on capital is even smaller than its growth-maximizing counterpart, and is also decreasing in the severity of the credit market friction.

Furthermore, we show that the reliance on external financing has the following impacts on credit market distortions and hence growth and welfare. First, we find that a higher fraction of lenders relative to borrowers gives rise to a higher verification probability. Intuitively, an increase in relative size of lenders to borrowers implies that each investment project will consist of a greater fraction that is financed externally through borrowing. This greater reliance on external financing exacerbates the distorted incentives in the credit market caused by asymmetric information, which in turn requires a higher auditing probability to keep the incentive compatibility constraint binding. Given this distortion arising from external financing, consequently, we show that the optimal (growth maximizing and welfare maximizing) capital income tax rates and the optimal growth rate

³ Internal finance is a standard ingredient in many macro models with CSV type of credit market frictions, see e.g. Bernake and Gertler (1989), Boyd and Smith (1997) and Joydeep (1998). We follow Bernake and Gertler (1989) and Boyd and Smith (1997) in modeling borrowers' wage income as the source of internal funds. In Joydeep (1998), internal funds are in form of bequests transferred from old borrowers to their off-springs. In these papers, external funds are needed because internal funds are assumed to be not enough to fully cover the (fixed) investment project size. But in the current paper, borrowers' desire for external funds arises because their expected payoff increases with the project size.

are decreasing with the relative size of lenders (or, the extent of external financing).

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 to accumulate 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 multi-period life cycle model, Conesa et al. (2009) illustrates that, when age-dependent labor income tax is not feasible, a positive tax rate on capital is optimal in order to mimic the required age-dependent tax structure for optimality (as established by Erosa and Gervais 2002). In a Ramsey model with formal and informal sectors, Penalosa and Turnovsky (2005) shows that capital should be 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. In section IV, we will discuss the implications of the credit market equilibrium and the population composition change as well as the optimal tax policy. We then conduct the welfare analysis of the taxation policy in Section V. 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 θ fraction of lenders and $1-\theta$ fraction of borrowers. While

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.

each of young lenders and borrowers owns one unit of labor, only the latter is endowed with 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

Each (young) lender supplies his endowed labor inelastically to earn wage income which is then deposited into a bank. The role of banks is to simply collect deposits and make loans, as well as enforce loan contracts (by verifying the project outcomes). We assume that any lender can establish and operate as a bank. Since there is a continuum of lenders, the market for the financial intermediary services is assumed to be perfectly competitive and hence all banks must offer the same deposit rate to lenders and make zero profit. In particular, there is a safe default technology (available to anyone) that converts one unit of time t consumption goods into ε units of time $t+1$ consumption goods. Such a default technology then serves as the opportunity cost of lending.

Each (young) borrower also first supplies his endowed labor inelastically to earn wage income which is then used as internal funds in his investment project. The investment projects of borrowers, which can be financed both internally and externally, produce an uncertain amount of capital for the next period and are identical *ex ante* across all borrowers. We consider here the simplest return structure of these risky projects: they fail to produce anything with a probability π and produce a positive amount, κ , of capital per unit of investment with a probability $1-\pi$.⁶ Borrowers with successful 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 are observable without cost only to borrowers who operate the respective projects but would cost a bank δ amount (in terms of capital goods) per unit of loan for auditing and verification.

In each period, the government levies taxes on both capital income and wage income 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

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 comparison between our result and theirs most transparent. However, our analysis can be extended to the case with a CRRA utility function over consumption in both periods for agents, when the intertemporal elasticity of substitution is sufficiently low.

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.

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:

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

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:

$$w_t = (1 - \gamma)AK_t, \quad (2)$$

$$\rho_t = \gamma A. \quad (3)$$

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

The credit market in this model operates as follows. As it will become clear later, a young borrower's expected payoff in equilibrium is strictly increasing with the size of the investment project so that he has incentives to approach a bank for external financing (in addition to the internal financing). In each period, funds (after-taxed wages of young lenders) are deposited into banks which in turn lend to borrowers (within the same cohort) in the form of standard loan contracts.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 the actual outcome of a project, *ex post* auditing (or verification) by banks is necessary to prevent borrowers from defaulting on their loans regardless of their projects' actual outcomes. 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)

⁷ As in Gale and Hellwig (1985) and Williamson (1986), the intermediated lending in our model would allow banks to achieve complete insurance against state-dependency in old age consumption since there is no aggregate uncertainty.

loan rate, $q_t (>0)$ is the loan size, and $\phi_t (>0)$ is the probability of auditing when zero outcome is claimed. In the event of auditing, a borrower will be penalized by forfeiting all his income if he is caught of underreporting. As is customary in the literature, we will focus on the equilibrium contract that induces truthful revelation of their projects' returns by the borrowers.

In each period, a large number of banks compete 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 of τ_w , a representative borrower's expected payoff (under truthful revelation) can be written as

$$(1 - \pi)(1 - \tau_\rho)(\kappa\rho_{t+1}Q_t - R_tq_t) \quad (4)$$

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:

$$(\kappa\rho_{t+1}Q_t - R_tq_t) \geq (1 - \phi_t)\kappa\rho_{t+1}Q_t \quad (5)$$

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 project outcome *and* successfully evades the *ex post* auditing by the bank. Second, the competition among banks will drive the economic profit of each bank to zero. Given the opportunity cost of funds and the auditing cost, the zero profit condition of a bank is given by

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

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:

$$\kappa\rho_{t+1} \geq R_t. \quad (7)$$

Finally, given that borrowers are ex-ante identical, the loan size that each borrower obtains

must be the same. Therefore, the following feasibility constraint on loan size should be satisfied:

$$q_t \leq \frac{\theta(1-\tau_w)w_t}{1-\theta}. \quad (8)$$

It is worth to note from (8), which will be binding in equilibrium, that the loan size is increasing with the fraction of lenders θ . This is simply because as the number of lenders increases, a bigger pool of funds is created, enabling each borrower to obtain a larger amount of loans from banks. As a result, the proportion of a borrower's project financed through external borrowing rises with θ and hence it can be interpreted as measuring the extent of external financing in the model economy.

We can now 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,

$$(1-\pi)\kappa - \theta\pi\delta > 0 \quad (9)$$

and

$$\gamma^2 A[(1-\pi)\kappa - \theta\pi\delta](1-\tau_\rho) > \varepsilon \quad (10)$$

which are satisfied with a large enough κ and/or 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 auditing probability from the binding constraint of (5), the zero-profit condition of (6), and a binding feasibility constraint of (8) as, respectively,

$$R_t \equiv R = \frac{\varepsilon\kappa}{[(1-\pi)\kappa - \theta\pi\delta](1-\tau_\rho)}, \quad (11)$$

$$\phi_t \equiv \phi = \frac{\theta\varepsilon}{\gamma A[(1-\pi)\kappa - \theta\pi\delta](1-\tau_\rho)}. \quad (12)$$

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) two interesting and important results. Firstly, the equilibrium auditing 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 banks to compensate for the loss of revenue due to the higher taxation. Consequently, more frequent auditing is required to keep the incentive compatibility constraint binding. To the extent that the *ex post* auditing 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 auditing activities. Secondly, the equilibrium auditing probability ϕ also increases with the external financing parameter θ . To understand this result, recall that as θ grows, so does the size of loan to be received by each borrower. Since it increases the potential gain to a borrower with successful project from claiming otherwise, the auditing probability must increase to suppress this elevated incentive to underreport.

IV. Optimal Taxation: Growth Maximizing

We explore in this section the impacts of capital income taxation and external financing, 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:

$$K_{t+1} = (1 - \theta)[(1 - \pi)\kappa Q_t - \delta\pi\phi q_t]. \quad (13)$$

Making use of (2), (8) with equality and the definition of Q_t , we can obtain the following constant growth rate of capital stock:

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

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

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

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

$$\alpha = (1-\gamma) \tau_w + \gamma \tau_\rho. \quad (15)$$

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

$$g = A(1-\gamma) \left[(1-\pi) \kappa - \theta \pi \phi \delta \right] \left(1 - \frac{\alpha - \gamma \tau_\rho}{1-\gamma} \right), \quad (16)$$

or, equivalently,

$$\ln g = \ln \left(1 + \frac{\gamma \tau_\rho - \alpha}{1-\gamma} \right) + \ln \left[(1-\pi) \kappa - \theta \pi \phi \delta \right] + \ln A(1-\gamma). \quad (17)$$

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

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 $\delta=0$ is given by $1 - [\varepsilon / \gamma^2 A(1-\pi) \kappa] (< 1)$.

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):

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

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

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

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

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

It is clear from (18) that $\tau_\rho^* < 1$. Under the parameter restrictions set by (9) and (10), it is easy to show that

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

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

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 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. Finally, equation (18) indicates that the optimal tax rate on capital income is

negatively related to the reliance on external financing as proxied by θ ($\partial \tau_\rho^* / \partial \theta < 0$). To understand this result, note from the second term of (17) that the negative growth effect of capital income taxation is increasing with θ . Hence, to alleviate the policy distortions, the optimal tax rate on capital income is lower when the reliance on external financing (relative to internal financing) in the economy is greater.

Under the optimal tax rate on capital income, it follows from substituting (18) into (12) that the optimal auditing probability is given by

$$\phi^* = \sqrt{\frac{(1-\pi)\kappa\varepsilon}{A(1-\alpha)\pi\delta[(1-\pi)\kappa - \theta\pi\delta]}} \quad (19)$$

which can be easily shown to be decreasing with the informational cost of δ when $0 < \delta < (1-\pi)\kappa/2\theta\pi$ and then increasing when $(1-\pi)\kappa/2\theta\pi < \delta$, but still less than $(1-\pi)\kappa/\theta\pi$ as implied by (9). This non-monotonic relationship implies that, as the credit market frictions worsen, economies should adopt more relaxed auditing policies (by lowering ϕ) as long as the market frictions remain relatively small, but should step up their auditing efforts when the market frictions become too severe. 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 income and hence lessens the incentive problem in the credit market, less auditing is required. When the informational cost is relatively small the second consideration dominates, while the contrary is true when the informational cost is relatively large. In addition, ϕ^* is increasing with the extent of external financing. There are two counter-acting effects at work behind this result. First, when θ rises, more frequent auditing is required to keep the incentive compatibility constraint in balance. However, increasing in θ reduces the optimal capital income tax rate and thereby mitigates the cheating incentives, leading to a lower auditing probability. The positive relation between the optimal auditing probability and the fraction of external financing by borrowers arises because the first effect dominates the second in our model.

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

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

Since $\partial \tau_\rho^* / \partial \delta < 0$ and $\partial \tau_\rho^* / \partial \theta < 0$ hold, it is easy to see that $\partial g^* / \partial \theta < 0$ and $\partial g^* / \partial \delta < 0$ are satisfied. Thus, the optimal growth rate in the model economy decreases both with the extent of information friction and the extent of external financing.

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 optimally to maximize growth, the above results suggest that 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 and the fraction of lenders.

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 information friction, as well as a greater reliance on external financing, in the credit market will again lower the optimal taxation on capital from the perspective 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

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

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 θ fraction of lenders and $1 - \theta$ fraction of borrowers, of which 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

$(1-\theta)\varepsilon q_{t-1}$ from the zero-profit condition of (6), which is equal to $\varepsilon(1-\tau_w)w_{t-1}$ after using 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:

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

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

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

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

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

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

$$\ln \Pi = \ln(\gamma A K_0) + \ln(1-\tau_\rho) - \ln(1-\beta g).$$

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 lowers 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:

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

Since $\tau_\rho^{**} < \tau_\rho^*$, the concavity of g with respect to τ_ρ implies that $\frac{\partial g}{\partial \tau_\rho} \Big|_{\tau_\rho = \tau_\rho^{**}} > 0$. 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

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

Similarly, one can easily show that the welfare maximizing optimal capital income tax rate is decreasing with the fraction of lenders as well through total differentiating the first order condition with respect to θ :

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).

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

Since we can obtain $\frac{\partial g}{\partial \theta} < 0$ and $\frac{\partial^2 g}{\partial \theta \partial \tau_\rho} < 0$ from (12) and (14), together with the

concavity of g in τ_ρ , it follows from the above equation that $\frac{\partial \tau_\rho^{**}}{\partial \theta} < 0$.

To summarize, though we cannot solve for the welfare-maximizing tax rate on capital analytically, we can conclude this section with the following three observations 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. At last, the negative relation between the optimal capital income tax rate and the extent of external financing also maintains in the case of welfare maximizing.

VI. Concluding Remarks

We have analyzed the growth and welfare implications of taxation on capital income vis-a-vis on labor income 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 in order 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 auditing 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

initially but more stringent as the market frictions become very serious.

In addition, we have considered an environment where both lenders and borrowers work to derive labor income when they are young so as to introduce both internal and external financing for the investment projects. While the lenders' wage incomes are deposited at banks and eventually become the source of external funds, the borrowers' wages are for internal investment use. In such a setting, it is shown that the extent of external financing by borrowers can have nontrivial effects on the auditing strategies, government policies and growth rate, which are not present in a standard growth model without credit market frictions. In particular, increasing the extent of external financing by borrowers distorts their incentive in a way favoring misreporting and hence a more frequent auditing strategy is needed to resume the balance of the incentive constraint. As a result, the optimal capital income tax rate and the growth rate are both decreasing with the extent of external financing by borrowers. These claims are also potentially testable using cross-country data samples.

Comparing with Ho and Wang (2007), the present paper makes several contributions. First, we extended the former analysis to an environment in which the population is no longer equally shared between lenders and borrowers. Banks arises naturally in this set up as in Williamson (1986) to pool up funds from lenders, make loans to borrowers and verify their investment returns. Our analysis in this regard offers some new insights about how external financing, information friction, and taxation policy interact to influence economic growth and social welfare. 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. Although 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. 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.

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. 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, especially when the extent of external financing by borrowers is high. 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 information friction and large fraction of external financing (relative to internal financing) by borrowers in the credit market.

References:

- Barro, R., 1990. "Government spending in a simple model of endogenous growth." *Journal of Political Economy* 98, S103-S125.
- Bernake, B., Gertler, M., 1989. "Agency cost, net worth and business fluctuations." *American Economic Review* 79, 14-31.
- Boyd, J. H., Smith B. D., 1997. "Capital market imperfections, international credit markets, and nonconvergence." *Journal of Economic Theory* 73, 335-364.
- Caballé, J., 1998. "Growth effects of taxation under altruism and low elasticity of intertemporal substitution." *Economic Journal* 108, 92-104.
- Chamley, C., 1986. "Optimal taxation of capital income in general equilibrium with infinite lives." *Econometrica* 54, 607-622.
- Chen, B.L. (2007) "Factor Taxation and Labor Supply in a Dynamic One-Sector Growth Model," *Journal of Economic Dynamics and Control* 31(12), 3941-3964.
- Conesa, J. C., S. Kitao, and D. Krueger (2009) "Taxing Capital? Not a Bad Idea After All!," *American Economic Review* 99 (1), 25–38.
- Erosa, A. and M. Gervais (2002) "Optimal Taxation in Life-Cycle Economies," *Journal of Economic Theory* 105, 338–369.
- Futagami, K., Morita, Y., Shibata, A. 1993. "Dynamic analysis of an endogenous growth model with public capital." *Scandinavian Journal of Economics* 95, 607-625.
- Gale, D., M. Hellwig. 1985. "Incentive compatible debt contracts: the one period problem." *Review of Economic Studies* 52: 647-663.
- Ho, W.H., Wang, Y., 2007. "Factor income taxation and growth under asymmetric information." *Journal of Public Economics* 91, 775-789.
- Jacobs, B., Bovenberg, A.L., 2004. "Optimal capital income taxation with endogenous human capital formation." Manuscript.
- Jones, L.E., Manuelli, R.E., 1992. "Finite lifetimes and growth." *Journal of Economic Theory* 58, 171-197.
- Jones, L.E., Manuelli, R.E., Rossi, P.E., 1997. "On the optimal taxation of capital income." *Journal of Economic Theory* 73, 93-117.
- Joydeep, B., 1998. "Credit market imperfections, income distribution and capital accumulation." *Economic Theory* 11, 171-200.
- Judd, K.L., 1985. "Redistributive taxation in a simple perfect foresight model." *Journal of Public Economics* 28, 59-83.
- Lau, S.H. Paul, 1995. "Welfare-maximizing vs. growth-maximizing shares of government investment and consumption." *Economic Letters* 47, 351-359.
- Lucas, R.E., 1990. "Supply-side economics: an analytical review." *Oxford Economic Papers* 42, 293-316.

- Milesi-Ferretti, G.M., Roubini, N., 1998. "On the taxation of human and physical capital in models of endogenous growth." *Journal of Public Economics* 70, 237--254.
- Pecorino, P., 1993. "Tax structure and growth in a model with human capital." *Journal of Public Economics* 52, 251-271.
- Penalosa, C.G., Turnovsky, S.J., 2005. "Second-best optimal taxation of capital and labor in a developing economy." *Journal of Public Economics* 89, 1045-1074.
- Rebelo, S., 1991. "Long run policy analysis and long run growth." *Journal of Political Economy* 99, 500-521.
- Uhlig, H., Yanagawa, N., 1996. "Increasing the capital income tax may lead to faster growth." *European Economic Review* 40, 1521-1540.
- Williamson, S.D. 1986. "Costly monitoring, financial intermediation, and equilibrium credit rationing." *Journal of Monetary Economics* 18. 159-179.
- Yakita, A., 2003. "Taxation and growth with overlapping generations." *Journal of Public Economics* 87, 467-487.