Asymmetric Information, Auditing Commitment and Economic Growth

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Abstract

We analyze in this paper the growth and welfare consequences arising from the lack of auditing commitment in a credit market with costly state verification. Specifically, two endogenous growth models, of which one allows lenders to commit to costly auditing strategies to identify borrowers' investment returns and the other does not, are compared. We show that the inability to commit acts as an additional source of informational friction that leads to more stringent contractual terms, which in turn result in lower capital accumulation, growth, and welfare. In addition, when a tax on capital is considered, the tax-induced investment distortions are amplified by the absence of auditing commitment. From the policy perspective, our analysis can be interpreted as suggesting a new micro-economic channel through which institutional failings hinder economic growth and social welfare.

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1 Introduction

There has been a growing interest, and body of work, in the literature in applying principal-agent contract theories to analyze macroeconomic issues such as business cycles, capital accumulation, and economic growth. For example, Williamson (1986, 1987) studies the impact of equilibrium credit rationing in a financial market with costly state verification problem. In a model with agency costs varying inversely with borrowers' net worth, Bernanke and Gertler (1989) argue that the credit market imperfection can amplify and propagate the external shocks to create significant economic fluctuations. Bose and Cothren (1996, 1997) examine the adverse effects of *ex-ante* asymmetric information on growth in a model that allows for both rationing and screening contracts. More recently, Ho and Wang (2005, 2007) investigate the impacts of adverse selection in the credit market on public capital provision, taxation policy, and economic growth. However, it is well recognized that the self-selection equilibrium used in many of these applications does not satisfy the time consistency property, as long as there are costs associated with the revelation principle in sustaining such an equilibrium. This problem of time (in)consistency can be simply stated as follows. In a typical principal-agent environment with the presence of asymmetric information, if agents will end up self selecting themselves according to their true types in equilibrium, the principal has the incentive to forgo the costly enforcement activities, such as screening or auditing as the case may be, that are specified and required in equilibrium contracts in order to induce the self selection of agents at the first place.[1] Moreover, there is another drawback associated with the self-selection equilibrium: it implies that all agents in those principal-agent setups will not lie about their types in equilibrium. This predication certainly appears to be at odds with the casual observation that fraudulent reporting and claims made by individuals and companies are in fact quite pervasive in real life. Indeed, some anecdotal and empirical evidences have been well documented.[2]

The present paper intends to study the credit market equilibrium that is free from the

[1] Perhaps less obvious, similar argument also applies in the cases with rationing contracts that do not require costly contract enforcement (see Bencivenga and Smith 1993, Bose and Cothren 1996 and 1997). In equilibrium, once the lenders announced the loan contract terms including the probability of obtaining funds, borrowers will self select in accordance with their own types. Then rationing is no longer optimal for the lenders: they can simply deny loans to the undesirable borrowers and allocate all funds to the borrowers of the preferred type.

[2] Tax evasion provides an obvious example of fraudulent behavior by agents in the principal-agent context. In this regard, the study by Andreoni, Erard and Feinstein (1998) estimated that the nominal tax gap, defined as the difference between the income taxes households owed and what they actually reported and paid voluntarily, had almost a fivefold increase from $22.7 billion to $95.3 billion in the United States for the tax years from 1973 to 1992.

above time inconsistency problem and explore its implications on economic growth and welfare in an endogenous growth framework. Specifically, we consider in our model a credit market in which investment returns are privately observed by borrowers and state verification by lenders is costly. Following the approach in Khalil (1997) and Khalil and Parigi (1998), we will assume that lenders cannot commit to a auditing strategy when making their loan offers to borrowers, and the interaction between lenders and borrowers is modeled as a two-stage problem. In the first stage, lenders choose and offer the optimal contracts consisting of the loan rates and the loan size. In the second stage, lenders and borrowers play a simultaneous Nash game to decide on their auditing and cheating strategies, respectively. Under this setup, the auditing strategy is not announced in the first stage as a part of the contractual terms due to the lack of auditing commitment and, rather, the equilibrium auditing and cheating strategies are simultaneously determined as the mutual best responses to each other in the second-stage Nash game. The equilibrium auditing strategy determined this way is, therefore, no longer subject to the aforementioned time inconsistency problem. Furthermore, it will be clear that the Nash equilibrium in the second-stage game is characterized by mixed-strategies for both lenders and borrowers, which implies that both auditing and cheating will take place with positive probabilities in equilibrium.[3] Consequently, the credit market equilibrium in this setup exhibits certain degree of cheating on the part of agents – an implication that squares well with those documented evidence of cheating behavior in real life.

More precisely, we consider a widely studied contractual environment with the presence of costly state verification. In this environment, borrowers (agents) seek loans from lenders (the principal) to finance their investment projects, whose random returns (high or low) are observed by agents themselves and can be verified by the principal only through costly auditing. As is typical in this kind of principal-agent situation, the self-selection equilibrium contracts assume the form whereby the borrowers who report low returns are audited with a positive probability while those who report high returns are never audited. However, as described in the time inconsistency problem earlier, this type of equilibrium can easily unravel due to the incentives of lenders to forgo the costly auditing once borrowers are

[3]An early example of this line of research that focuses on commitment issues in contact/game situations can be found in Graetz *et al* (1986), which studies a game between taxpayers and tax collector (IRS) wherein the auditing strategy of IRS cannot be committed *ex ante*, and an individual taxpayer's cheating strategy and IRS's auditing strategy are characterized by Nash equilibrium. The work by Bester and Strausz (2001) modifies and extends the revelation principle in more general environments in which the principal cannot commit to the outcome induced by a mechanism. In the generalized equilibrium, the optimal strategy of the agent needs not to entail truthful reporting with certainty, but only does so with a positive probability.

induced to report their true investment returns. For such a self-selection equilibrium to be viable, one needs to assume (either explicitly or implicitly) that the lenders can commit to the pre-announced auditing policy. But such an assumption on lenders' commitment is indeed questionable on several grounds. First of all, it is against lenders' self interest. Secondly, in most of the existing literature, the interaction between borrowers and lenders only lasts for one period and hence precludes the possibility of using any reputation mechanisms to resolve the time inconsistency problem.[4] Moreover, the lack of proper institutional mechanisms to enforce and bind lenders' auditing decisions will ultimately render such commitment (by lenders) untenable. Thus, for much of our analysis, we will take the position that it is in fact not possible for lenders to commit to any pre-announced auditing strategy and such inability to commit by lenders is known to both sides of the contract.

We then imbed the above credit market friction into a framework similar to those in Bernanke and Gertler (1989) and Bhattacharya (1998). The economy consists of overlapping generations of heterogeneous agents who live for two periods. In each period, young lenders (or workers) earn their wage income, which in turn constitutes the source of loan supply in the credit market, by supplying their endowed labor in the labor market. On the other hand, young borrowers (or entrepreneurs), who are endowed with capital-producing projects, approach lenders for loans in the credit market amidst the previously described informational frictions. In order to understand the consequences of the inability-to-commit assumption, we first discuss the benchmark model with the conventional assumption that commitment to pre-announced auditing is always upheld by lenders. Not surprisingly, the usual self-selection equilibrium in the credit market prevails in this benchmark model. Next, we examine our main model under the assumption that lenders cannot commit to a pre-announced auditing policy. In this case, the auditing strategy by lenders is simultaneously determined with the cheating strategy by borrowers as the equilibrium of Nash game. By contrasting the benchmark model with the main model, we can then show how the lenders' ability to commit, or the lack of it, will affect the nature of the credit market equilibrium and subsequently the macroeconomy.

Our analysis yields the following main findings. First, while the equilibrium contracts in both cases with and without commitment to auditing offer the same loan rate to borrowers who report low returns, the case without commitment to auditing has a higher equilibrium

[4]Bose and Cothren (1996) relies on a brand name that each lender purchases from a lender of the previous generation as a commitment device to solve the time inconsistency problem – only if a lender honors the brand name by implementing the terms of the separating contracts, he can sell his own brand name in the future. However, it is difficult to see how such a mechanism can be matched with some real world practices.

loan rate for borrowers who report high returns. This is because, when lenders cannot commit, the equilibrium contract entails some cheating activities (under reporting) by borrowers with high investment returns, which in turn will lower lender's expected payoff in the high-return state. As a result, lenders have to charge a higher loan rate for borrowers who truthfully report high returns in order to compensate for the loss of revenue arising from the cheating borrowers in this state. Second, analogous to Khalil (1997), the inability to commit will lead to a higher auditing probability in equilibrium comparing to the benchmark model. This result comes about because, since the higher loan rate for borrowers with high returns under the no-commitment regime will also increase the incentives for these borrowers to cheat, the auditing probability then must increase in order to keep the borrowers indifferent between cheating and complying. Since auditing is wasteful as it expends resources, the more frequent auditing arising from the inability to commit will result in less capital accumulation and lower economic growth. In addition, due to the higher loan rate that borrowers with high investment returns need to pay in our main model, the inability to commit is associated with a lower level of social welfare as well. Finally, we study the effect of capital income taxation on the credit market equilibrium and how it is affected by the ability to commit by lenders. In this regard, we find that an increase in the tax rate on capital will generate greater credit market distortions under the no-commitment regime. The existing studies, by assuming commitment to auditing strategies by lenders, thus tend to under estimate the credit market distortions caused by capital income taxation.

The present paper also lends itself well in the expanding line of inquiry that examines the role of institutional factors in economic growth and development. The received wisdom emerged from this literature argues that institutional factors offer a potential explanation for the divergent growth experiences across different countries, with in particular weak institutions leading to slower economic growth. For example, La Porta *et al.* (1998) and Levine (1999) find that strong institutions in legal enforcement of private property rights, support of private contractual arrangements, and protection of the legal right of investors, foster financial development, which in turn promote capital accumulation and economic growth. Beck and Levine (2004) provide a more detailed survey on this law-finance-growth nexus, which by and large suggests a strong link among legal institutions, financial development, and growth. In a recent paper using data on a cross-section of 17 countries covering the period from 1880 to 1997, Bordo and Rousseau (2006) find that deep institutional fundamentals, such as legal origin and some political factors, can explain a good part of the cross-sectional variation in financial development and growth. Acemoglu *et al.* (2005) study the interaction between political power/institution and economic institution (in the sense of private property right protection) and argue that economic institutions encourage economic growth when political institutions allocate power to groups with interests in broad-based property rights enforcement. In all of these studies, the institutional strength is customarily measured in terms of protecting creditors' rights and reining in borrowers' fraudulent behavior. In this regard, we examine instead the importance in constraining lender's behavior and making their pre-announced auditing policies binding and credible. Although in practice, even in economies that are commonly associated with having strong legal/political institutions, the (ex-post) decisions to audit borrowers or not are largely left free to the lenders, our analysis suggests that it may be desirable to introduce some commitment mechanisms to bind such free choices of the lenders.[5] Viewed in this light, the present paper offers a new micro-economic channel through which institutional failings (i.e., the lack of commitment mechanisms) can lead to greater credit market distortions, lower economic growth, and lower social welfare.

The rest of the paper is organized as follows. Section 2 lays out the basic environment. We devote section 3 to the benchmark model where commitment to auditing by lenders is assumed. The main model under no commitment is analyzed in section 4. Section 5 compares the economic growth rates and the social welfare of those two models in previous sections. Section 6 studies the credit market distortions caused by capital income taxation, with and without auditing commitment. We finally conclude and discuss some possible extensions in section 7.

2 The Environment

The basic framework of our model is similar to Bernanke and Gertler (1989) and Bhattacharya (1998). In the economy, there is an infinite sequence of two-period lived overlapping generations. All generations are identical in size and composition, with each generation consisting of an equal size of lenders (or workers) and borrowers (or entrepreneurs). The population of young lenders/borrowers is normalized to a continuum with a measure of one (thus the population of each generation has a measure of two). Lenders are at first workers

[5] One possible commitment mechanism of this sort is perhaps to delegate auditing to a third-party, independent auditor. The auditor automatically carries out the necessary auditing, on the behalf of the lender (for a fee of course), according to the probability specified in the offered contract initially. This way, the pre-announced auditing strategies by the lenders are likely be binding, since the independent auditors have incentives (the fees to be collected) to follow through with the pre-announced auditing even if the lenders themselves do not. Of course, this mechanism of delegated auditing is only as effective as the system that monitors the independent auditors themselves, as the recent corporate scandals involving some of the accounting powerhouses like Auther Anderson had shown.

who are endowed with one unit of labor when young, which is supplied inelastically on the labor market at the competitive wage rate. They then play the role of lenders as their wages provide the only source of loanable funds in the economy. On the other hand, each borrower is an entrepreneur who is endowed with a project that produces capital goods and needs be financed externally. The output of a borrower's project can take one of two possible values of κ_1 and κ_2, where $0 \leq \kappa_1 < \kappa_2$. The event κ_1 (bad state) occurs with the probability π_1 and κ_2 (good state) with π_2, where $\pi_1 + \pi_2 = 1$. Therefore, for $i \in \{1, 2\}$, an investment project can with probability π_i convert one unit of time t consumption good into κ_i units of time $t+1$ capital good.All capital goods are supplied competitively at the market rental rate. For simplicity, it is also assumed that both borrowers and lenders are risk neutral and consume only when they are old.

The credit market operates as in Bencivenga and Smith (1993). In each period, after earning the market wage, a young lender can lend his wage income to a borrower in exchange for consumption goods in the next period. A lender makes an offer of a loan contract and, if the contract is not dominated by others, a borrower will approach him to sign the contract. Each lender will be approached by one borrower only and the competition in the credit market will drive the lender's economic profit to the reservation level, which is normalized to zero. Alternatively, a lender has access to a default, risk-free technology that converts one unit of his time t wage into q units of time $t+1$ consumption good.

To introduce asymmetric information in the credit market, we assume that a lender can observe the output level, κ_1 or κ_2, of an individual borrower only after costly auditing. Specifically, δ amount of capital goods, per unit of the loan, will be lost in the auditing process. The project returns of a borrower will be appropriated by the lender if the borrower is caught of lying under auditing.

Each borrower becomes a firm owner in his old age to produce the consumption good by hiring capital and labor at the market rates. Each firm at time t produces the consumption good according to the Cobb-Douglas production function:

$$y_t = A\bar{k}_t^{\alpha} k_t^{\gamma} l_t^{1-\gamma} \tag{1}$$

where y_t is the output per firm, A is a technology parameter, $\bar{k}_t$ is the average capital stock per firm, k_t is the capital input of the firm and l_t is the labor input of the firm. To sustain perpetual long-run growth, it is assumed that $\alpha = 1-\gamma$ with $0 < \gamma < 1$ as in the endogenous growth literature. Since all firms hire the same amount of labor and there is an equal number of borrowers and lenders, the number of labor force per firm, l_t, must be equal to one in each time period. The symmetry of firms also implies that $\bar{k}_t = k_t$ for all t. Hence, the rental rate, ρ_t, and the wage rate, w_t, in period t are equal to the marginal products of capital and labor, respectively:

$$\rho_t = \gamma A, \tag{2}$$

$$w_t = A(1-\gamma)k_t. \tag{3}$$

Without loss of generality, physical capital is assumed to depreciate fully after one period of use.

Finally, we maintain the following technical conditions throughout the paper:

$$\gamma A \kappa_1 < q < \gamma A(\pi_1 \kappa_1 + \pi_2 \kappa_2 - \delta). \tag{4}$$

The first inequality says that the return from the risky investment in the bad state is less than that from the risk-free, default technology. The second inequality is adopted to guarantee the expected (net) return of the risky investment to be superior to the return of the risk-free technology.

3 The Benchmark Model: Auditing with Commitment

As the basis for comparison, we first study a model in which the commitment to pre-announced auditing by lenders is taken to be binding. As argued above, such a presumption is necessary in order to avoid the time-consistency problem in many previous studies with principal-agent setups. In this case, the loan contract at time t offered by a lender to a borrower can be specified as $C_t = [\phi_t^1, \phi_t^2, R_t^1, R_t^2, x_t]$, where ϕ_t^1 and ϕ_t^2 are the auditing probabilities when low and high output levels are reported respectively; R_t^1 and R_t^2 are the gross loan rates (in real terms) when low and high output levels are reported respectively; and x_t is the loan size.[6]

Following the tradition in the literature, we will consider the equilibrium contracts that give rise to the self-selection of borrowers. The expected payoff to a borrower of generation t in such an equilibrium is then given by

$$\pi_1(\kappa_1 \rho_{t+1} - R_t^1)x_t + \pi_2(\kappa_2 \rho_{t+1} - R_t^2)x_t. \tag{5}$$

Furthermore, in order to induce borrowers to truthfully report their output levels, the following incentive compatibility constraints must be satisfied:

$$(\kappa_1 \rho_{t+1} - R_t^1)x_t \geq (1-\phi_t^2)(\kappa_1 \rho_{t+1} - R_t^2)x_t, \tag{6}$$

[6]As in Khalil (1997) and Wang and Williamson (1998), we do not further differentiate between the loan rate in the state with auditing and that in the state without auditing to simplify the analysis.

$$(\kappa_2\rho_{t+1} - R_t^2)x_t \geq (1-\phi_t^1)(\kappa_2\rho_{t+1} - R_t^1)x_t. \tag{7}$$

Because the credit market is assumed to be perfectly competitive, lenders always earn zero expected economic profit in equilibrium. This zero profit condition can be expressed as

$$\pi_1[\phi_t^1(R_t^1 - \delta\rho_{t+1}) + (1-\phi_t^1)R_t^1]x_t + \pi_2[\phi_t^2(R_t^2 - \delta\rho_{t+1}) + (1-\phi_t^2)R_t^2]x_t = qx_t. \tag{8}$$

The left hand side of this equation describes the expected income from making loans and the right hand side the forgone income of the loan. In addition, the equilibrium loan size must also satisfy the following feasibility constraint:

$$x_t \leq w_t. \tag{9}$$

Now, we can define the equilibrium in the credit market as follows.

Definition 1. An equilibrium in the credit market with commitment to audit is represented by a sequence of contracts $\{C_t\}$, where $C_t = [\phi_t^1, \phi_t^2, R_t^1, R_t^2, x_t]$, that maximizes (5) subject to (6) - (9) taking the price sequences of $\{\rho_t\}$ and $\{w_t\}$ as given.

We proceed with deriving the equilibrium contracts here by assuming a standard property in this type of models with adverse selection: in equilibrium, only the incentive compatibility constraint for reporting high output, i.e. (7), is binding but not that for reporting low output, i.e. (6).[7] As a result, the binding incentive compatibility constraint of (7) yields that

$$\phi_t^1 = \frac{R_t^2 - R_t^1}{\kappa_2\rho_{t+1} - R_t^1}. \tag{10}$$

Making use of the zero-profit condition (8), one can show that the expected payoff to a borrower is strictly decreasing in the auditing probabilities of ϕ_t^1 and ϕ_t^2. Thus, since the incentive compatibility constraint of (6) is not binding, implying that a borrow with the low output will not have incentive to report the high output, it will not be optimal in equilibrium for lenders to audit any borrowers who report the high level of output, i.e. $\phi_t^2 = 0$. Moreover, it follows from (10) that ϕ_t^1 is strictly decreasing with R_t^1. Hence, lenders will set R_t^1 as high as possible, i.e. $R_t^1 = \gamma A\kappa_1$, in order to maximize the borrower's expected payoff. The

[7] Indeed it can be easily verified that (6) holds with strict inequality and (7) holds with equality once the the complete equilibrium contracts are derived. Intuitively, this property arises primarily because, in equilibrium, the loan rate for reporting the low output level is lower than that for reporting the high output level (i.e. $R_t^1 < R_t^2$). Hence, borrowers with high project returns have incentives to masquerade as those with low project returns, but not vice versa.

equilibrium loan rate for borrowers reporting the high output level can then be solved from (8):

$$R_t^2 = \frac{q}{\pi_2} - \frac{\gamma A \pi_1}{\pi_2}(\kappa_1 - \delta \phi_t^1). \tag{11}$$

Substituting (11) into (10) in association with $R_t^1 = \gamma A \kappa_1$, the auditing probability for borrowers reporting the low output level is given by

$$\phi_t^1 \equiv \phi = \frac{q - \gamma A \kappa_1}{\gamma A[\pi_2(\kappa_2 - \kappa_1) - \delta \pi_1]}, \tag{12}$$

where $0 < \phi < 1$ follows from the technical assumptions in (4).

Combining (11) and (12), we can derive the equilibrium loan rate for borrowers reporting the high output level as

$$R_t^2 = \frac{(\kappa_2 - \kappa_1)(q - \gamma A \pi_1 \kappa_1) - \delta \gamma A \pi_1 \kappa_1}{\pi_2(\kappa_2 - \kappa_1) - \delta \pi_1}. \tag{13}$$

It is worth to note that, from (13), $R_t^2 > R_t^1$ $(= \gamma A \kappa_1)$ holds under (4).

Finally, it can be easily verified that in equilibrium $\kappa_i \rho_{t+1} - R_t^i$ are non-negative for $i = 1, 2$. It then follows immediately that (9) must hold with equality in equilibrium, which determine the loan size for borrowers.

We now summarize the above results in the following proposition.

Proposition 1. In each period t, the equilibrium loan contract is given by $C_t = [\phi_t^1, \phi_t^2, R_t^1, R_t^2, x_t]$ *with* $\phi_t^1 = \frac{q - \gamma A \kappa_1}{\gamma A[\pi_2(\kappa_2 - \kappa_1) - \pi_1 \delta]}$, $\phi_t^2 = 0$, $R_t^1 = \gamma A \kappa_1$, $R_t^2 = \frac{(\kappa_2 - \kappa_1)(q - \gamma A \pi_1 \kappa_1) - \delta \gamma A \pi_1 \kappa_1}{\pi_2(\kappa_2 - \kappa_1) - \pi_1 \delta}$, $x_t = w_t$.

Note that next period's capital is produced by the investment projects of current borrowers. Since those borrowers that report high output level are never audited while those with low output level are (with probability ϕ), recalling the investment technology of the borrowers and full depreciation of capital, the economy-wide capital stock at $t + 1$ is given by:

$$K_{t+1} = (\pi_1 \kappa_1 + \pi_2 \kappa_2 - \delta \pi_1 \phi) w_t.$$

Since the total number of firms is equal to one and $w_t = A(1 - \gamma)k_t$, the growth rate of capital stock per firm, and hence of aggregate production, over period t is given by

$$g_t \equiv \frac{k_{t+1}}{k_t} = A(1 - \gamma)(\pi_1 \kappa_1 + \pi_2 \kappa_2 - \delta \pi_1 \phi). \tag{14}$$

The social welfare of this economy is simply the sum of borrowers' and lenders' expected payoffs

$$W_t = \pi_1(\gamma A \kappa_1 - R_t^1) w_t + \pi_2(\gamma A \kappa_2 - R_t^2) w_t + q w_t. \tag{15}$$

Auditing with commitment enables lenders to use pre-announced auditing probabilities to achieve self selection from borrowers. However, this assumption is indeed problematic as it is not a sub-game perfect behavior for lenders: Once the borrowers are induced to reveal their output levels truthfully, it is no longer optimal for lenders to audit anymore. In what follows, we are going to characterize the optimal contracts under which this assumption no longer holds and study its impacts on economic growth and social welfare.

4 The Main Model: Auditing without Commitment

In this section, we consider the more realistic scenario in which the commitment by lenders to any pre-announced auditing strategies is taken as not possible for reasons we articulated previously. This inability to commit implies that it would not be meaningful to include any auditing probabilities in lenders' contract offers, as they would simply be disregarded as non-credible and hence non-binding. Under this no-commitment regime, the loan contract offered by a lender to a borrower at time t is characterized as $C_t = [R_t^1, R_t^2, x_t]$, where R_t^1, R_t^2, and x_t are similarly defined as in the previous section. Following Khalil (1997) and Khalil and Parigi (1998), the auditing probabilities of lenders are determined together with the cheating probabilities of borrowers in a simultaneous Nash game after the contract C_t is offered. Thus, the credit market equilibrium in the current model will be captured by a two-stage problem which can be solved backwards. In the second stage, the lenders' auditing strategies and borrowers' cheating strategies are simultaneously determined for the given contract terms. The equilibrium contract terms are then determined in the first stage by maximizing the borrowers' expected payoff subject to a proper set of constraints.

We consider the second-stage problem first. For $i = 1, 2$, let ϕ_t^i be the lender's auditing probability when the borrower reports the state-i output and ν_t^i be the probability that a borrower with the state-i output but reports the state-j output instead, where $i \neq j$. For a given contract offer of C_t, the Nash equilibrium auditing and cheating strategies of ϕ_t^i and ν_t^i $(i = 1, 2)$ can be derived as follows. As will be shown later that $R_t^1 < R_t^2$ holds in the equilibrium contract,[8] it is then obvious that truth-telling is the dominant strategy for borrowers who experience the adverse shock and end up with the low output level $(i = 1)$, hence $\nu_t^1 = 0$. Since borrowers with low output level never cheat $(\nu_t^1 = 0)$, as a part of the Nash equilibrium response, lenders would never need to audit borrowers who report the high output level, hence $\phi_t^2 = 0$. Thus, only those borrowers with the high output level have

[8] We will explicitly verify in the appendix that indeed this is the case.

incentives to cheat, whereas lenders only need to audit those who report the low output level. Specifically, these mixed-strategy Nash equilibrium of cheating (ν_t^2) and auditing (ϕ_t^1) for the second-stage problem between borrowers and lenders are determined from the following conditions:[9]

$$(1-\phi_t^1)(\kappa_2\rho_{t+1}-R_t^1)x_t = (\kappa_2\rho_{t+1}-R_t^2)x_t, \tag{16}$$

$$\frac{\pi_2\nu_t^2}{\pi_1+\pi_2\nu_t^2}(\kappa_2\rho_{t+1}-\delta\rho_{t+1})x_t + \frac{\pi_1}{\pi_1+\pi_2\nu_t^2}(R_t^1-\delta\rho_{t+1})x_t = R_t^1 x_t. \tag{17}$$

The left hand side of equation (16) is the expected payoff of a borrower with the high project return but chooses to underreport (cheats), while the right hand side is the expected payoff if the same borrower reports truthfully. This equation says that, given lenders' auditing strategy, borrowers with high project returns are indifferent between cheating and complying in equilibrium. Analogously, the left hand side of equation (17) represents a lender's expected payoff when he audits (someone who reports the low output level), while the right hand side measures his payoff when he simply takes the borrower's words and does not audit. Thus, given borrowers' cheating strategy, lenders are indifferent in equilibrium between auditing and not auditing borrowers who report low project returns.

Solving ϕ_t^1 and ν_t^2 from (16) and (17), in terms of the contractual terms in C_t, we obtain that

$$\phi_t^1 = \frac{R_t^2-R_t^1}{\kappa_2\rho_{t+1}-R_t^1}, \tag{18}$$

$$\nu_t^2 = \frac{\delta\pi_1\rho_{t+1}}{\pi_2(\kappa_2\rho_{t+1}-\delta\rho_{t+1}-R_t^1)}. \tag{19}$$

Together with $\phi_t^2=\nu_t^1=0$, (18) and (19) complete the characterization of the equilibrium for the second-stage Nash game.

The above characterization of ϕ_t^i and ν_t^i $(i=1,2)$ from the second-stage problem can then be used to determine the first-stage equilibrium contract $C_t=[R_t^1,R_t^2,x_t]$. Since $\phi_t^2=\nu_t^1=0$, the expected payoff to a borrower of generation t can be written as follows:

$$\pi_1(\kappa_1\rho_{t+1}-R_t^1)x_t + \pi_2\left[\nu_t^2(1-\phi_t^1)(\kappa_2\rho_{t+1}-R_t^1)+(1-\nu_t^2)(\kappa_2\rho_{t+1}-R_t^2)\right]x_t. \tag{20}$$

[9] It is easy to see that there is no pure-strategy equilibrium of $\phi_t^1$and v_t^2. For instance, if lenders never audit those who report low output ($\phi_t^1=0$), borrowers with high output level would always cheat ($v_t^2=1$), but then $\phi_t^1=0$ would not be optimal. Similarly, if lenders always audit those who report low output ($\phi_t^1=1$), borrowers with high output level would never cheat ($v_t^2=0$), but then $\phi_t^1=1$ would not be optimal.

Assuming perfect competition in loan making in the credit market, as is customary in the literature, in equilibrium lenders will offer the most favorable contractual terms to borrowers to the extent possible.

In equilibrium, due to competitive loan making and since $\phi_t^2 = \nu_t^1 = 0$, the zero (economic) profit condition for lenders again holds and can be written as

$$(\pi_1 + \pi_2\nu_t^2)\left\{\phi_t^1\left[\frac{\pi_2\nu_t^2}{\pi_1 + \pi_2\nu_t^2}(\kappa_2\rho_{t+1} - \delta\rho_{t+1}) + \frac{\pi_1}{\pi_1 + \pi_2\nu_t^2}(R_t^1 - \delta\rho_{t+1})\right] + (1-\phi_t^1)R_t^1\right\}x_t$$
$$+\pi_2(1-\nu_t^2)R_t^2 x_t = qx_t. \tag{21}$$

The first term on the left hand side of (21) represents the expected payoff that a lender can collect from a borrower who reports the low output level, which occurs with probability $\pi_1 + \pi_2\nu_t^2$. If the lender audits such a borrower, he will find that with probability $\pi_2\nu_t^2/(\pi_1+\pi_2\nu_t^2)$ this borrower is indeed under reporting his project return (i.e. the borrower had actually encountered a favorable output shock), in which case the borrower's entire investment output will be appropriated and the lender's net profit is equal to $\kappa_2\rho_{t+1} - \delta\rho_{t+1}$ times the loan size; and with probability $\pi_1/(\pi_1 + \pi_2\nu_t^2)$, however, the borrower is reporting truthfully, in which case the lender's net profit is equal to $R_t^1 - \delta\rho_{t+1}$ times the loan size. On the other hand, if the lender does not audit the low-output-reporting borrower, he will simply collect R_t^1 per unit of loan irrespective of whether the borrower is cheating. The second term on the left hand side of (21) is lender's expected payoff collected from a borrower who reports the high output level, which occurs with probability $\pi_2(1-\nu_t^2)$ (recall that there will be no auditing in this case). The right hand side of this equation is simply the opportunity cost of the loan.

In addition, the equilibrium contracts must also satisfy the following feasibility condition:

$$x_t \leq w_t. \tag{22}$$

Now, we can define the equilibrium in the credit market formally as follows.

Definition 2. An equilibrium in the credit market without commitment to audit is represented by a sequence of contracts $\{C_t\}$, where $C_t = [R_t^1, R_t^2, x_t]$, and a sequence of auditing and cheating strategies $\{\phi_t^i, \nu_t^i\}$ $(i = 1, 2)$, where $\phi_t^2 = \nu_t^1 = 0$, that maximize (20) subject to (18), (19) , (21), and (22) taking the price sequences of $\{\rho_t\}$, $\{w_t\}$ as given.

To derive the complete credit market equilibrium, we first note that with substitution from (16) the borrowers' expected payoff function (20) can be rewritten as

$$\pi_1(\kappa_1\rho_{t+1} - R_t^1)x_t + \pi_2(\kappa_2\rho_{t+1} - R_t^2)x_t. \tag{23}$$

Similarly, by substituting (17) into the lenders' zero profit condition (21), we obtain that

$$(\pi_1 + \pi_2 \nu_t^2) R_t^1 x_t + \pi_2 (1 - \nu_t^2) R_t^2 x_t = q x_t. \tag{24}$$

By combining (19), (23), and (24), we show in the appendix that a borrower's expected payoff is strictly increasing with R_t^1. Hence, it will again be optimal to set R_t^1 to be as high as possible, i.e., $R_t^1 \equiv R^1 = \kappa_1 \rho_{t+1} = \gamma A \kappa_1$. Substituting this result into (19) yields the following equilibrium cheating probability:

$$\nu_t^2 \equiv \nu = \frac{\delta \pi_1}{\pi_2 (\kappa_2 - \kappa_1 - \delta)}. \tag{25}$$

We then can solve from (24) after making use of (25) and $R_t^1 = \gamma A \kappa_1$ that

$$R_t^2 = \frac{(\kappa_2 - \kappa_1)(q - \gamma A \pi_1 \kappa_1) - \delta q}{\pi_2 (\kappa_2 - \kappa_1) - \delta}. \tag{26}$$

Substituting (26) and $R_t^1 = \gamma A \kappa_1$ into (18) gives us the following equilibrium auditing probability:

$$\phi_t^1 \equiv \phi = \frac{(q - \gamma A \kappa_1)(\kappa_2 - \kappa_1 - \delta)}{\gamma A (\kappa_2 - \kappa_1)[\pi_2 (\kappa_2 - \kappa_1) - \delta]}. \tag{27}$$

Again, since it is easy to verify that $\kappa_i \rho_{t+1} - R_t^i$ $(i = 1, 2)$ are non-negative, the resource constraint (22) must hold with equality. Furthermore, $0 < v < 1$ and $0 < \phi < 1$ are both guaranteed by the technical assumptions in (4).

Now we summarize the above results in Proposition 2.

Proposition 2. In each period t, the credit market equilibrium is characterized in two parts. First, the equilibrium loan contract is given by $C_t = [R_t^1, R_t^2, x_t]$ with $R_t^1 = \gamma A \kappa_1$, R_t^2 from (26) and $x_t = w_t$. Second, the cheating and auditing probabilities are given by $\nu_t^1 = \phi_t^2 = 0$, $0 < \nu_t^2 < 1$ from (25), and $0 < \phi_t^1 < 1$ from (27).

In the credit market equilibrium outlined in Proposition 2, cheating on the part of borrowers (those who have high investment returns) does take place, as does auditing by lenders. This leads to a non-separating equilibrium where borrowers are no longer sorted by their true investment outcomes. In particular, among the borrowers reporting the low output level, some are those whose projects had truly received the unfavorable shock but some are those who underreport. Auditing offers the only means of distinguishing the types of borrowers in this case. In what follows, we will primarily focus on the macroeconomic consequences of such a credit market equilibrium.

Recalling that the cost of auditing essentially represents the deadweight loss in capital accumulation, and with full capital depreciation, the economy-wide aggregate capital stock in period $t+1$ in this model is equal to

$$K_{t+1} = [\pi_1 \kappa_1 + \pi_2 \kappa_2 - \delta(\pi_1 + \pi_2 \nu)\phi]\, x_t.$$

Since the number of firms is normalized to 1 and $w_t = A(1-\gamma)k_t$, the growth rate of capital stock and hence of aggregate output for period t is equal to

$$g_t = \frac{k_{t+1}}{k_t} = A(1-\gamma)[\pi_1 \kappa_1 + \pi_2 \kappa_2 - \delta(\pi_1 + \pi_2 \nu)\phi]. \tag{28}$$

From the law of large numbers, there is no aggregate uncertainty in the total payoffs to the population of borrowers, as well as in that of lenders. Since their sizes are normalized to one, the total payoffs to borrowers and lenders are given in (23) and (24), respectively. By aggregating the payoffs across borrowers and lenders, the time-t economy-wide social welfare is then represented by

$$W_t = \pi_1(\gamma A \kappa_1 - R_t^1)w_t + \pi_2(\gamma A \kappa_2 - R_t^2)w_t + q w_t. \tag{29}$$

5 The Consequences of the Inability to Commit

We discuss in this section the economic implications, particularly on growth and welfare, of the inability to commit by lenders to auditing contracts in the credit market. Technically, this can be easily accomplished by comparing the two models analyzed in the previous two sections since they differ only in the assumption regarding the lenders' ability in making auditing commitment. Throughout this and the remaining sections of this paper, all endogenous variables in the main model without auditing commitment will be capped with the symbol "tilde" to facilitate the comparison between these two models. Such a comparison yields the following results with regard to the terms of equilibrium contract, the economic growth rate, and the level of social welfare.

Proposition 3. Comparing the benchmark model and the main model with and without auditing commitment, respectively, the following inequalities hold: $\tilde{R}_t^2 > R_t^2$, $\tilde{\phi}_t^1 > \phi_t^1$, $\tilde{g}_t < g_t$, *and* $\tilde{W}_t < W_t$.

Proof: Recalling (4), it follows directly from (13) and (26) that

$$\begin{aligned} \tilde{R}_t^2 - R_t^2 &= \frac{(\kappa_2 - \kappa_1)(q - \gamma A \pi_1 \kappa_1) - \delta q}{\pi_2(\kappa_2 - \kappa_1) - \delta} - \frac{(\kappa_2 - \kappa_1)(q - \gamma A \pi_1 \kappa_1) - \delta \gamma A \pi_1 \kappa_1}{\pi_2(\kappa_2 - \kappa_1) - \pi_1 \delta} \\ &= \frac{\delta^2 \pi_1 (q - \gamma A \kappa_1)}{[\pi_2(\kappa_2 - \kappa_1) - \delta][\pi_2(\kappa_2 - \kappa_1) - \pi_1 \delta]} > 0. \end{aligned}$$

Similarly, from (12) and (27), we obtain that

$$\begin{aligned}\tilde{\phi}_t^1 - \phi_t^1 &= \frac{(q-\gamma A\kappa_1)(\kappa_2-\kappa_1-\delta)}{\gamma A(\kappa_2-\kappa_1)[\pi_2(\kappa_2-\kappa_1)-\delta]} - \frac{q-\gamma A\kappa_1}{\gamma A[\pi_2(\kappa_2-\kappa_1)-\pi_1\delta]} \\ &= \frac{(q-\gamma A\kappa_1)\pi_1\delta^2}{\gamma A(\kappa_2-\kappa_1)[\pi_2(\kappa_2-\kappa_1)-\delta][\pi_2(\kappa_2-\kappa_1)-\pi_1\delta]} > 0.\end{aligned}$$

Since $\tilde{\phi} > \phi$ and $0 < \nu$ (< 1), $\tilde{g}_t < g_t$ follows immediately by comparing (14) and (28). Finally, since $\tilde{w}_t = w_t$, $\tilde{R}_t^1 = R_t^1$ and $\tilde{R}_t^2 > R_t^2$, $\tilde{W}_t < W_t$ follows from inspection of (15) and (29). Hence, the proposition is proved. QED

Some observations are in order. First, $\tilde{R}_t^2 > R_t^2$ implies that the inability to commit by lenders leads to a higher equilibrium loan rate for borrowers who report the high output level. The intuition for this result can be understood as follows. In order to minimize the incentives of cheating by high-return borrowers, the loan rate for reporting the low output is set to be as high as possible, and hence the same ($\tilde{R}_t^1 = R_t^1$), in both cases with and without auditing commitment by lenders. However, under no-commitment, the equilibrium exhibits a positive probability of cheating behavior by borrowers with high returns: in equilibrium, a fraction of the high-return borrowers will underreport in order to avoid paying a higher interest rate ($\tilde{R}_t^1 < \tilde{R}_t^2$). As can be seen from (24), lenders expect to recover their loans only according to the lower loan rate of $\tilde{R}_t^1$ from this fraction of borrowers.[10] To compensate for the loss of revenue recovered from the fraction of cheaters, lenders must raise the loan rate that applies to borrowers who truthfully report the high output level, R_t^2, in order to maintain their zero profit condition (24).

Next, the inability to commit also leads to more frequent auditing by lenders in the equilibrium ($\tilde{\phi}_t^1 > \phi_t^1$). This result is analogous to that of Proposition 3 in Khalil (1997). Intuitively, a higher loan rate of $\tilde{R}_t^2$ under no-commitment, than its counterpart in the case with auditing commitment, increases the potential benefit from cheating. To counter balance such a tightened incentive to cheat, a greater probability of auditing is needed to maintain the equilibrium condition (16).

The macro implications of the inability to commit are straightforward. The result here on growth says that the growth rate in the model without auditing commitment will be

[10] In fact, not all borrowers who cheat end up paying the same amount to lenders: those who were caught (by auditing) will have their entire investment output appropriated and those who got away (not being audited) will pay only the lower loan rate of R_t^1. However, from (17), in equilibrium a lender's expected payoff from auditing a borrower reporting the low output has to be the same as the payoff from not auditing, which is equal to R_t^1 per unit of loan. Thus lenders are expected to recover from any borrowers, including the cheaters, who report the low output at the loan rate of R_t^1 regardless if auditing takes place.

lower than that in the benchmark model. This result comes about because that the lack of auditing commitment brings cheating and hence more frequent auditing in the credit market and that auditing activities are costly in the sense of causing deadweight loss in real resources. Consequently, under no-commitment, the process of capital accumulation is less efficient and economic growth is slower.

Finally, as in (15) and (29), the social welfare in any period consists of the aggregate payoffs/consumption over three groups of individuals: the borrowers with low project returns, the borrowers with high project returns, and the lenders. Recalling $R_t^1 = \gamma A \kappa_1$ in both cases with and without auditing commitment, the net payoff of a borrower with low output will be squeezed to zero in both models. Furthermore, a lender's payoff in both models will be simply equal to the (opportunity) cost of funds due to competition in lending.[11] Thus, for any given level of capital, which model gives rise to a higher welfare level hinges upon the equilibrium payoffs of the borrowers with high project returns. Although some of these high-return borrowers will cheat under no-commitment, from (16), their expected payoffs from cheating in equilibrium will in fact be just the same as that from complying. Therefore, the aggregate payoff to the high-return borrowers as a group is always determined as if they all comply. When auditing commitment is absent, since compliance means paying a higher interest rate ($\tilde{R}_t^2 > R_t^2$), the lower total payoffs to the group of high-return borrowers, and hence the economy-wide welfare, will be lower.

To conclude, with equal initial conditions, the economy in which lenders are unable to pre-commit any auditing strategies would grow slower and enjoy lower social welfare than that in which such commitment is operative. Interpreting the ability for lenders to make auditing commitment as reflecting the strength of financial and legal institutions in an economy, the above results are consistent with the line of research that suggests weak institutions as a cause for the divergence in growth and living standards among different countries.

6 The Effects of Capital Income Taxation

In this section, we extend the above analysis to study the effects of a capital income tax policy. The main purpose is to show how the effects of such a government taxation policy is affected by the consideration of auditing commitment in the credit market. To this end, we introduce into the previous basic environment a constant flat tax, at the rate of τ, levied on capital

[11] Specifically, each lender's expected payoff is equal to q times loan size.

income, presumably to finance some exogenously given government expenditures.[12] We again divide our discussion into two cases with different auditing commitment assumptions.

6.1 The commitment case

We first examine the credit market equilibrium when lenders' commitment to auditing is taken as given. In this case, after the imposition of the capital income tax, the equilibrium loan contract in period t is then given by the solution to the following problem:

$$\max \pi_1[(1-\tau)\kappa_1\rho_{t+1} - R_t^1]x_t + \pi_2[(1-\tau)\kappa_2\rho_{t+1} - R_t^2]x_t \tag{30}$$

subject to

$$[(1-\tau)\kappa_1\rho_{t+1} - R_t^1]x_t \geq (1-\phi_t^2)[(1-\tau)\kappa_1\rho_{t+1} - R_t^2]x_t, \tag{31}$$

$$[(1-\tau)\kappa_2\rho_{t+1} - R_t^2]x_t \geq (1-\phi_t^1)[(1-\tau)\kappa_2\rho_{t+1} - R_t^1]x_t, \tag{32}$$

$$\pi_1[\phi_t^1(R_t^1 - \delta\rho_{t+1}) + (1-\phi_t^1)R_t^1]x_t + \pi_2[\phi_t^2(R_t^2 - \delta\rho_{t+1}) + (1-\phi_t^2)R_t^2]x_t = qx_t, \tag{33}$$

$$x_t \leq w_t. \tag{34}$$

Eqs. (31) - (34) are simply the incentive compatibility constraints, the lender's zero profit condition, and the feasibility constraint on loan size, respectively. Following the similar procedures in section 3, one can easily derive the equilibrium loan contracts in this credit market, which are stated in a proposition in below.

Proposition 4. In each period t, the equilibrium loan contract is given by $C_t = [\phi_t^1, \phi_t^2, R_t^1, R_t^2, x_t]$ with $\phi_t^1 = \frac{q-(1-\tau)\gamma A\kappa_1}{\gamma A[\pi_2(1-\tau)(\kappa_2-\kappa_1)-\delta\pi_1]}$, $\phi_t^2 = 0$, $R_t^1 = (1-\tau)\gamma A\kappa_1$, $R_t^2 = \frac{(1-\tau)\{(\kappa_2-\kappa_1)[q-(1-\tau)\gamma A\pi_1\kappa_1]-\delta\gamma A\pi_1\kappa_1\}}{\pi_2(1-\tau)(\kappa_2-\kappa_1)-\delta\pi_1}$, and $x_t = w_t$.

One immediate result of interest is that, as can be readily verified from the expression of ϕ_t^1, that the equilibrium auditing probability is positively related to the tax rate, τ, on capital income. To see the intuition of this result, note that in equilibrium the incentive constraint (32) will be binding. More precisely, after x_t is removed from both sides, this constraint becomes

$$[(1-\tau)\kappa_2\rho_{t+1} - R_t^2] = (1-\phi_t^1)[(1-\tau)\kappa_2\rho_{t+1} - R_t^1],$$

[12] To ensure that, after taxation, the equilibrium auditing and cheating strategies are strictly between zero and one and borrowers' expected payoff is increasing with the loan size, we need to replace (4) by: $(1-\tau)\gamma A\kappa_1 < q < \gamma A(1-\tau)(\pi_1\kappa_1 + \pi_2\kappa_2) - \gamma\delta$, which implicitly requires that $\tau < \frac{\pi_2 A(\kappa_2-\kappa_1)-\delta}{\pi_2 A(\kappa_2-\kappa_1)}$.

where the left hand side of the equation is the net payoff (per unit of loan) to a high-return borrower from reporting truthfully and the right hand side is that from underreporting his output. After substituting in the equilibrium loan rates and some algebraic manipulation, one will see that, increasing the capital income tax rate, τ, will hurt the net payoff to a honest borrower (the left hand side) more than it will do a dishonest one. Therefore, a high-return borrower will have a stronger incentive to masquerade as one with low return when the tax rate rises. In order to keep this constraint in balance, as a result, the auditing probability must increase. To the extent that auditing leads to deadweight loss in resources, this result says that a higher tax rate on capital gives rise to greater distortions in the credit market.

6.2 The no-commitment case

Under no-commitment, the credit market equilibrium will be determined from the two-stage problem described in Section 4. Similarly, we can obtain that $\nu_t^1 = \phi_t^2 = 0$ holds in equilibrium. The rest of the credit market equilibrium can then be solved from the following:

$$\begin{aligned}&\max \pi_1[(1-\tau)\kappa_1\rho_{t+1} - R_t^1]x_t + \pi_2\{\nu_t^2(1-\phi_t^1)[(1-\tau)\kappa_2\rho_{t+1} - R_t^1] \\ &+(1-\nu_t^2)[(1-\tau)\kappa_2\rho_{t+1} - R_t^2)]\}x_t \end{aligned} \tag{35}$$

subject to

$$(\pi_1+\pi_2\nu_t^2)\{\phi_t^1\left[\frac{\pi_2\nu_t^2}{\pi_1+\pi_2\nu_t^2}[(1-\tau)\kappa_2\rho_{t+1}-\delta\rho_{t+1}] + \frac{\pi_1}{\pi_1+\pi_2\nu_t^2}(R_t^1-\delta\rho_{t+1})\right]$$
$$+(1-\phi_t^1)R_t^1\}x_t + \pi_2(1-\nu_t^2)R_t^2 x_t = qx_t, \tag{36}$$
$$(1-\phi_t^1)[(1-\tau)\kappa_2\rho_{t+1} - R_t^1] = (1-\tau)\kappa_2\rho_{t+1} - R_t^2, \tag{37}$$
$$\frac{\pi_2\nu_t^2}{\pi_1+\pi_2\nu_t^2}[(1-\tau)\kappa_2\rho_{t+1}-\delta\rho_{t+1}] + \frac{\pi_1}{\pi_1+\pi_2\nu_t^2}(R_t^1-\delta\rho_{t+1}) = R_t^1, \tag{38}$$
$$x_t \leq w_t. \tag{39}$$

In the above problem, the borrowers' expected payoff function is maximized subject to four constraints: (36) is the lenders' zero profit condition, (37) and (38) are the Nash equilibrium conditions for determining the second-stage cheating and auditing strategies (ϕ_t^1 and ν_t^2), and (39) is the feasibility constraint on loan size. The complete credit market equilibrium can be similarly derived and characterized by the following proposition.

Proposition 5. In each period t, the equilibrium loan contract is given by $C_t = [R_t^1, R_t^2, x_t]$ with $R_t^1 = (1-\tau)\gamma A\kappa_1$, $R_t^2 = \frac{\{(1-\tau)(\kappa_2-\kappa_1)[q-(1-\tau)\gamma A\pi_1\kappa_1]-\delta q\}}{\pi_2(1-\tau)(\kappa_2-\kappa_1)-\delta}$ and $x_t = w_t$; while the equilibrium *cheating and auditing strategies are given by* $\{\phi_t^i, \nu_t^i\}$ *(*$i = 1, 2$*) with* $\nu_t^1 = \phi_t^2 = 0$, ϕ_t^1 *and* ν_t^2 *(both strictly between 0 and 1) determined as follows*

$$\phi_t^1 = \phi = \frac{[q - (1-\tau)\gamma A\kappa_1][(1-\tau)(\kappa_2 - \kappa_1) - \delta]}{\gamma A(1-\tau)(\kappa_2 - \kappa_1)[\pi_2(1-\tau)(\kappa_2 - \kappa_1) - \delta]}, \tag{40}$$

$$\nu_t^2 = \upsilon = \frac{\delta\pi_1}{\pi_2[(1-\tau)(\kappa_2 - \kappa_1) - \delta]}. \tag{41}$$

Several implications can be drawn. First, it is easy to verify that both ϕ and ν are increasing with the tax rate on capital, τ. While the positive relation between ϕ and τ is in accordance with and can be explained in the same way as in the commitment case, the one between ν and τ is novel. Intuitively, when τ is increased, a lender's expected payoff from auditing for any given ν decreases by more than does his expected payoff from no auditing, which would lower his incentive to audit. In response, those high-return borrowers would cheat more intensively by raising ν. More precisely, recall the following equation that pins down the equilibrium cheating probability ν by comparing a lender's net expected payoff from auditing and that from no-auditing

$$\frac{\pi_2\nu_t}{\pi_1 + \pi_2\nu_t}[(1-\tau)\kappa_2\rho_{t+1} - \delta\rho_{t+1}] + \frac{\pi_1}{\pi_1 + \pi_2\nu_t}(R_t^1 - \delta\rho_{t+1}) = \frac{\pi_2\nu_t}{\pi_1 + \pi_2\nu_t}R_t^1 + \frac{\pi_1}{\pi_1 + \pi_2\nu_t}R_t^1.$$

The left hand side of the above equation is a lender's net expected return from auditing and the right hand side is that from no auditing. After substituting in the relevant equilibrium loan contract terms, it is easy to verify that increasing the tax rate τ reduces the left hand side more than it does the right hand side for any given ν. Consequently, lender has a lower incentive to audit, which in turn induces the high-return borrowers to cheat with a higher frequency.

Second, it is straightforward to show that, for any tax rate τ, the equilibrium auditing probability under no-commitment is higher than that with auditing commitment, i.e., $\tilde{\phi}_t^1 > \phi_t^1$. This implies that the tax-induced credit market distortions (in the form deadweight loss due to auditing) are more pronounced when the mechanism for auditing commitment is absent. Intuitively, the inability to commit leads to positive equilibrium cheating, which is only countered by increased auditing activities, and thus results in greater market distortions. Furthermore, it is easy to show $\frac{\partial(\tilde{\phi}_t^1 - \phi_t^1)}{\partial\tau} > 0$, which implies that the additional credit market distortions resulted from the inability to commit rises with the level of tax rate on capital.

Lastly, since a simple comparison reveals that $\tilde{R}_t^2 > R_t^2$ and $\tilde{\phi}_t^1 > \phi_t^1$ continue to hold for a given capital income tax rate, the growth and welfare implications obtained in Proposition

3 also carry over to the current setting with capital income taxation. In other words, the inability to commit by lenders again leads to slower economic growth and lower social welfare in the economy with positive taxation on capital.

To end this section, from the policy perspective, it is worth to emphasize that the inability to commit exacerbates the incentive distortions created by the capital income tax policy at the first place, through raising the borrowers' cheating probability and the lenders' auditing probability in the credit market equilibrium. Therefore, the studies that implicitly assume auditing commitment by lenders run the risk of under estimating the macroeconomic effects of government taxation policies.

7 Conclusion

It has been widely argued that weak institutions can prevent poor countries from catching up with the rich. Presumably, institutional strength for contract enforcement can be measured in terms of not only its ability to rein in borrowers' fraudulent behavior, as has been much scrutinized in the existing literature, but also to discipline lenders' contractual commitment. In this regard, our analysis proposes a new micro-economic channel – the inability to commit to auditing in a credit market with costly state verification – through which the widely held view is confirmed. Alternatively, our analysis in the present paper can be interpreted as suggesting how the failings in institutional arrangements to bind lenders' auditing responsibilities could be detrimental to economic growth and social welfare.

To demonstrate how this channel works, we developed and compared two endogenous growth models. In the first model, lenders, by committing to a costly auditing technology, are able to identify the true output levels of borrowers by inducing the self-selection behavior from them. As opposed to this common approach in this line of research, we assume that lenders cannot commit to their auditing strategy a la Khalil (1997) in the second model. The lack of commitment to auditing implies that the interaction between lenders and borrowers becomes a two-stage problem. In the second stage of the problem, a mixed strategy equilibrium is found in which both lenders audit and borrowers cheat with positive probabilities. In the first stage, lenders determine the optimal loan contract terms that are consistent with the mixed strategy equilibrium in the second stage. We found that the loan rate and auditing probability are higher, while economic growth rate and social welfare lower, in the regime without commitment. It is also shown that, a capital income tax policy generates an additional adverse incentive effect on growth and social welfare via the cheating probability when commitment to auditing is absent.

In typical studies of asymmetric information, the announced contractual enforcement (e.g., auditing and monitoring) by lenders is implicitly assumed to be taken at its face value and the separating contracts are then designed accordingly. Such an assumption can be quite problematic for at least two types of reasons. First, the equilibrium suffers from the time-inconsistency problem: lenders will be unwilling to carry out the required costly enforcement activities once they know the carefully designed contracts would indeed work to induce self selection. Second, weak contractual enforcement and weak legal institutions will not be able to renege the time-inconsistency problem by using institutional mechanisms as a commitment device to make lenders' auditing strategy binding. As has been shown in our analysis, this inability to commit by lenders, acting as an additional source of informational friction, has non-trivial consequences. It is also worth pointing out that the lack of commitment to audit by lenders will lead to non-separating equilibrium, where cheating behavior by the (some) borrowers is a necessary condition of the equilibrium. It is precisely this cheating behavior by borrowers eventually justifies more stringent contractual terms and results in greater credit market distortions.

Since the idea of commitment to audit has been embedded in a model with relatively simple structure in the present paper, potential ways of extensions are possible. One possibility is to introduce transitional dynamics into a neoclassical version of the model, which will allow us to study how both the auditing and cheating probabilities evolve and interact at different stages of development. Another possible extension is to develop potential remedies for fixing the inability to commit to audit. In Khalil and Parigi (1998), lenders choose to give a higher loan size under no-commitment case as a commitment device, hoping to convince the borrowers that they are at stake to audit since the expected returns from auditing positively depends on the loan size. In the current setup, loan size plays no such role since borrowers always prefer to obtain as much funds as they can. Therefore, it will be interesting to examine, when the loan size is endogenized, whether the same results in the current model will continue to hold.

Appendix

Proofs of claims in deriving the credit market equilibrium under no commitment

Claim 1: In equilibrium, the loan rate for reporting the low output level is lower than that for reporting the high output level, i.e. $R_t^1 < R_t^2$*, under the parameter assumptions in (4).*

Proof: From the equilibrium loan rates given in Proposition 2, we have

$$\begin{aligned} R_t^2 - R_t^1 &= \frac{(\kappa_2-\kappa_1)(q-\gamma A\pi_1\kappa_1)-\delta q}{\pi_2(\kappa_2-\kappa_1)-\delta} - \gamma A\kappa_1 \\ &= \frac{(\kappa_2-\kappa_1)(q-\gamma A\pi_1\kappa_1)-\delta q - \gamma A\kappa_1\left[\pi_2(\kappa_2-\kappa_1)-\delta\right]}{\pi_2(\kappa_2-\kappa_1)-\delta} \\ &= \frac{(\kappa_2-\kappa_1-\delta)(q-\gamma A\kappa_1)}{\pi_2(\kappa_2-\kappa_1)-\delta}. \end{aligned}$$

Since $\kappa_1 < \pi_1\kappa_1 + \pi_2\kappa_2 - \delta$ from (4) and $\pi_1+\pi_2 = 1$, it is obvious that $\kappa_2-\kappa_1-\delta > \pi_2(\kappa_2-\kappa_1)-\delta > 0$. Together with $\gamma A\kappa_1 < q$, again, from (4), we obtain from the above equation that $R_t^2 - R_t^1 > 0$. Hence, the claim is proved. QED

Claim 2: In equilibrium, the expected payoff to a borrower is increasing with R_t^1 *under (4). Therefore, it will be optimal to set* $R_t^1 = \kappa_1\rho_{t+1} = \gamma A\kappa_1$*.*

Proof: With the substitution of (16) into (20), a borrower's expected payoff is given by

$$U_t \equiv (\pi_1\kappa_1+\pi_2\kappa_2)\rho_{t+1}x_t - (\pi_1 R_t^1 + \pi_2 R_t^2)x_t,$$

which can be rewritten after substituting R_t^2 from the zero-profit condition (24) as

$$\begin{aligned} U_t &= (\pi_1\kappa_1+\pi_2\kappa_2)\rho_{t+1}x_t - (\pi_1 R_t^1 + \frac{q}{1-\nu_t} - \frac{\pi_1+\pi_2\nu_t}{1-\nu_t}R_t^1)x_t \\ &= (\pi_1\kappa_1+\pi_2\kappa_2)\rho_{t+1}x_t - \frac{q}{1-\nu_t}x_t + \frac{\nu_t}{1-\nu_t}R_t^1 x_t \\ &= (\pi_1\kappa_1+\pi_2\kappa_2)\rho_{t+1}x_t - qx_t - \frac{\nu_t}{1-\nu_t}(q-R_t^1)x_t. \end{aligned}$$

where $\nu_t = \frac{\delta\pi_1\rho_{t+1}}{\pi_2(\kappa_2\rho_{t+1}-\delta\rho_{t+1}-R_t^1)}$. Then, we have

$$\begin{aligned} \frac{\partial U_t}{\partial R_t^1} &= -\frac{\partial(\frac{\nu_t}{1-\nu_t})}{\partial R_t^1}(q-R_t^1)x_t + \frac{\nu_t x_t}{1-\nu_t} \\ &= \frac{\delta\gamma A\pi_1(\gamma A\pi_2\kappa_2 - \pi_2 q - \gamma A\delta)}{(\gamma A\pi_2\kappa_2 - \pi_2 R_t^1 - \gamma A\delta)^2}x_t. \end{aligned}$$

It follows from (4) that $(\gamma A\pi_2\kappa_2 - \pi_2 q - \gamma A\delta) - \pi_1(q - \gamma A\kappa_1) > 0$, which implies that $\gamma A\pi_2\kappa_2 - \pi_2 q - \gamma A\delta > \pi_1(q - \gamma A\kappa_1) > 0$. Therefore, $\frac{\partial U_t}{\partial R_t^1} > 0$, and hence the claim is proved. QED

Claim 3: In equilibrium, $\kappa_2\rho_{t+1} - R_t^2$ must be positive under (4).

Proof: In equilibrium, $R_t^2 = \frac{(\kappa_2-\kappa_1)(q-\gamma A\pi_1\kappa_1)-\delta q}{\pi_2(\kappa_2-\kappa_1)-\delta}$, it is easy to check that

$$\begin{aligned} &\gamma A\kappa_2 - \frac{(\kappa_2-\kappa_1)(q-\gamma A\pi_1\kappa_1)-\delta q}{\pi_2(\kappa_2-\kappa_1)-\delta} \\ = &\frac{[(\kappa_2-\kappa_1)(\gamma A\pi_1\kappa_1+\gamma A\pi_2\kappa_2-q)-\delta(\gamma A\kappa_2-q)]}{\pi_2(\kappa_2-\kappa_1)-\delta} > 0. \end{aligned}$$

The last inequality follows from the assumptions in (4). QED

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