OCCUPATIONAL CHOICE AND PROFIT TAXATION UNDER INFORMATIONAL ASYMMETRIES

by

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Abstract

This paper develops a simple general equilibrium model with signalling in the presence of adverse selection in the financial market and with occupational choice in the labor market, in order to examine the efficiency cost and incidence of an entrepreneurial profit tax. The model yields an informationally-constrained efficient equilibrium in which the high-productivity agents tend to choose the high-return, high-risk occupation. Three different equilibrium types are identified depending upon the occupational distribution, and the population distribution among agent types is emphasized as one of the determining factors of equilibrium characteristics and tax consequences. As the high-productivity agents become more scarce, a stronger signal is necessary, but a lower wage is paid to workers. The tax does not always discourage entrepreneurial activities, but when it does, workers share the tax-burden with entrepreneurs. This paper also highlights the beneficial risk-sharing effects of taxation on risky behavior which have often been neglected in the literature, or analyzed in models where capital market imperfections are not endogenously derived.

Keywords and JEL Codes:
Incidence(H22) and Excess Burden(H21) of Profit Tax(H25),
Signalling in Financial Market(G14), Occupational Choice(J24).
I. Introduction

While there have been many studies on occupational choice and risk-taking by individuals, considering occupational choice consequences of taxation is relatively a new addition to the literature. Kihlstrom and Laffont [1979] showed that more risk averse agents choose to work for safe wages and the less risk averse choose to operate risky firms of which the sizes depend upon their degree of risk-aversion. Kanbur [1981] considered ex ante homogeneous agents to conclude that a marginal profit tax with subsidy to workers enhances the utilitarian social welfare. Boadway, Marchand, and Pestieau [1991] argued that the optimal marginal tax rate is 100% due to the so-called risk-sharing effect of taxes when agents are heterogeneous either in their ability or in their risk preferences.

Among other things, this literature is characterized by individual but non-diversifiable risk due to the non-existence of perfect insurances and the financial market. Allowing individuals to make occupational choice leads to more realistic specifications of labor market and income source, and hence, to richer explanations for firm entry and exit in the contexts of income and occupational taxes. Due to the binary nature of occupational choice between risky and safe occupations and the equilibrium condition that both occupations give the same expected utility, however, the implications on tax policy is rather simple. The risk-sharing effect of income tax highlighted earlier by Domar and Musgrave [1944] is so dominant that the optimal tax rate is often 100% since, intuitively speaking, the tax and subsidy scheme can be seen as a mechanism that converts the risky money paid as tax to the safe money returned from the government. This seems to be the limit of the studies that take occupational choice as an alternative to other individual choice such as portfolio choice. Motivated by this observation, this paper intends to provide a model with multiple dimensions of decision-making in order to better understand tax consequences.

This paper develops a simple general equilibrium model to study the consequences
of an entrepreneurial profit tax when agents with private information make decisions not only between being a worker and an entrepreneur, but also, as an entrepreneur, on the financial structure of his own firm. To be specific, each agent is endowed with a single risky project, and chooses between being a worker paid the safe equilibrium wage and an entrepreneur who earns risky income generated by his project. If he decides to become an entrepreneur, he has to set up a firm, issue equity in the financial market, and recruit workers in the labor market. To have a realistic model, we assume that the true quality of each project, hence the true value of equity issued by each firm is not publicly known so that the typical adverse selection problem prevails in the financial market. Owing to the market imperfection caused by this private information, the project risk cannot be spread costlessly through equity trade, and, consequently, entrepreneurs may necessarily bear a certain fraction of the risk of their own projects. In this paper, therefore, the market imperfection is endogenously derived from informational asymmetries; previous studies did not model the imperfection.

A signalling mechanism is adopted to handle the adverse selection problem. More specifically, the project quality is signalled by the share of risk borne by the entrepreneur. In other words, entrepreneurs signal their types with their inside equity positions which reveal their willingness to bear the risk of their own projects. Entrepreneurs want to bear as little risk as possible and sell all the equity of their own firms to cash out their risky projects. However, such a sale signals low value, so entrepreneurs would not do so.

While the signalling model approach to the adverse selection problem is standard in the literature on the financial markets, it is a rather recent approach in the tax literature. Bernheim [1990] and Cheong [1991] are examples of such studies that employ signalling models in the analysis of taxes.

Signalling with inside equity position has been often employed in previous studies such as Leland and Pyle [1977] and Grinblatt and Hwang [1989]. The main concern of
these studies was, however, the equilibrium financial structure of firms and they did not include applications to tax analysis. Signalling or holding inside equity hurts risk-averse entrepreneurs, and hence incurs waste of resources relative to the full information situation that needs no signalling. Given this dissipative nature of the inside equity position, the possibility of costless signalling was explored by Brennan and Kraus [1984], [1987] who showed the adverse selection problem may be costlessly overcome by an appropriate combination of financial decisions under certain conditions. In the case in which project types are ordered by first-degree stochastic dominance as in this paper, it is required that the (firm's) payoff function be "V-shaped". However, when firms are allowed only one way of external financing, which in this paper is equity-issue, the payoff function turns out monotone but not V-shaped.

It should be emphasized that the choice of signalling mechanism reflects the competitive nature of the financial market in which equity is issued to the public and there are no financial intermediaries. Cheong [1991] suggested that the existence of financial intermediaries that can issue a secondary (mutual fund-type) security may lead to a Pareto improvement. It should be also noted that the equilibrium allocation obtained in this paper is supported only in economies with an equity market, and more precisely, only in the context of signalling. The same allocation may not be an equilibrium or may not be efficient in the economy where private information is transferred through a different mechanism. For example, Innes [1992] showed that the financial market with the bank-loan type contracts between entrepreneurs and investors obtains a Miyazaki equilibrium ¹ which is usually Pareto superior to the (separating) signalling equilibrium.

The signalling model in this paper assumes, for simplicity, only two types of agents (or equivalently, projects): high-productivity and low-productivity agents. With Pareto-

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¹ See Miyazaki [1977]. This equilibrium is in fact the solution to the optimal subsidization problem in Rothschild and Stiglitz [1976].
dominant signalling equilibrium in the financial market, three different general equilibrium types are identified, depending upon the occupational distribution in the economy. Regime I refers to the type of equilibrium in which all of the high-productivity agents and some of the low-productivity agents are operating their own firms, Regime II the type of equilibrium in which types of agents are completely revealed by their occupations, and Regime III the type of equilibrium in which all of the low-productivity agents and some of the high-productivity agents are employed as workers.

This paper emphasizes the role of the population distribution among types as a determining factor of the equilibrium characteristics. The more scarce the high-productivity agents are, the stronger the required signal is, but the lower the workers' wage is in equilibrium; thus, the high-productivity agents are not necessarily better off, while the low productivity agents are definitely worse off.

The incidence and efficiency cost of a proportional profit tax with full loss offsets are examined theoretically and through numerical experiments. It is shown that a tax increase in Regimes I and III leads to a new occupational distribution in which fewer firms hire more workers at a lower wage than before the tax increase. Thus, entrepreneurial activities are clearly discouraged, but the burden of the tax levied on these activities is shared by workers. In contrast, the tax is almost neutral in Regime II in the sense that nothing but the inside equity position varies with the tax rate, and firms bear the full tax burden.

The efficiency cost analysis shows that the marginal excess burden is heavier at a higher initial tax rate, which implies that the tax becomes more distortionary as its rate rises. It is also found that entrepreneurs benefit substantially from the risk-sharing effect of the proportional tax. In Regime II, this effect is added to another tax effect of lowering inside equity position, and, as a result, the welfare loss (computed in the monetary unit) of a small tax increase to each entrepreneur is only a fraction of the increase in his tax payment. Even in Regime I, in which a tax increase causes a distortion in occupational
choice but does not affect the required inside equity position, a sufficiently low initial tax rate may cause the beneficial risk-sharing effect to dominate all the cost of tax distortions in aggregation, so that the marginal excess burden turns out to be negative. This paper, therefore, indicates that the risk-sharing effect should not be ignored in the analysis of taxation on risk-taking; whereas it has been often neglected or considered in models with risk-taking induced only by exogenous market imperfections.

The profit tax considered in this paper may be seen as a tax on entrepreneurship in the sense that it is, in effect, lump sum to outside investors. This tax on entrepreneurial human capital is in parallel with a tax on income from (physical) capital which has been the main focus of the traditional corporate tax research pioneered by Harberger [1962], followed by Shoven [1976], Gravelle and Kotlikoff [1989], and others. It has been found in this line of research that the corporate tax burden is rarely shifted but incurs a huge efficiency cost to the economy. Generally speaking, this result is due to the inelastic supply of capital which seems a reasonable assumption in static models. In contrast, (entrepreneurial human) capital as well as labor are not fixed in an occupational choice model but are endogenously determined by occupational choice. It is found in this paper that the tax burden is usually shared between entrepreneurs (capital) and workers (labor) as a result of partial tax-shifting from capital to labor, and that it is borne solely by entrepreneurs only when they have no choice to be workers (in Regime II), which is consistent with the standard elasticity result in tax theories that the less flexible party suffers more. Therefore, the findings in this paper include the standard result of corporate income tax analysis as the result of a special case, as well as new contributions to the understanding of the tax consequences on risk-taking and occupational choice. It is claimed in this sense that the model developed in this paper is more general and gives new insights into the nature of capital income taxes.

The rest of this paper is organized as follows. Section II sets up the model, and
Section III characterizes the signalling equilibrium. In Section IV, three kinds of general equilibrium are examined with emphasis on the differences from symmetric information equilibrium. Section V theoretically analyzes the tax consequences, especially the tax incidence. Section VI discusses the results from three groups of numerical experiments: the zero tax economy, the tax incidence, and the efficiency cost of the tax. Section VII concludes the paper.

II. The Model

The economy consists of three markets: the commodity market, the labor market, and the financial market. Commodity is the only consumption good and taken to be the numeraire. Each agent is either an employer as an entrepreneur or an employee as a worker in the labor market, depending upon his preference. In the financial market, each entrepreneur sells the equity of his own firm to outside investors including other entrepreneurs.

We consider the general equilibrium in this economy when every agent makes occupational choice prior to other decision-making. Each agent has two occupational alternatives open to him. He may choose to be an entrepreneur and execute his project plan. To do this, he must set up a firm and hire other agents as workers. The firm’s profit, which is the cash-flow net of labor costs, taxes, etc., is the income of the entrepreneur and/or outside investors. Alternatively, he may choose to become a worker and earn wage income, ignoring his project plan. The occupational choice is motivated by individual utility-maximization, and, in equilibrium, no agent has an incentive to change his occupation.

Allowing occupational choice is not meaningful unless agents are different in some respect. We assume agents are distinct in the profitability of their project plans when executed, while they are equally productive as workers. The distinction may be due to the differences in the projects or in the agent’s entrepreneurial capability. Without specifying the source, we assume for simplicity that there are only two kinds of agents (or equivalently,
projects) in the economy: *High*-productivity type and *Low*-productivity type. In the model, types are indicated by the probability that the execution of a project plan does not fail, assuming that no output is produced in case of a project failure. Thus, the higher the probability is, the more profitable a project is thought to be on average. Types are attributes of agents, but we may refer to them with their occupational choices included. For example, a High type firm indicates it is run by a High-productivity agent.

We assume agents are risk averse, and project returns are risky. Risk aversion implies that entrepreneurs desire to pass on as much risk as possible, which in the model takes the form of issuing equity in the financial market. However, it is not always possible for an entrepreneur to sell all the equity, and in this sense, one’s occupational choice determines not only the amount of money earned but also the nature of the money: *safe* or *risky*. A worker is paid the safe income amounting to the equilibrium wage, while an entrepreneur earns his share of the risky profits from his project.

Now we make a crucial assumption that the knowledge regarding type is private information. Agents know their own types and the frequencies of all types in the economy, but cannot distinguish others by type without additional information. This creates an informational asymmetry between each equity-issuing entrepreneur and the other agents, and generates an adverse selection problem in the financial market, since outside investors are hardly aware of the true value of the equity they are purchasing. In the presence of this adverse selection problem, the financial market cannot perform properly without information transfer.

The information transfer process featured in the model is a signalling mechanism in which the *informed* party moves first by sending a signal to which the *uninformed* party reacts. The model includes a financial market in which entrepreneurs actively seek external financing from outside investors who bid for financial assets in Bertrand fashion. The signal employed in the model is the inside equity position of each firm, that is, the fraction
of the firm's equity retained by the entrepreneur. Holding inside equity means bearing one's own risk, which is costly to a risk-averse agent. It should be pointed out that the inside equity position alone cannot separate types since firms of different types may hire different numbers of workers. However, as will be shown, the number of workers hired by an entrepreneur reveals his type costlessly, and in this sense, the term *signal* is used only for the inside equity position.

Low type agents may want to pretend to be High types. Such behavior of Low type agents imposes an incentive compatibility constraint on a High type's utility maximization, and consequently, the optimal decision by a High type deviates from what it would be in an economy with symmetric information in which types are known freely and no signalling is necessary.

We assume that equity is the only means of external financing, and so it is the only channel of risk-trading among agents. We further assume that there is no economy-wide risk, and all the project returns are uncorrelated, which implies that a properly diversified portfolio is virtually risk-free, and there is no risk premium necessary in the trades of equity. These assumptions allow a simple equity-pricing rule in the financial market — equity is priced at the expected value of a project's proceeds once its type is revealed. ²

Given this equity-pricing, every entrepreneur wants to sell all the equity of his firm and thus hold no inside equity, since it thereby cashes his risky project without penalty in the financial market. It is, however, not feasible (at least for some agents) as long as the adverse selection problem persists in the financial market. To cure the problem, agents choose to hold inside equity in order to signal information on the value of their own firms. This makes it clear that the signalling cost is the opportunity cost of being stuck with risk.

² This describes a separating equilibrium. In contrast, types are not revealed and both types of equity are priced at the weighted sum of expected values in a pooling equilibrium. The next section discusses the concepts of equilibrium in detail.
which otherwise could be diversified away through financial transactions.

In addition to the financial decision on the inside equity position, an entrepreneur has to make a labor-hiring decision. In contrast, an agent who has chosen to be a worker has no further decisions to make, and he is paid the riskless equilibrium wage. Despite these differences in the transactions that follow occupational choices, we assume that every agent has the same utility function which depends only upon the consumption level (or equivalently, the net cash income since the consumption good is the numeraire).

The tax considered in the model takes the form of a profit tax with full loss offsets. Each firm pays tax or receives subsidy proportional to the difference between the revenue from the commodity sale and the production cost. This kind of tax affects the profitability of projects but none of the decision-making by firms, and therefore, the tax is neutral in partial equilibrium analyses. But, the general equilibrium effects of the tax are generally not neutral due to subsequent changes in relative prices. Moreover, there are two additional sources of non-neutrality of the tax in the model. First, the general equilibrium effect on wage directly affects the occupational choices made by agents. For example, a tax increase makes the entrepreneurial occupation less attractive, and consequently, more workers will be supplied in the labor market. Secondly, a change in the profitability of a project implies a change in the opportunity cost of sharing the risk of the project, hence a change in the signalling cost. For example, a tax increase may ease the burden for entrepreneurs by lowering the signalling cost, which tends to shorten the deviation from the symmetric information equilibrium caused by the adverse selection problem.
III. The Separating Equilibrium: Existence and Efficiency

In the model, a signalling equilibrium is represented by the combination of the inside equity position and the number of workers announced by each entrepreneur, and the implicit equity-evaluation schedule for him, or the summary of his beliefs on the responses from outside investors to his announcement. An equity-evaluation schedule is a pricing rule by which a firm's equity is priced according to the signal sent by the firm in the competitive financial market, and an entrepreneur makes decisions on his inside equity position and the number of workers to be hired on the basis of his own expectation on the schedule. In equilibrium, all the entrepreneurs of the same type expect the same equity-evaluation schedule and send the same signal. ³

Many signalling models suffer the existence of too many equilibria, and the model presented here is not an exception. Every equilibrium is a Nash equilibrium due to the competitive pricing in the financial market, and the collection of equilibria includes separating and pooling equilibria. Among them, we choose the Pareto-dominant separating equilibrium as the equilibrium in the model. This equilibrium is the only signalling equilibrium that satisfies the so-called Cho and Kreps' Intuitive Criterion, and it is, in fact, the equilibrium defined by Riley. ⁴ In this equilibrium, none of the Low type entrepreneurs holds inside equity, but High type entrepreneurs hold the minimum position required to separate themselves from Low types, and the expected-value pricing rule separates the types.

In the equilibrium, Low types bear virtually no risk; hence they obtain the first-best outcome of a symmetric information economy. The occupational choices are based upon

³ In fact, the schedules need not be exactly identical, but should reflect identical beliefs at least on the points that are seen in equilibrium. The stipulation on the points unseen in equilibrium is related to the refinement of equilibrium in game theories.

⁴ While the original papers, Cho and Kreps[1987] and Riley[1975], are not easy reading, Ch.17 in Kreps[1990] provides a better exposition.
individual assessment of the maximum utility expected from different occupations. The expected utility of a Low type entrepreneur is the utility from the expected profit of his firm, and thus his optimal labor-hiring decision equates the expected marginal revenue product of labor and the prevailing wage. Therefore, in equilibrium, it holds that

\[ P_L f'(l_L) - W = 0 \]  

where \( P_L \) is the probability\(^5\) that a Low type firm produces the output level specified by a concave production function \( f \), \( f'(l_L) \) is the marginal product of labor, \( l_L \) is the number of workers employed in a Low type firm, and \( W \) is the wage rate.

The expected utility of a High type entrepreneur is maximized through financial and labor-hiring decision-making subject to the incentive compatibility constraint which deters Low types' pretending to be High types. That is, the optimal choices of the inside equity position, denoted by \( \alpha \), and the number of workers, denoted by \( l_H \), are the solution to the following programming problem:

\[
\max_{\alpha, l_H} \quad P_H U(\Gamma) + (1 - P_H) U(\gamma) \\
\text{subject to} \\
U(W) \geq P_L U(\Gamma) + (1 - P_L) U(\gamma) \tag{2}
\]

where
\[
\Gamma = \alpha (f(l_H) - l_H W) + (1 - \alpha) V_H \\
\gamma = -\alpha l_H W + (1 - \alpha) V_H \\
V_H = P_H f(l_H) - l_H W
\]

and \( P_H \) is defined as the same as \( P_L \) except it is the probability for High types, and \( U \) is a concave utility function. Setting up a Lagrangian function with \( \lambda \) denoting the Lagrangian

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\(^5\) Clearly, \( 1 - P_L \) is the probability that a Low type firm fails to produce any output.
multiplier for the constraint (Inequality (2)), we obtain the following three equations as the first order conditions:

\[
(P_H - \lambda P_L)(1 - P_H)U'(\Gamma) + \((1 - P_H) - \lambda(1 - P_L))(-P_H)U'(\gamma) = 0
\]

\[
(P_H - \lambda P_L)((1 - \alpha)P_H f'(l_H) + \alpha f'(l_H) - W)U'(\Gamma)
\]

\[
+ ((1 - P_H) - \lambda(1 - P_L))((1 - \alpha)P_H f'(l_H) - W)U'(\gamma) = 0
\]

\[
U(W) - P_L U(\Gamma) - (1 - P_L)U(\gamma) = 0
\]

The second-order condition requires that the Bordered Hessian matrix for the Lagrangian function should be negative definite, which we assume for the existence of the equilibrium. From the first-order conditions, we establish one of the main results of the model — the first-best labor-hiring decision for High type entrepreneurs is incentive compatible in the separating equilibrium.

**Proposition 1.** In equilibrium, High type entrepreneurs hire the same number of workers as they would in the first-best equilibrium.

**Proof:** The proof is straightforward since the Equations (3) and (4), by simple manipulation, reduce to the equation:

\[
P_H f'(l_H) - W = 0
\]

Obviously, firm size, defined as the number of workers employed by a firm in equilibrium, varies with the type of firm. It is easy to see \(l_H > l_L\) for a concave production function \(f\) from the Equations (1) and (6).

**Proposition 2.** In equilibrium, High-type firms hire more workers than Low-type firms.

Proposition 2 is a direct implication of the first-best equivalence stated in Proposition 1. Although the size of firm conveys information on types, it alone does not identify types
in equilibrium due to the structure of the maximization problem for High types. The incentive constraint in the problem requires that a Low type worker should not be worse off than a Low type taken for a High type. Inequality (2) shows that a Low type succeeds in pretending to be a High type only if he announces the same inside equity position and the intent to hire the same number of workers as High types do. Thus, Low types have no incentive to imitate only a part of High types' behavior since it will merely be a costly failure. At the same time, a High type would not deviate from the optimal solution to the maximization problem since otherwise he is perceived as a Low type in the financial market.

Every agent is maximizing his utility in an equilibrium which is unique by construction. In addition, the incentive compatibility constraint is exactly binding with equality so that High type entrepreneurs are sacrificing the minimum required signalling cost. Therefore, no Pareto-improving allocation is feasible given the informational asymmetries, and hence, the equilibrium is informationally-constrained efficient.  

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6 The same equilibrium allocation may not be efficient in a screening game. In order to be efficient, the allocation has to be the solution to the cross-subsidization problem in Rothschild and Stiglitz [1976]. Cheong [1991] showed that a financial intermediary can perform the cross-subsidization in the financial market in a signalling model similar to the one developed in this paper. The existence of financial intermediaries is not assumed in this paper.
IV. Three Regimes for General Equilibrium

In establishing the existence, uniqueness and constrained efficiency of the separating equilibrium, we assume that the adverse selection problem persists in the financial market. In the model, the true quality of equity is private information, and is revealed only through costly signalling. The signalling mechanism is effective in eliciting an informationally-constrained equilibrium, but do we always need such a costly correcting mechanism given the informational asymmetries? No, not always, because an adverse selection occurs only when both types are willing to be entrepreneurs. Suppose, for example, Low type agents can be hired at a wage rate which is no lower than the potential profits of High type firms in the separating equilibrium. All of them will unquestionably choose to be workers, and there is no adverse selection problem in the financial market. The signalling mechanism is not necessary, and we obtain a different equilibrium condition for that wage rate.

This example suggests that the configuration of the equilibrium may have to be modified in accordance to the market conditions. To explore the possibility, we first note that the potential equilibrium wage is bounded both from above and from below. The lower boundary is the rate at which Low types are indifferent between being workers and being entrepreneurs with their type revealed in the separating equilibrium. No wage rate below this boundary can be an equilibrium wage since there would be no supply of labor, and hence the economy could not be sustained. The upper boundary is reached when the same occupational indifference applies to High types. If the wage is higher than this boundary, no agent wants to be an entrepreneur, which means there is no demand for labor, and again the economy collapses. For the rates between these boundaries, agents are obviously more and more attracted to the option of being worker as the wage rate goes up.

There should be both entrepreneurs and workers in order to have an equilibrium, and it is High type agents, if separated, who become entrepreneurs. Thus, there are only
three kinds of occupation distributions possible in equilibrium. In one of these, types are completely separated by occupations. In other words, every High type agent is an entrepreneur, and every Low type agent is a worker. If this happens in equilibrium, we say that the economy is in Regime II. As will be shown later, the equilibrium wage falls between the two boundary wages in this regime. Another possibility is that some of the Low type agents as well as all the High type agents are entrepreneurs. The diversity of occupation for Low types is due to their indifference between occupations, which requires that the equilibrium wage be exactly the lower boundary wage. We define Regime I as the economy that has such an equilibrium. In the third possibility, a diversity of occupations can be seen among High type agents, while all the Low types are workers. The equilibrium wage is necessarily the upper boundary wage, and this economy defines Regime III.

Although regimes are described in terms of equilibrium wage and the distribution of occupations, it is basically the exogenous variables in the economy which determine to which regime the economy belongs. These variables include technology, population frequency of types, tax system, etc. and the change in one or more exogenous variables may lead to a change of regimes for the economy.

It is sufficient to investigate two markets for a general equilibrium in this model of a three market economy. By construction, the financial market is in equilibrium. Outside investors are willing to absorb whatever volume of equity left over after the optimal signalling, since buying equity without systematic risk at the expected value is neither costly nor risky in a well-diversified portfolio.

For an equilibrium in the labor market, we use the following identity:

\[ N_H + N_L = N_H^E (1 + l_H) + N_L^E (1 + l_L) \]  \( (7) \)

where \( N_H \) and \( N_L \) denote the number of High type agents and Low type agents, respectively, exogenously given in the economy, and \( N_H^E \) and \( N_L^E \) denote the number of High
type entrepreneurs and Low type entrepreneurs, respectively. This identity simply states that every individual is either an employer or an employee. From this, we draw the labor market-clearing condition for each regime by imposing appropriate restrictions.

In the Regime I equilibrium, it is required that

\[ N^E_H = N_H \quad \text{and} \quad N^E_L > 0 \]  

From these conditions along with Identity (7), we obtain

\[ N^E_L = \frac{N_L - N_H l_H}{1 + l_L} > 0 \]

or equivalently,

\[ l_H < \frac{N_L}{N_H} \]  

The implication of Inequality (9) is obvious. Not all the Low type agents are hired by High type agents; otherwise, there will be no Low type entrepreneurs. It should be noted that \( l_H \) is obtained independently of \( N_H \) and \( N_L \), and therefore, the inequality constitutes a necessary condition for the equilibrium in Regime I.

The Regime I equilibrium, if any, is specified as the solution to the simultaneous equation system consisting of Equations (1), (5), (6), and Identity (7), and also the equation given by

\[ U(W) = U(P_L f(l_L) - l_L W). \]  

Equation (10) states that both occupations lead to the same level of utility of Low type agents in equilibrium. The equation system determines the five unknowns such as the equilibrium wage \( W \), the optimal sizes of firms \( (l_H, l_L) \), the optimal inside equity position for High types \( (\alpha) \), and the number of Low type firms \( N^E_H \).  

\[ \text{7 In fact, the equation system is a nested system in which } W \text{ and } l_L \text{ are solved by Equations (1) and (10), then, } l_H \text{ is solved in Equation (6), and then, Equation (5) and Identity (7) respectively determine } \alpha \text{ and } N^E_H. \]
The Regime II equilibrium allows no diversity in occupation for either type. Thus, we have the restrictions:

\[ N_H^E = N_H \quad \text{and} \quad N_L^E = 0 \]

which simplify Identity (7) to be

\[ l_H = \frac{N_L}{N_H} \quad (11) \]

The equilibrium size of firms is decided exogenously, which reflects the important property of equilibrium that the labor-hiring decision is not affected by incentive compatibility. Given a predetermined \( l_H \), the first-order conditions of the High types' optimization, that is, Equations (5) and (6), determine the equilibrium wage and the optimal inside equity position.

Unlike Regime I or Regime II, Regime III is free from the adverse selection in the financial market. This is because the wage is so high that Low types have strict preference for being workers. At the same time, High type workers are compensated just as much as High type entrepreneurs; thus,

\[ U(W) = EU(l_H, \alpha) \quad (12) \]

where \( EU(l_H, \alpha) \) denotes the expected utility obtained by the optimal choices of \( l_H \) and \( \alpha \). The restrictions on Identity (7) in this regime are

\[ 0 < N_H^E < N_H \quad \text{and} \quad N_L^E = 0 \]

which lead to the condition

\[ l_H > \frac{N_L}{N_H} \quad (13) \]

that should be satisfied in equilibrium, if it exists. In equilibrium, no firm holds inside equity; hence, \( \alpha = 0 \). The optimal firm size and the equilibrium wage are determined by
Equations (6) and (12), and then the number of High type firms is determined by Identity (7).

It is worth noting that the optimal size of a High type firm is not identical in different regimes. To make this point clear, we compare the necessary conditions for regimes (with the superscripts denoting each regime):

\[
l_H^I < \frac{N_L}{N_H} \quad (14)  
\]

\[
l_H^II = \frac{N_L}{N_H} \quad (15)  
\]

\[
l_H^III > \frac{N_L}{N_H} \quad (16)  
\]

These conditions relate the type of regime to a given population distribution. Equivalently, they identify the type of regime for which a given economy is eligible. The following proposition is the first step towards an important result that the population distribution uniquely identifies the regime.

**Proposition 3.** The size of Low type firms in Regime I is exactly the size of High type firms in Regime III.

**Proof:** \(l_L^I\) is obtained from Equations (1) and (10) which reduce to

\[
f(l_L^I) = (1 + l_L^I)f'(l_L^I) \quad (17)  
\]

\(l_H^{IIII}\) is obtained from Equations (6) and (12) with \(\alpha = 0\), which reduce to

\[
f(l_H^{IIII}) = (1 + l_H^{IIII})f'(l_H^{IIII}) \quad (18)  
\]

From Equations (17) and (18), it follows that \(l_L^I = l_H^{IIII}\) since \(f\) is concave.

It is remarkable that the equality in the proposition depends upon nothing but the nature of equilibrium in each regime. It should be also pointed out that \(P_H\) and \(P_L\) do not appear in any of Equations (17), (18) and (11). Thus, the size of the firms, and hence
the number of firms, operating in equilibrium is independent of the probability of total failure in production, while the probability clearly affects the equilibrium wage. Simply combining Propositions 2 and 3, we draw the following summarizing result.

**Proposition 4.** Relative population frequencies of types, represented by \( \frac{N_L}{N_H} \), uniquely determine the regime, hence the equilibrium, if any, in the following way, other things being equal. If \( \frac{N_L}{N_H} \) is greater than \( l_H^I \), the economy is in Regime I in which the equilibrium wage is at the lower boundary rate defined earlier. If \( \frac{N_L}{N_H} \) is smaller than \( l_H^{III} \), the economy is in Regime III in which the equilibrium wage is at the upper boundary rate. If \( \frac{N_L}{N_H} \) falls between \( l_H^I \) and \( l_H^{III} \), the economy is in Regime II in which the equilibrium wage, determined by Equation (6) with \( l_H^I = \frac{N_L}{N_H} \), falls between the two boundary rates.

When we defined regimes earlier, we started with the discussion of equilibrium wages. The range of equilibrium wage is divided into three segments: the lower boundary, the interval, and the upper boundary, and they correspond to Regime I, Regime II, and Regime III in that order. Proposition 4 asserts that regimes are equivalently defined in terms of the relative scarcity of types.

In the discussion of equilibrium, we began with the construction of the separating equilibrium in which occupational choices do not completely reveal the types of agents since a Low type agent may be hired by a High type agent or another Low type agent. However, when Low types strictly prefer to be workers while High types do not, complete occupational separation occurs, and the equilibrium wage decreases as the frequency of Low types increases (i.e. as \( \frac{N_L}{N_H} \) increases). This tendency characterizes Regime II. However, when the frequency of High types is relatively too low, the potential equilibrium wage is so low that Low types would choose to be entrepreneurs. There will be no production without workers, and thus, the equilibrium wage should be just high enough to have Low types indifferent between two occupations. This is Regime I, the type of equilibrium we initially
considered, in which types are partially revealed and some of the Low types operate their firms. On the other hand, the equilibrium wage required for occupational separation may be too high when High types are relatively abundant. In that case, it is necessary to have occupational indifference of High types in equilibrium. This is Regime III in which types are partially revealed and some of the High types are workers. In this regime, the adverse selection problem does not occur since Low types have no incentive to deviate from being workers given the high-enough equilibrium wage. Unlike Regime I and II, therefore, Regime III obtains a first-best equilibrium despite the existence of private information.

The maximum utility that an agent can achieve in equilibrium depends not only upon his type but also upon how rare his type is in the population. Proposition 4 shows that the equilibrium wage is a weakly-decreasing function of $\frac{N_L}{N_H}$ which also determines the regime, ceteris paribus. Thus, it is clear that Low types become worse off as they become relatively more abundant. Is it also implied that High types become better off as they become more and more scarce? The answer is not obvious because their utility level begins to depend upon the signalling cost as well as the labor cost if they become so scarce that the economy is no longer in Regime III. Once the economy enters Regime II, the wage decreases as $\frac{N_L}{N_H}$ increases, which is favorable to High types. However, at the same time, they are subject to a new cost item, the signalling cost. The change of the signalling cost induced by the increase of $\frac{N_L}{N_H}$ in Regime II is governed by two conflicting tendencies. Both types of agents see their net project values grow as the wage decreases. The increased High type's value means the increased potential gain for a Low type from pretending to be a High type. Thus, a High type is required to bear more risk in order to separate himself from Low types. On the other hand, the increased Low type's value means that Low types have less incentive to pretend due to the decreased potential gain from doing so. This, in turn, implies that High types can have separation with weaker signals than before. If
the first tendency is dominated by the second, then the bigger $\frac{N_L}{N_H}$ becomes, the less High types have to sacrifice. In other words, the scarcity pays off in Regime II. However, if the first tendency more than offsets both the second one and the effects from decreased wages, we may have a reversed result.

In Regime I, High types are so rare that their scarcity does not even matter in the sense that their signalling cost and both type firms' labor costs, hence the utility levels of both type agents, are constant. However, High types are better off than Low types, unlike in Regime III, due to the lower equilibrium wage. Therefore, it is not conclusive in the model $^8$ whether High type agents benefit from being rare while Low type agents lose from being abundant.

Suppose, in a Regime II economy, the number of High types is fixed and we add Low types one by one. This will increase $\frac{N_L}{N_H}$ gradually. It is certain that all the existing Low types become worse off as an additional Low type agent enters the economy. Everyone in the economy suffers if High types lose too, as a result of the increased burden of signalling costs. If this is the case, it can be said that the signalling mechanism is too costly and thus may not be a proper correcting mechanism. It is, thus, presumed that High type agents do not become worse off at all as they become more scarce, if the signalling mechanism is to be well-supported. However, it should be emphasized that this uniform relation between the individual welfare and scarcity of High type agents depends upon the fact that the number of agents in the economy keeps increasing, in other words, the economy is expanding in this experiment. On the contrary, the economy will shrink as High type agents become more and more scarce if High type agents are replaced by newly-introduced Low type agents. It is possible in this case that everyone loses even in the economy without the incentive

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$^8$ Comparative static experiments show that the signs of $\frac{d\alpha}{d\frac{N_L}{N_H}}$ and $\frac{dEU}{d\frac{N_L}{N_H}}$ are indefinite, depending upon the (local) curvature of the production and utility functions.
problem, and we cannot expect the same uniform relation from a signalling model.

The above suggests that the source of ambiguity in the direction of High types’ welfare change is the informational asymmetries. If every agent can tell the type of any other agent, High type entrepreneurs need not bear the signalling costs, and the first-best equilibrium will persist. The following proposition compares this first-best equilibrium and the signalling equilibrium.

**Proposition 5.** The equilibrium with asymmetric information has the same configuration as the first-best equilibrium except that High type entrepreneurs hold positive position of inside equity when \( \frac{N_L}{N_H} \) is not smaller than \( t_{III}^{H} \) defined earlier.

**Proof:** If \( \frac{N_L}{N_H} \) is smaller than \( t_{III}^{H} \), the economy is in Regime III, and has no incentive problem, and hence obtains the first-best equilibrium despite the informational asymmetries. In equilibrium of Regime I or II, it is easily seen that \( \alpha \) is obtained in Equation (5) after the other variables are determined. Since this equation is the only difference from the equations defining the first-best equilibrium, the two equilibria have identical configurations except the existence of positive \( \alpha \) in the signalling equilibrium.

This proposition shows that other markets are not disturbed by the introduction of financial market imperfection. The only consequence of asymmetric information is that High type entrepreneurs solely bear the costs of the correcting mechanism in the financial market. Thus, this proposition directly implies Propositions 1 and 2, and also supports the (constrained) efficiency of the equilibrium in the model, as the equilibrium signal is the minimum risk-bearing required for the separation of types.
V. Tax Consequences

The tax levied on entrepreneurial profits with full loss offsets is neutral in partial equilibrium analyses. Factor demands, and hence the output level, are not affected, and the tax payment is a proportional transfer to the government. Since labor is the only factor of production, the model also has no difficulty of defining the tax base with respect to the capital costs. In consequence, the labor-hiring decision rules for both types of entrepreneurs are still Equation (1) and (3) regardless of the tax rate, and thus, the size of a firm is independent of the tax rate as long as the equilibrium wage remains the same after a tax change. It should be noted that the full loss offset provision is crucial in drawing this neutrality result. A profit tax with partial or no loss offset is a distortionary tax since the after-tax profit is no longer a fixed fraction \((1 - \tau)\), where \(\tau\) is the tax rate) of the before-tax profit.

Generally, the general equilibrium effects of a profit tax come from the induced changes in relative prices, and are often decomposed into the output effect and the factor substitution effect. Such decomposition, however, does not apply in models with a single output and a single production factor. In our model, it is rather the distortion of occupational choices that generates the general equilibrium effects since the model allows occupational substitutions only.

The imposition of a new tax, or a tax increase, instantly discourages entrepreneurial activities as it decreases both their profits and cash-flows from their equity sales. As given in Equations (19) and (20) below, the equity price reflects the proportional reduction in the net-of-tax expected value of the firm.

\[
V_H^* = (1 - \tau)(P_H f(l_H) - l_H W)
\]  
\[
V_L^* = (1 - \tau)(P_L f(l_L) - l_L W)
\]

Whether or not this instant effect actually leads to a real distortion depends upon the
regime of the economy as well as the extent of the tax change.

First, in Regime I, workers and Low type entrepreneurs enjoy the same level of utility, which sets up the following relation:

\[ U(W) = U(V_L^I) \]  \hspace{1cm} (21)

It can be seen from Equations (20) and (21) that the equilibrium wage in Regime I decreases as the tax rate increases. This is due to the equivalence between wage income and the expected profit for a Low type firm. Any tax change will negate the existing occupational indifference for Low type agents. In the case of a tax increase, Low types will prefer being a worker to being an entrepreneur. The indifference is restored only when enough Low type agents switch from entrepreneurs to workers to lower the wage (because of increased labor supply) until it becomes equivalent to the reduced profit of a Low type firm. A wage decrease then causes both types of firms to increase their sizes as seen in Equations (1) and (3). Therefore, a tax increase in Regime I eventually restructures the economy so that fewer firms hire more workers than before.

It is important to note that a tax change may even lead to a change of regimes. The increase in the size of High type firms after a tax increase implies that the economy with a value of \( \frac{N_L}{N_H} \) between the before-change \( l_H^I \) and the after-change \( l_H^I \) is no longer in Regime I. This suggests that the government can pick a regime for an economy with a given \( \frac{N_L}{N_H} \) by choosing a tax rate. Although the topic of optimal taxation lies beyond the scope of this paper, it is interesting to note that the existence of the incentive problem, as well as the individual decision-making by agents, are subject to the government’s control via the practice of tax policy.

Consider an economy that does not change from Regime I with a given tax increase. Entrepreneurs pay larger fractions of their profits in taxes, but at the same time they benefit from the lower wage. It is obvious that the beneficial effect for Low type entrepreneurs
cannot outweigh their increased tax payment since they will only be as well-off as workers who lose from the reduced equilibrium wage. While Low type agents definitely suffer from a tax increase, it is not evident that High types do too, and the unpredictable direction of change in the required inside equity position only adds to the ambiguity. However, the tax incidence via wage change is only a secondary effect of a tax change, and it is likely that High type agents also lose in Regime I.

Unlike Regime I, the tax is neutral in Regime II where the types are fully revealed by occupations. The size of firms and the equilibrium wage are determined independently of the tax rate, but the inside equity position is still subject to change. Remarkably, this implies that the tax burden is not shifted at all to workers but solely borne by entrepreneurs, which is consistent with the economic intuition that the less elastic party suffers more. Thus, High type agents lose as a result of a tax increase while Low type agents neither gain nor lose in this regime.

As indicated above, the only tax consequence in Regime II is its effect upon the risk-bearing by High type agents. It is important to note that tax effects on risk-bearing can be decomposed into two parts. First, a tax change may alter the inside equity position or the volume of explicit risk borne by entrepreneurs. Secondly, it also affects the riskiness of projects itself since a profit tax naturally truncates the fluctuation of firm’s revenue because the output fluctuation and tax payment move in the same direction. This positive effect of a profit tax is called risk-sharing with, or risk-absorption by the government. While the first effect may or may not occur, the risk-sharing effect comes in whenever a risky income is subject to a proportional tax.

In Regime III, a high-enough wage eliminates the adverse selection problem, and all the risk is diversified away. High types have occupational indifference, and the equilibrium wage moves inversely with the tax rate as in Regime I. Also, a tax increase leads to fewer-but-bigger firms. Through the wage change, the tax burden is shifted to workers, and in
effect, every agents suffers the same loss.

It should be pointed out that a tax increase, no matter how big it may be, would never cause a change of regimes if the economy is already in Regime III. The range of \( \frac{N_L}{N_H} \) for Regime III only gets larger as the tax rate rises, which implies that Regime II with relatively many High type agents may be easily converted into Regime III by government tax policy. This egalitarian policy to move towards Regime III, in which everyone is at the same level of utility, may be possible even for an economy in Regime I if the equilibrium wage is sufficiently lowered by a tax increase. The higher \( \frac{N_L}{N_H} \) is, the higher is the tax rate necessary to move to Regime III. However, the higher the tax rate is, the more costly the equality is as every agent in the economy ends up with the same, but lower level of utility.

VI. Numerical Experiments: Equilibrium and Tax Consequences

Even though the model is simple in many senses, it is complicated enough not to produce rich analytic results. For better understanding of the equilibrium characteristics and tax effects, various numerical experiments aimed at examining the consequences of small perturbations to the initial equilibrium were performed, and this section discusses the results of these experiments.

In the experiments, we employ the utility function of the form: \( U(C) = \frac{1}{1 - \epsilon} C^{1-\epsilon} \), where \( C \) is the consumption variable, and \( \epsilon \), the coefficient of relative risk aversion. While this utility function is not free from the wealth effect, it has the useful properties of constant relative risk aversion and decreasing absolute risk aversion. The production function is assumed to take the form of \( f(l) = l^\beta \), where \( \beta \) is the proportion of labor costs to the expected total revenue, since \( \beta = \frac{l_H W}{P_H f(l_H)} \) or \( \frac{l_L W}{P_L f(l_L)} \). This function can be thought of as a Cobb-Douglas production function for the inputs of labor and capital when capital is the entrepreneurial human capital which is always 1 in the model. This argument makes it clear that \( 1 - \beta \) represents the share of the economic rent on the entrepreneurial ability.
which is common to both type entrepreneurs. It was found that similar qualitative patterns are repeated in many experiments with different parameter values, and we show the results of a typical series of experiments with $P_H = 0.8$ and $P_L = 0.5$.

1. Equilibrium without Taxes

Proposition 4, along with Proposition 5, shows how to specify equilibrium for an economy with a given population distribution. Equilibrium wage ($W$) and inside equity position ($\alpha$) are continuous in the relative population frequency ($\frac{N_L}{N_H}$), and moreover constant in Regime I or Regime III. It is easy to see that, with a concave production function, $W$ is monotone-decreasing in $\frac{N_L}{N_H}$ as illustrated in Figure 1A. Figure 1A depicts how $W$ and $\alpha$ change with the frequency of High types in total population when $\epsilon$ and $\beta$ are fixed at 0.8 and 0.7 respectively. The figure shows that the economy obtains Regime I equilibrium when High types are less than 9% of total population. When the High type frequency is between 9% and 30%, the economy is in Regime II where $W$ and $\alpha$ vary with the frequency. In the figure, $W$ increases with the frequency of High types as more firms compete for fewer workers; whereas $\alpha$ decreases with the frequency as High types face fewer potential threats, that is, Low types. As the frequency of High types goes above 30% of the population, the economy enters Regime III where the wage is highest and the cost of risk-bearing is zero.

Recall that Low type agents always get the safe earnings equivalent to the equilibrium wage. Thus, the wage graph in Figure 1A also represents the welfare of Low types, which is inversely related to their population frequency. High types' earnings depend upon their degree of risk-bearing as well as the wage, which move in opposite directions as the High type frequency changes. Figure 1B illustrates the variation of High types' certainty equivalent consumption, which is chosen as a proxy for their welfare level. It shows that the first-best welfare level is inversely related with the High type frequency, as the theory predicts. It also shows that, for the chosen parameter values, High types lose more from
the increased labor cost than they gain from the reduced signalling cost, which was not obvious from the theoretical discussion in Section V.

Since the equilibrium wage is independent of the risk-aversion coefficient ($\epsilon$), it becomes less likely, as $\epsilon$ increases, that increasing frequency of High types causes them to become worse off, due to the dominance of the increased labor cost over the reduced signalling cost. This is illustrated by Figures 2B, 3B, 4B, and 5B, which are all based on the same parameters as those used for Figure 1B with the exception of $\epsilon$. These figures show that High types are better off in Regime I than in Regime III when they are relatively less risk averse, in this case, when $\epsilon$ is smaller than 3, while they are better off in Regime III than in Regime I when they are relatively more risk averse, that is, when $\epsilon$ is equal to or bigger than 3. It should be also noted that High types' welfare is not necessarily monotonically related to their frequency. For example, Figures 3B, 4B, and 5B show the welfare level first rising until it starts to decline at the point of 20% for the High type frequency.

The parameter $\beta$ indicates the productivity of labor input since it determines the total output produced by a given number of workers. At the same time, it is also inversely related to the profitability of a project since it is the fraction of the total output used to compensate workers. Therefore, as $\beta$ increases, it is not intuitively clear whether or not entrepreneurs become better off, although it is obvious for workers. It is easy to see that the equilibrium wage rises, and firms hire more workers in Regimes I and III, as $\beta$ increases. In Regime II, however, the size of firms is constant at $\frac{N_L}{N_H}$ while the wage rises as $\beta$ increases.

The comparison of Figures 6A, 7A, 8A, 9A, 10A reveals that the equilibrium wage gets higher as $\beta$ increases, no matter which regime the economy is in. These figures also show that the equilibrium inside equity position ($\alpha$) decreases as $\beta$ increases, in other words, High type entrepreneurs are required to bear less risk for the separation from Low types.
Since $\alpha$ increases with the value of High type projects, but decreases with the value of Low type projects, this numerical result implies that High type projects become relatively less superior with an increase in $\beta$, which is also consistent with the previous result that it is possible for more agents choose to be workers at higher wages.

Figures 6A, 6B, ..., 10A, 10B show that the change of regimes occurs at a lower frequency of High type agents when $\beta$ is bigger, demonstrating that the entrepreneurial occupation becomes relatively less attractive as $\beta$ increases. The frequency of High type agents at which the economy changes regimes is the threshold at which agents would begin to give up their projects and become workers if their frequency were raised gradually while other things were equal. When all the Low type agents become workers, the economy change regimes from Regime I to Regime II, and when High type agents begin to be workers, the change of regimes from Regime II to Regime III occurs. Therefore, it can be said that entrepreneurs are more likely to give up their occupation as $\beta$ increases. For example, the frequency of High type agents at which the economy changes from Regime I to Regime II is 29%, 18%, 9%, or 3% when $\beta$ is 0.5, 0.6, 0.7, or 0.8, respectively. When $\beta$ is 0.9, Regime I is not even possible, and Regime II is in effect with only 1% of High type agents.
2. Tax Incidence

A new tax or a tax increase immediately reduces the value of projects. In Regime I or Regime III, it also distorts the occupational choice, and in the end, workers also bear the tax burden to the extent that their wage is lowered. There remain, in consequence, fewer firms that hire more workers at a lower wage than before. In Regime II, on the contrary, firms (or equivalently, High types) bear all the tax burden, and the wage for workers or Low types is not affected by a tax change. These results are illustrated in Figure 11A. Although the figure depicts the case of $\beta = 0.7$ and $\epsilon = 0.8$, the value of $\epsilon$ will not affect the figure since the equilibrium wage is independent of risk preferences. The figure shows the relation between the tax rate and the equilibrium wage for four different cases of population distribution, and hence, also shows the threshold tax rates that lead to the regime changes. When High type agents are only 2% of total population, the wage gradually falls from 0.27 to 0.17 until the tax rate reaches 77% at which the economy changes from Regime I to Regime II, then remains constant while the economy is in Regime II, and then starts again to fall when the economy changes to Regime III at the tax rate of 96%. This is an example of extensive tax consequences that include not only the change of relative prices (hence the welfare of agents), but also the nature of incentive problems (hence the equilibrium characteristics). The figure also shows that the limits of these tax effects depend upon the distribution of types in the economy since neither the equilibrium wage nor the type of regime is affected until the tax rate reaches 42% when the frequency of High types is 20% of total population.

Figure 11B illustrates the tax effects on the required risk-bearing, that is, the inside equity position ($\alpha$) in equilibrium. It shows that $\alpha$ is affected by a tax change only in Regime II, and in fact, $\alpha$ is significantly lowered by a tax increase in the regime. This suggests that the extent to which a tax increase lessens the burden of risk-bearing crucially
depends upon which regime the economy is in. In Regime I, the tax benefit on risk-bearing is only up to the risk-sharing effect of a profit tax; whereas in Regime II, much less risk is borne due to the decrease in $\alpha$ in addition to the risk-sharing effect. In Regime III, a tax change cannot affect risk-bearing since no agent bears risk.

It should be noted that the insensitivity of $\alpha$ in response to the tax rate in Regime I is due to the properties of the functional forms used in numerical experiments. In specific, the production function generates the following relationship:

\[
\begin{align*}
l_L &= \frac{\beta}{(1 - \tau)(1 - \beta)} \\
l_H &= (\frac{P_H}{P_L})^{1 - \beta} l_L \\
W &= P_L \beta l_L^{\beta - 1}
\end{align*}
\]

Then, it follows that the wage and High type's consumption have the factor of $(1 - \tau)^{1 - \beta}$ in common, which leads to $\alpha$'s independence from the tax rate given a constant-relative-risk-aversion utility function.

Figures 11B, 12, and 13 provide an explanation of how the risk preferences ($\epsilon$) affect the relation between the tax rate and the inside equity position. These figures show very similar patterns, which is consistent with the observation made earlier that the inside equity position is not very sensitive to the degree of risk aversion. Rather, the figures show that the population frequency of High types is the more dominant factor in determining the tax effects.

Whether or not Low type agents suffer from a tax change is simply checked by looking at the change of the equilibrium wage since it equals their consumption level. As shown earlier, they lose from a tax increase unless the economy stays in Regime II before and after the tax change. Thus, in most cases, workers share the burden of the tax which is levied on firms, that is, on the entrepreneurial human capital in the model. Entrepreneurs physically pay the taxes, but at the same time, they can benefit from a tax increase since
it will also bring about either a decrease of the equilibrium wage (in Regime I and III) or a decrease of the required inside equity position (in Regime II). However, these beneficial effects are secondary, and cannot reverse the direction of High type's welfare loss from the increased tax payment. Their welfare level gradually decreases as the tax rate increases, but it is always higher than the welfare level of Low types except when the economy is pushed into Regime III in which every agent enjoys the same amount of consumption as the equilibrium wage.

The final set of Figures 14A, 14B, ..., 16A, 16B illustrates the results from the incidence exercises with different $\beta$'s when $\epsilon$ is fixed at 1.5. It was found earlier that, in no-tax equilibrium, an increase of $\beta$ discourages rather than encourages entrepreneurial activities, because the beneficial effect of increased total output is dominated by the harmful effect of decreased profit share. This trend is repeated in the figures since the depressing effect of a tax increase on entrepreneurs is accelerated, or regime changes are seen at lower tax rates, as $\beta$ gets bigger. For example, the tax rate at which the economy of 10% High type agents moves from Regime II to Regime III falls from 84% to 75% to 56% as $\beta$ rises from 0.6 to 0.7 to 0.8, respectively.

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$^9$ Figure 15A is in fact the same as Figure 11A because the equilibrium wage is independent of the degree of risk aversion.
3. Efficiency Cost of Tax

The profit taxation in the model distorts at least one of the occupational choice, labor-hiring decision, and risk-taking by the agents, depending upon which regime the economy is in. Moreover, a tax change may cause a change of regimes, and hence the nature of the equilibrium. Given these potential distortions, one would expect a heavy deadweight loss from the same tax in a model without uncertainty or a model in which no agent bears systematic risk in any form. If everyone's type is known publicly in the model, there is no need for signalling since outside investors are willing to take away all the risk. Without taxes, the economy would obtain the first-best equilibrium, and the introduction of the tax would cause a substantial efficiency loss.

However, the tax effect may not be all harmful to the economy in which the tax revenue is generated by the uncertain performance of agents. In a sense, a profit tax is like an insurance offered to entrepreneurs by the government, although it is compulsory and is not actuarially fair since the government makes a profit of positive (expected) tax revenue. Risk-averse agents as well as risk-neutral agents will become worse off with this kind of unfair insurance. However, while risk-neutral agents lose exactly as much as their tax payment, risk-averse agents lose less than their tax payment since they bear less risk due to the government insurance. Consequently, the tax burden on entrepreneurs is alleviated, and this is the risk-sharing effect of a profit tax.

The existence of the risk-sharing effect of a proportional tax has often been ignored in the traditional tax literature which mostly deals with certainty models. Gordon [1981] drew attention to this effect by indicating that investment incentives are not so severely discouraged as previously thought because the tax absorbs a certain fraction of risk as well as the expected return. Thus, despite the sizeable tax revenues, the economy experiences only a small efficiency loss, or possibly even a gain in efficiency.
This section presents the outcome of numerical experiments on the welfare changes caused by small tax changes. In the experiments, the initial equilibrium with a given tax rate is computed, and then the change of individual welfare and the economy-wide welfare change are measured after a tax rate increase of 0.1% which is so small that the economy does not change regimes. The welfare change for each individual is normalized by the average of before-tax and after-tax marginal utility of wealth, so that it is expressed in the wealth-equivalent unit, that is, in dollars. Individual welfare changes are then aggregated by the following formula:

$$100 \times \left( \frac{\text{wealth equivalent change in individual welfare summed over all agents}}{\text{change in the government tax revenue}} \right) - 1.$$ 

This formula sums up the unweighted individual welfare change in excess of tax contribution; it measures in cents the effect of extra one dollar tax revenue on the deadweight loss to the whole economy — that is, the marginal excess burden of the tax. The marginal excess burden of a lump sum tax is zero since individual tax payers suffer only to the extent of their tax payment. However, the marginal excess burden of a distortionary tax would be positive since the welfare loss to individual tax payers exceeds their contribution to the tax revenue.

Tables 1, 2, 3, and 4 summarize the numerical results obtained with different frequencies of High type agents when $\beta$ is fixed at 0.7. First, it should be noted that agents are affected differently by a tax change, depending upon their types and occupations. In a Regime I economy, there are four different groups: Low type agents who used to be and remain workers after a tax increase, Low type agents who used to be entrepreneurs but become workers, Low type agents who used to be and remain entrepreneurs, and High type agents who are always entrepreneurs. Because Regime II does not allow occupational changes, types define all the possible groups in the regime. In Regime III, there are three groups: agents of either type who used be and remain workers, High type agents who
used be entrepreneurs but become workers, and High type agents who used be and remain entrepreneurs.

The tables show the frequencies of different groups, the normalized individual welfare loss of different groups, and the change of individual tax payment of different groups. Individual welfare loss is computed not only for the signalling equilibrium (and denoted by Uasy), but also for the first-best equilibrium (and denoted by Usym). Thus, Uasy and Usym show differences only for High type entrepreneurs in Regime I or II because they are the only ones that bear risk and they do so only in these regimes. While the differences in Regime I account for the risk-sharing effect, the differences in Regime II are the mixed consequences of the lowered $\alpha$ as well as the risk-sharing effect.

Obviously, Uasy depends upon the degree of risk aversion; hence, so does the marginal excess burden (denoted by MEBasy) while the same index computed for the first-best equilibrium (denoted by MEBsym) is invariant with the risk aversion.

One may see how meaningful are the conclusions we can draw from the results of our numerical experiments by comparing our numerical results with what the basic theories may suggest. In tax theories, the introduction of an infinitesimal tax would incur no deadweight loss since all the welfare consequences would be of the second order. $^{10}$ Our numerical experiments indeed demonstrate that MEBsym is always zero without respect to the population distribution or the type of regime when $\tau = 0$. Another theoretical result that can be checked here is that a profit tax is neutral in partial equilibrium analyses. In the model, the economy in Regime II under symmetric information resembles the economy in a partial equilibrium analysis in the sense that a tax change does not affect occupational choices or labor-hiring decisions unless it leads to a change of regimes. Our numerical results are consistent with the theoretical result since MEBsym is zero in every case of

a Regime II economy. As one can see in the tables, the increase in tax revenue exactly matches the welfare loss to High type agents while Low types are unaffected at all since they are all workers.

The most remarkable result obtained from the numerical experiments is that MEBasy is negative in many cases, which implies that it costs less than one dollar for the economy to make one dollar tax revenue for the government. In other words, the tax may do good rather than harm to the economy as a whole. Specifically, this is possible due to the reduced risk-bearing from which High type agents benefit substantially. When this positive tax effect on High type agents is large enough to outweigh the overall loss to the economy, the tax increase turns out to be beneficial. However, it is worth noting that a negative MEBasy does not mean net gains for any agent, and certainly not a Pareto-improvement. It rather implies that some agents suffer much less than their actual tax payment while others still lose from the tax. Moreover, a negative MEBasy implies an efficiency gain only in the context of the social welfare function underlying the measure itself: the unweighted sum of wealth-equivalents of individual welfare levels, added to the government tax revenue.

In Tables 1 and 2, almost all cases belong to Regime I economies. In Regime I, all the Low type agents suffer the same loss no matter what their occupations are before or after a tax increase. High type entrepreneurs suffer much more than Low type agents under symmetric information; however, they suffer less than Low type agents under asymmetric information due to the increased risk-sharing of the tax. For example, $|U_{sym}|$ for a High type agent is $0.78 \times 10^{-3}$ but $|U_{asy}|$ for him only ranges between $0.1 \times 10^{-3}$ and $0.14 \times 10^{-3}$ while $|U_{sym}|$ or $|U_{asy}|$ for a Low type agent is $0.16 \times 10^{-3}$ with the introduction of a small tax.

Individual welfare loss due to a small tax increase gets heavier as the initial tax rate rises. The tables show that a small tax increase from the existing tax rate of 50% costs each agent over 60% more than the cost of the same small tax increase from a zero tax
rate, no matter which type of agent he is. On the contrary, the extent to which High type agents benefit from bearing less risk does not rise so much with the tax rate in Regime I since the inside equity position is independent of the tax rate in the regime. As a result, in Regime I, the overall burden to the economy ever increases with the tax rate. Table 1 shows, for a 2% High-type economy, the range of MEBasy increases from -7.8 ~ -7.3 to 78.9 ~ 79.8 as the (initial) tax rate rises up to 50%. The MEBasy changes its sign from negative to positive at some tax rate between 10% and 20%, which would be the optimal tax rate that maximizes the social welfare defined implicitly by the formula of the marginal excess burden. In comparison with Table 1, Table 2 shows that the marginal excess burden is lower and it changes signs (from negative to positive) at higher tax rates. In this table, we see that the optimal tax rate would be between 20% and 30%, which is higher than that in Table 1 since the cases in Table 1 include more High type agents hence more recipients of the beneficial tax effect.

Tables 1 and 2 show that the more risk averse High type agents are, the more they suffer from the same small tax increase in Regime I. Given that inside equity position(α) does not vary with the tax rate in Regime I, it is believed that the (local) curvature of the utility function is the main factor in this effect. In contrast, Tables 2, 3, and 4 show that, in Regime II, High type agents lose less as they become more risk averse. Moreover, their welfare level is almost unaffected by a tax increase in many cases with ε = 6, which implies that the government can collect tax revenues almost without hurting anybody in the economy. This is possible because the inside equity position itself declines as the tax rate increases in Regime II. Then, their risk burden is further lessened by the increased risk-sharing effect of the tax, and this saving on the signalling cost is large enough to offset the increased tax payment. In Table 3, for example, the individual welfare loss to a High type agent is not more than 1.1 (×10⁻³) while his tax payment is increased by 2.2 (×10⁻³).
In all four tables, we find only one case in which the economy is in Regime III. Seen in Table 4, it is the economy in which 20% of the population are High types and the tax rate is 50%. In this economy, every agent suffers the same welfare loss no matter what his type or occupation is. Moreover, no one bears (non-diversifiable) risk, hence the tax does not generate the beneficial risk-sharing effect. However, the welfare loss to a High type entrepreneur is smallest in all the cases shown in the tables. It is not surprising because workers, which include some of the High types, bear the same tax burden as entrepreneurs in Regime III while they bear little or no burden in other regimes.

Regime III is not desirable in the sense that some of the High type agents do the same as Low type agents do, and their productive projects go unused. A tax increase clearly aggravates the allocation since more High type agents become workers paying no taxes, which results in high efficiency costs of taxes for the economy. The example in the table shows MEBsym (and MEBasy) is as high as 94% which means that almost a half of what tax payers give up would not reach the government treasury, but instead become a deadweight loss.
VII. Concluding Remarks

This paper introduces a simple, yet useful general equilibrium model of occupational choice and entrepreneurial profit taxation in which the existence of private information about the project quality leads to signalling in the financial market.

The general equilibrium is informationally-constrained efficient, and uniquely determined by technology, population distribution, and tax system. When the high-productivity agents are more scarce, a stronger signal is necessary, but a lower wage is paid to workers.

Firms and workers share the burden of a tax levied on firms (in Regimes I and III) unless occupational choice is irresponsive to tax changes (i.e. Regime II).

Numerical experiments with a small tax increase find that risk-averse agents significantly benefit from their reduced risk-bearing including the risk-sharing effect, so that, in some cases, the marginal excess burden computed for the whole economy becomes negative.

The profit tax in this paper is in effect a tax on entrepreneurship or a tax on income from risky activity. Although the assumption of no physical capital limits the analysis of more realistic income taxes, the model can be immediately extended in several meaningful directions. Such extensions would include introducing additional taxes (e.g. labor income tax) and allowing more heterogeneity among agents (e.g. risk aversion, initial wealth). Especially, the consideration of additional labor income taxes will lead to an analysis of differential income taxation or even further to a study of the optimal (progressive) income tax system, extending the traditional approach which has concentrated on the choice between leisure and labor supply, often ignoring occupational alternatives or market imperfections.
Wage and Inside Equity Position When $\beta = 0.7$

Legend
- --- Wage
- - - Inside Equity Position

Figure 1A: $\varepsilon = 0.8$

Figure 1B: $\varepsilon = 0.8$

Certainty Equivalent Consumption of High Type Agents When $\beta = 0.7$

Legend
- --- First-Best Equilibrium
- - - Signalling Equilibrium

Figure 2A: $\varepsilon = 1.5$

Figure 2B: $\varepsilon = 1.5$

Figure 3A: $\varepsilon = 2.5$

Figure 3B: $\varepsilon = 2.5$
Wage and Inside Equity Position When $\beta = 0.7$

Legend
- --- Wage
- ..- Inside Equity Position

Certainty Equivalent Consumption of High Type Agents When $\beta = 0.7$

Legend
- --- First-Best Equilibrium
- ..- Signalling Equilibrium

Figure 4A: $\epsilon = 3.0$

Figure 4B: $\epsilon = 3.0$

Figure 5A: $\epsilon = 6.0$

Figure 5B: $\epsilon = 6.0$
Wage and Inside Equity Position When $\epsilon = 2.0$

Certainty Equivalent Consumption of High Type Agents When $\epsilon = 2.0$

Figure 6A: $\beta = 0.5$

Figure 6B: $\beta = 0.5$

Figure 7A: $\beta = 0.6$

Figure 7B: $\beta = 0.6$

Figure 8A: $\beta = 0.7$

Figure 8B: $\beta = 0.7$
Wage and Inside Equity Position When $\varepsilon = 2.0$

**Legend**
- **Wage**
- **Inside Equity Position**

**Figure 9A: $\beta = 0.8$**

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<thead>
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<th>Percentage of High Type Agents</th>
<th>Wage, Inside Equity Position</th>
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Certainty Equivalent Consumption of High Type Agents When $\varepsilon = 2.0$

**Legend**
- **First-Best Equilibrium**
- **Signalling Equilibrium**

**Figure 9B: $\beta = 0.8$**

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**Figure 10A: $\beta = 0.9$**

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</table>
Wage When $\beta = 0.7$

Inside Equity Position When $\beta = 0.7$

Legend:
- 20% High Type Agents
- 10% High Type Agents
- 5% High Type Agents
- 2% High Type Agents

Figure 11A: $\varepsilon = 0.8$, 3 and 6

Figure 11B: $\varepsilon = 0.8$

Figure 12: $\varepsilon = 3$

Figure 13: $\varepsilon = 6$
Wage When $\varepsilon = 1.5$

Legend:
- 20% High Type Agents
- 10% High Type Agents
- 5% High Type Agents
- 2% High Type Agents

Inside Equity Position When $\varepsilon = 1.5$

Figure 14A: $\beta = 0.6$

Figure 14B: $\beta = 0.6$

Figure 15A: $\beta = 0.7$

Figure 15B: $\beta = 0.7$

Figure 16A: $\beta = 0.8$

Figure 16B: $\beta = 0.8$
### Table 1: Components of a Small Tax Change with P = 0.7 and 72% High Type Agents

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<tr>
<th>Barriers/High Type Agents</th>
<th>Low Type Agents</th>
<th>Employees of High Type</th>
<th>Employees of Low Type</th>
<th>Degree of Relative Risk Aversion</th>
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<td>Employees of Low Type</td>
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<td>Degree of Relative Risk Aversion</td>
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**Note:** The table details the components of a small tax change with specific parameters. The table is structured to show the distribution of agents across different types and their impact on barriers and risk aversion. The values in the table are hypothetical and illustrate the concept rather than actual data.
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<th>Degree of Risk</th>
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Table 2: Consequences of a Small Change with 50% and 50% High Type Ages
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<th>Degree of Residence Risk Aversion</th>
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</table>

Table: Consequences of a Small Tax Change with d = 0.7 and 10% High Type Agents

Notes: MEF = marginal excess burden of the tax under symmetric information
MGE = marginal excess burden of the tax under asymmetric information
ε = the change of individual welfare under symmetric information
η = the change of individual welfare under asymmetric information
<table>
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<tr>
<th>Category</th>
<th>Weighted Mean</th>
<th>Weighted Median</th>
<th>Number of Participants</th>
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<td>Low Tax</td>
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</table>

Table 4: Consequences of a Small Tax Change with 6% and 20% High Type Agrees

Legend:
- **WE** = Weighted Expressions
- **ME** = Mean Expressions
- **N** = Number of Participants

Note: The table above provides a comparison of weighted mean and median for different categories of tax change, with a focus on high type agreements.
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