The Singapore Economic Review, Vol. 68, No. 2 (2023) 467–483

DOI: 10.1142/S0217590819500115

SOCIAL INSURANCE UNDER FRAUD AND REDISTRIBUTIVE TAXATION

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Published Online 2 April 2019

This paper examines the equity and efficiency effects of social insurance in the presence of insurance fraud and linear income taxes and shows the following findings. (i) Under the commonly accepted assumption of decreasing absolute risk aversion (DARA), the social insurance benefit may increase insurance fraud, whereas raising the marginal tax rate (lumpsum transfer) of the linear income tax also causes insurance fraud to increase (decrease). (ii) Equity and efficiency effects of social insurance are conflicting rather than complementary with each other.

Keywords: Social insurance; income taxes; insurance fraud.

JEL Classification: H21, H26.

1. Introduction

The debate over the necessity of social insurance is long-standing. Conventional literature provides three arguments for government intervention in insurance markets by providing social insurance[1]: (i) Saving the administrative cost if it is higher under private insurance

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[1] See Culter (2002) and Boadway *et al*. (2006).

than that under social insurance[2]; (ii) Correcting the market failures caused by adverse selection or moral hazard problems; and (iii) Redistributing income from the rich to the poor for improving social equity.

In addition to spreading risks among people, social insurance is an important policy instrument to help the poor in many countries. Hence, it is often considered as an important income redistribution tool for them. However, as income tax systems have been playing an essential role in income redistribution, social insurance seems redundant in this aspect. In order to clarify this quandary, in the setting of perfect insurance markets Rochet (1991) and Cremer and Pestieau (1996) argued that although income taxes redistribute income between individuals of different productivities, social insurance transfers resources from high-ability individuals in a low-risk state to low-ability individuals in a high-risk state, thus further enhancing social equity without aggravating the income tax distortion. Due to its simplicity and intuitive appeal, the Cremer–Pestieau model has become a baseline for studying income taxation and social insurance.

Cremer and Pestieau (2014) investigated the role of the government provision of social insurance when income taxation and private insurance markets are imperfect. They considered that an economy consists of an arbitrary number of types of individuals, pointing out in the linear subsidy case that it is desirable for the government to provide social insurance when the government cannot use a uniform lumpsum transfer policy. In our paper, although we also adopt a similar framework to Cremer and Pestieau (2014), we consider insurance fraud, which is often seen in real life, and re-examine the necessity of the government provision of social insurance. Boadway *et al*. (2003, 2006) incorporated moral hazard and adverse selection problems into the Cremer–Pestieau framework and suggested that, in addition to income redistribution, governments should provide more social insurance to cope with market failures in the insurance industry. Nishimura (2009) derived the same conclusions as Cremer and Pestieau (1996) from a model with non-linear income taxation and adverse selection problems. Bovenberg and Sørensen (2009) showed that incomplete social insurance is optimal in a two-period setting, because it can encourage consumers toward self-insurance through more work and savings.

Netzer and Scheuer (2007) argued that although social insurance can correct the adverse selection problem, it could also reduce precautionary labor supply. If the drawback of distortion in the labor market is greater than the benefit of market failure correction, then the government should not provide social insurance. From empirical studies, Aaron (1977), Wilkinson (1992) and Feinstein (1993) argued that high income usually accompanies longevity. Therefore, the rich enjoy greater insurance resources than the poor, thus conflicting with the distributional objective of social insurance.

The above literature focuses on the implications of adverse selection and moral hazard on the desirability of social insurance, but to the best of our knowledge, it sparsely explores the impact of insurance fraud on social insurance. Nevertheless, insurance fraud is a non-trivial issue in addition to adverse selection and moral hazard problems. Insurance fraud has the form of *ex-post* moral hazard.[3] The policyholder may commit fraud to gain benefit

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[2] See Diamond (1992) and Mitchell (1996).

[3] See Boyer (2000, 2001).

from the insurance payment by falsely declaring a car stolen or pretending illness. As Derrig (2002) noted, when railroads were the proverbial deep pockets in the late 19th century, organized fakers slipped on banana peels, feigned paralysis and extracted as much as $500 per fall from the railway companies, according to Dornstein, author of *Accidentally on Purpose* (1996).

Much empirical data indeed indicate that the amount of insurance fraud is astronomical. For instance, it is estimated that the settlement of insurance claim from insurance fraud amounts to US$18 billion per year in the U.S.[4] In Germany, insurance fraud costs property and casualty insurers more than 4 billion Euros annually.[5] The investigated annual loss from insurance fraud is nearly 2 billion pounds in the U.K. as well.[6] These investigations all indicate the severity of fraud in the insurance market. According to Akerlof (1970), in an extremely deteriorated condition of information asymmetry, the market may not exist any longer. Hence, when the impact of insurance fraud is seriously harmful and causes significant efficiency loss, then our argument for not providing social insurance appears quite persuasive.

The purpose of this paper is to examine the necessity of social insurance in the presence of insurance fraud when linear income taxes are available. To elaborate on this idea, we construct a model similar to Cremer and Pestieau (1996, 2014), where there is an economy of heterogeneous individuals. However, we incorporate Boyer's (2000, 2001) insurance fraud model into the framework of Cremer and Pestieau (1996, 2014) to extend their discussion and provide different viewpoints. It is worth noting that two major analyzing frameworks of optimal taxation are commonly adopted by traditional literature. (1) The economy is composed of heterogeneous individuals with their types being continuous or discrete. Mirrlees (1971) and Saez and Stantcheva (2016) used the former, whereas Diamond and Mirrlees (1971), Diamond (1975), Kanbur *et al*. (2018) used the latter. (2) In the discrete type models, individuals are usually simplified into two types — for example, high and low abilities — as in the seminal paper of Stiglitz (1982) and a follow-up by Bastani *et al*. (2015). In our model, individuals are heterogeneous with n discrete types, and it is this setting that makes our result more general compared with two-type models.[7]

Following Boyer (2000, 2001), it is assumed here that the policyholder knows whether she or he was involved in an accident, but the insurer does not. In his pioneering model, Boyer argued that in a market with insurance fraud, taxation on insurance benefits is more efficient than taxation on insurance premiums. Succeeding studies have found fraud crucial in many other fields, such as incentive contracts and auditing claims.[8]

In sum, Cremer and Pestieau (1996, 2014) considered income redistribution, but ignored insurance fraud, whereas Boyer (2000, 2001) incorporated insurance fraud, but overlooked income redistribution. This paper utilizes the interaction between income

[4] See Coalition Against Insurance Fraud (2001).
[5] See German Insurance Federation, http://www.gdv.de/index.html.
[6] National Fraud Authority, http://www.attorneygeneral.gov.uk.
[7] In the model of two-type individuals, the economy is composed of consumers with high and low propensities to commit fraud only. In contrast, with n different types of consumers, the setting in our model is more general and the conclusion is more robust than in traditional ones.
[8] For example, see Crocker and Morgan (1998), Picard (1996) and Tennyson and Salsas-Forn (2002).

redistribution and insurance fraud for analysis. As shown below, overlooking such an insurance fraud effect may lead to misleading policy making.

The contribution of this paper is as follows. First, under the commonly accepted assumption of decreasing absolute risk aversion (DARA), social insurance benefits induce more insurance fraud. A higher linear income tax rate (lumpsum transfer) also causes more (fewer) insurance fraud. These findings, except for the lumpsum transfer effect, are novel compared to Boyer (2000, 2001). In his model, Boyer presented that a tax on insurance premiums induces more fraud, whereas a tax on insurance benefits induces less fraud.

The second contribution is that we consider the interaction between a government's income redistribution policy and insurance fraud, which is an issue that has received virtually no attention so far in the literature. If insurance fraud is an issue that should not be ignored, then aside from efficiency and equity as traditional literature mentioned, the arguments for optimal income taxation have to incorporate these behaviors of individuals into the matter. For efficiency, when the net compensated elasticity of labor supply is larger, the optimal tax rate should be lower. For equity, when the government cares more about income redistribution, then the optimal tax rate should be higher. Moreover, the income tax rate should be reduced whenever the taxation system is aggravating people's insurance fraud behavior, which is not considered by the traditional literature.

This paper further points out that the optimal provision of social insurance should consider four effects simultaneously: income redistribution effect, tax revenue effect, insurance fraud effect and risk transfer effect.[9] We argue that, although social insurance is an effective policy for income redistribution, it should not be provided as long as the negative effect of insurance fraud on social welfare outweighs the positive effects of other factors.

We find in an economy with insurance fraud that the government should not provide social insurance whenever the benefit of redistribution is less than the cost arising from insurance fraud. Note that by considering insurance fraud, this paper derives different results from Cremer and Pestieau (1996, 2014) and Boadway *et al*. (2003, 2006). Our conclusion leans toward supporting the viewpoint of Netzer and Scheuer (2007) that the equity and efficiency effects of social insurance are conflicting rather than complementary with each other.

The remainder of this study is organized as follows. Section 2 sets up the basic model. Section 3 studies the optimal auditing and fraud policy. Section 4 analyzes the insurance contract and labor supply in equilibrium. Section 5 discusses the optimal redistribution policies. Finally, Section 6 concludes this paper.

2. The Basic Model

Following Cremer and Pestieau (1996, 2014), Boyer (2000) and Lehr (2016), let us consider an economy that consists of n types of individuals, where the proportion of each

[9] The conventional literature has used the covariance of net marginal social benefit of tax and accidental rate to describe the income redistribution effect. We use the same notion, but in the situation of insurance fraud, such that the income redistribution effect is described by the co-variance of marginal net social benefit of detection probability of social insurance fraud and the income tax rate.

type i ($i = 1,\ldots,n$) is f_i, such that $\sum_{i=1}^{n} f_i = 1$. The wage rate of type i individuals is w_i and their probability of having an accident is p_i. Assuming that the insurance market is perfectly competitive, insurers are risk neutral, while policyholders are risk averse.

Denote (α_i, β_i) as the insurance contract offered to type i consumers, where α_i is the premium and β_i is the coverage. When an accident occurs, the policyholder i has a loss of d (same for all types) and receives a payment of β_i from the insurance company. On top of that, he can also get an additional social insurance payment s from the social insurance system, and thus the net loss of the policyholder i is $\beta_i + s - d$. On the other hand, the government levies a linear income tax, which includes a proportional tax rate t and a lumpsum transfer T for income redistribution and for financing the social insurance system. Hence, the after-tax income of policyholder i is $(1-t)w_i l_i + T$, where l_i is his labor supply.[10]

The policyholder may commit fraud to gain the benefit from the insurance payment. If he successfully commits insurance fraud, then he can receive a gain of $\beta_i + s$.[11] On the other hand, to prevent loss from fraud, insurers will choose to audit some payment claims with a cost of c for each one audited. Moreover, if the fraud is audited, then in addition to no payment received, the policyholder suffers a stigmatic loss equivalent to an amount of F. Since the accidental rate varies among different type of persons, insurers choose differential audit rates for different contracts. Let σ_i denote the probability of a type i policyholder to file an insurance claim (or the cheating rate when the insured commits insurance fraud), and let θ_i denote the portion of insurers chosen to be audited on type i policyholders' payment claims.[12] Thus, σ_i and θ_i are the strategies of policyholders i and insurers in this game, respectively.

As a social insurance provider, the government uses information from insurance companies for payment approval rather than audit insurance fraud by itself. The reason is that in a competitive market, as expected, profits are zero for insurance companies, there is no incentive for the insurer to misreport data to the government. Therefore, governments are not confronted with information-asymmetric problems.[13] This assumption follows Boadway *et al*. (2006) and Netzer and Scheuer (2007).

Even though the three-stage game structure of this paper is similar to that of Boyer (2000), two games are still different. In the first stage of the game, this paper assumes that the government chooses both the social insurance and income tax rates, while Boyer (2000) assumed that the government sets up only the social insurance tax rate. The second and third stages of the game are the same in this paper and Boyer (2000).

According to the descriptions above, attaining the economy's equilibrium is a three-stage procedure. First, the government chooses its policy set (t, T, s). Subsequently,

[10] Suppose in addition to labor income that no other incomes are available for policyholder i.

[11] In our model, it is irrational for a utility maximizing individual to commit fraud on a private insurance policy, but not on social insurance. This is because social insurance payments depend on the report from insurance companies only, without additional applications from the individual. Moreover, fraud is assumed to be costless to policyholders.

[12] We suppose that the insurer knows the type of each policyholder, as in Boyer (2000).

[13] Insurers and policyholders might conspire to cheat the government for social insurance payments, although this is not the case in our model.

facing the government policy of (t, T, s), insurance companies make insurance contracts (α_i, β_i) with type i individuals who supply l_i labor in the labor market, respectively. Finally, confronted with the government policy of (t, T, s) and the private insurance contract of (α_i, β_i), as well as individual labor supply l_i, policyholders i make their application decisions and insurance companies make their audit decisions.

Figure A.1, as shown in Appendix A, illustrates a three-stage game regarding the interaction between policyholders and insurers. First, nature decides the occurrence of loss known to policyholders only. Second, an individual decides whether or not to claim an insurance payment (including private and social insurance). Finally, the insurance company decides whether to audit or not. According to the strategies, players in this game receive their respective payment, thereby ending the game.

There are two information sets connected with dash lines in Figure A.1. Each one contains two decision points, at which the insurer chooses whether to audit or not, irrespective of the policyholder's strategy. Hence, eight outcomes are presented at the bottom of the game tree. Table 1 shows the payments of players in this game.

We assume that a type i individual's utility function is[14]:

$$U(\omega_i^j) - \varphi(l_i), \quad i = 1, \ldots, n; j = na.1, \ldots, na.4, a.1, \ldots, a.4,$$

where $U(\cdot)$ is the utility of wealth, with $U' > 0$, $U'' < 0$; and $-\varphi(\cdot)$ is the disutility of labor, with $\varphi' > 0$, and $\varphi'' > 0$. Using the backward induction method, the third-stage equilibrium is derived from the optimal auditing strategy and the optimal fraud strategy in this game. Subsequently, insurance companies design insurance contracts and individuals decide their labor supply. Finally, the government chooses the optimal tax policy, as well as the optimal social insurance policy.

Table 1. Payoffs to the Policyholder and Insurer

Situation	State of Nature	Policyholder's Strategy	Insurer's Strategy	Policyholder's Payoff	Insurer's Payoff
$na.1$	No loss	No file	Audit	$\omega_i^{na.1} = (1-t)w_i l_i - \alpha_i + T$	$\alpha_i - c$
$na.2$	No loss	No file	No audit	$\omega_i^{na.2} = (1-t)w_i l_i - \alpha_i + T$	α_i
$na.3$	No loss	File claim	Audit	$\omega_i^{na.3} = (1-t)w_i l_i - \alpha_i + T - F$	$\alpha_i - c$
$na.4$	No loss	File claim	No audit	$\omega_i^{na.4} = (1-t)w_i l_i - \alpha_i + \beta_i + s + T$	$\alpha_i - \beta_i$
$a.1$	Loss	No file	Audit	$\omega_i^{a.1} = (1-t)w_i l_i - d - \alpha_i + \beta_i + s + T$	$\alpha_i - \beta_i - c$
$a.2$	Loss	No file	No audit	$\omega_i^{a.2} = (1-t)w_i l_i - d - \alpha_i + T$	α_i
$a.3$	Loss	File claim	Audit	$\omega_i^{a.3} = (1-t)w_i l_i - d - \alpha_i + \beta_i + s + T$	$\alpha_i - \beta_i - c$
$a.4$	Loss	File claim	No audit	$\omega_i^{a.4} = (1-t)w_i l_i - d - \alpha_i + \beta_i + s + T$	$\alpha_i - \beta_i$

[14] This is a frequently used assumption in the analysis of income tax models in, for example, Kessing and Konrad (2006), Cremer and Pestieau (2006, 2014) and Cremer and Roeder (2017).

3. Optimal Auditing and Fraud Policy

With the policy set (t, T, s) by the government and the private insurance contract (α_i, β_i), as well as the individual labor supply l_i, we define the mixed strategy equilibrium (Perfect Bayesian Nash Equilibrium, PBNE) as[15]: (i) the policyholder will definitely apply for an insurance payment if a loss does occur; (ii) the insurance company will not audit unless policyholders apply for payment; (iii) the optimal audit and optimal fraud rates are, respectively

$$\theta_i^* = \frac{U(\omega_i^{na.4}) - U(\omega_i^{na.2})}{U(\omega_i^{na.4}) - U(\omega_i^{na.3})}, \tag{1}$$

$$\sigma_i^* = \frac{p_i c}{(1 - p_i)(\beta_i - c)}, \tag{2}$$

where $\omega_i^{na.2}$, $\omega_i^{na.3}$, and $\omega_i^{na.4}$ are policyholder i's payment of different outcomes in Table 1 (see Appendix B for deriving the PBNE outcomes).

Equation (1) is consistent with that of Boyer (2000). However, Equation (2) is closely related to, but not the same as, that of Boyer (2000), because the present paper focuses on social insurance and income taxes rather than on insurance taxes. According to PBNE, we can omit situations $a.1$, $a.2$ and $na.1$. Therefore, only five outcomes are relevant for our discussion. The next section shall explore these five outcomes in detail. Using the result of comparative statics of Equations (1) and (2), we derive the following lemma.

Lemma 1. *In the presence of insurance fraud, the greater the insurance coverage, the higher the audit rate of insurance companies, and the lower the fraud rate for policyholders.*

Proof. From Equation (1), we know that

$$\frac{\partial \theta_i^*}{\partial \beta_i} = \frac{U'(\omega_i^{na.4})[U(\omega_i^{na.2}) - U(\omega_i^{na.3})]}{[U(\omega_i^{na.4}) - U(\omega_i^{na.3})]^2}.$$

Since $U(\omega_i^{na.2}) > U(\omega_i^{na.3})$, $\partial \theta_i^* / \partial \beta_i > 0$. Next, from Equation (2), we derive

$$\frac{\partial \sigma_i^*}{\partial \beta_i} = \frac{-p_i c}{(1 - p_i)(\beta_i - c)^2} < 0.$$

The intuition behind Lemma 1 is simple. When policyholder i purchases more insurance coverage β_i from (B.1), the insurer will need to audit more in order to make the policyholder i become indifferent between fraud and non-fraud. Economically speaking, Lemma 1 means that when the insurance coverage is larger, the insurer needs more audits, because this larger coverage leads to greater losses in case of fraud. Similarly, in order to make the insurers be indifferent between audits and non-audits, less fraud is necessary. It implies that policyholders do not commit more frauds, because there are more audits. □

[15] Myerson (1991) indicated in a two-player game that mixed strategy PBNE has one solution at most if players only have two actions each. Boyer (2000) discussed the sufficient condition of a PBNE as $p_i < 0.5$.

4. Insurance Contract and Labor Supply in Equilibrium

Confronting the government policy set (t, T, s) and competitive market (hence, zero profits for insurers), the insurance contracts in equilibrium are determined by the optimization decisions of policyholders. The optimal (also the equilibrium) insurance contract (α_i^*, β_i^*) and labor supply l_i^* of a type i individual are the solutions of the following problem (Γ^A):

$$(\Gamma^A) \quad \max_{\alpha_i, \beta_i, l_i} \quad \Phi_i = (1-p_i)(1-\sigma_i^*)U(\omega_i^{na.2}) + (1-p_i)\sigma_i^*\theta_i^*U(\omega_i^{na.3}) + (1-p_i)\sigma_i^* \times (1-\theta_i^*)U(\omega_i^{na.4}) + p_i\theta_i^*U(\omega_i^{a.3}) + p_i(1-\theta_i^*)U(\omega_i^{a.4}) - \varphi(l_i),$$

$$\text{s.t.} \quad \alpha_i = (1-p_i)\sigma_i^*\theta_i^*c + (1-p_i)\sigma_i^*(1-\theta_i^*)\beta_i + p_i\theta_i^*(\beta_i + c) + p_i(1-\theta_i^*)\beta_i, \tag{3}$$

$$\theta_i^* = \frac{U(\omega_i^{na.4}) - U(\omega_i^{na.2})}{U(\omega_i^{na.4}) - U(\omega_i^{na.3})}, \tag{1A}$$

$$\sigma_i^* = \frac{p_i c}{(1-p_i)(\beta_i - c)}. \tag{2A}$$

Equation (3) is the constraint of zero expected profit for the insurance company in competitive equilibrium. Formulae (1A) and (2A) correspondingly represent the PBNE strategy of insurer and policyholder *i*. Substituting θ_i^* and σ_i^* into Φ_i and (3), we can rewrite (Γ^A) as

$$(\Gamma^{A.1}) \quad \max_{\alpha_i, \beta_i, l_i} \quad \Phi_i = (1-p_i)U(\omega_i^{na.2}) + p_i\theta_i^*U(\omega_i^{a.3}) + p_i(1-\theta_i^*)U(\omega_i^{a.4}) - \varphi(l_i),$$

$$\text{s.t.} \quad \alpha_i = p_i\frac{(\beta_i)^2}{\beta_i - c}. \tag{3A}$$

Two arguments are worth noting in (3A). First, if $c = 0$, then this model degenerates into a traditional one. Second, when the policyholder claims insurance payment for a real loss, being audited or not does not change his final income, thus making $\omega_i^{a.3} = \omega_i^{a.4}$.

The first-order conditions of $(\Gamma^{A.1})$ are

$$\Phi_{\beta_i} = p_i(1 - p_i\chi_i)U'(\omega_i^{a.3}) - (1-p_i)p_i\chi_iU'(\omega_i^{na.2}) = 0, \tag{4}$$

$$\Phi_{l_i} = (1-t)w_iEU_i' - \varphi'(l_i) = 0, \tag{5}$$

where $\chi_i = \beta_i(\beta_i - 2c)/(\beta_i - c)^2 < 1$, and $EU_i' = p_iU'(\omega_i^{a.3}) + (1-p_i)U'(\omega_i^{na.2})$ is the marginal expected utility of policy holder *i*. To satisfy the first-order condition (4), we assume that $\beta_i > 2c$ for all $i = 1, \ldots, n$.

Defining the solutions of Equations (4) and (5) as $\beta_i^* = \beta_i(t, T, s)$ and $l_i^* = l_i(t, T, s)$, the indirect utility function of policyholder i is $V_i(t, T, s)$. Therefore, by the envelope theorem, we have

$$\frac{\partial V_i}{\partial t} = -w_il_iEU_i', \quad \frac{\partial V_i}{\partial T} = EU_i', \quad \frac{\partial V_i}{\partial s} = p_iU'(\omega_i^{a.3}). \tag{6}$$

Next, rewriting (4) as

$$\frac{U'(\omega_i^{a.3})}{U'(\omega_i^{na.2})} = \frac{(1-p_i)\chi_i}{1-p_i\chi_i}, \tag{7}$$

we can see that the numerator on RHS of (7) is less than the denominator. Hence, $U'(\omega_i^{a.3}) < U'(\omega_i^{na.2})$ and $\omega_i^{a.3} > \omega_i^{na.2}$, implying policyholders are over-insured (i.e., $\beta_i^* + s > d$).[16] We thus now present another lemma.

Lemma 2. *In the presence of insurance fraud along with the utility function exhibiting DARA*:

(i) *an increase in marginal tax rate t* (*lumpsum transfer T*) *or social benefit s reduces* (*increases*) *individual insurance coverage*, *and vice versa*;
(ii) *an increase in marginal tax rate t* (*lumpsum transfer T or social benefit s*) *increases* (*reduces*) *individual labor supply*, *and vice versa*.

Proof. See Appendix C. □

The economic intuition behind Lemma 2 is that when governments increase tax rates, individual wealth decreases. Under the assumption of DARA,[17] individuals become more risk averse, thus decreasing insurance coverage, which reduces the audit rate as well as income uncertainty. The same argument can be applied to the effect of raising T, which makes policyholders less risk averse as well. An increase in social insurance benefits reduces policyholders' loss in accidents and reduces their demand for private insurance.

When the tax rate rises, policyholders' wealth decreases, thus making them more risk averse and increasing precautionary labor supply.[18] Contrarily, raising s or T lifts individual wealth and decreases precautionary labor supply. Combining Lemmas 1 and 2 yields the following proposition.

Proposition 1. *In the presence of insurance fraud*, *a rise in marginal tax rate t or social benefit s* (*lumpsum transfer T*) *will decrease* (*increase*) *individual insurance coverage under DARA*. *Therefore*, *insurance companies will audit less* (*more*) *and policyholders will cheat more* (*less*), *and vice versa*.

By Lemma 2, an increase in the marginal tax rate t or social benefit s reduces individual insurance coverage, which subsequently decreases the insurer's audit rate and increases the policyholder's fraud rate, according to Lemma 1. Similarly, a rise in the lumpsum transfer T increases individual insurance coverage, which successively lifts the insurer's audit rate and decreases the policyholder's fraud rate. Therefore, Proposition 1 implies that both the government tax and social insurance policies influence the private insurance market,

[16] This result is the key point of our finding regarding the welfare effect of providing social insurance, which differs from the findings of conventional literature, in which (without insurance fraud) consumers purchase a full insurance contract.
[17] See McKee (1989) and Holt and Laury (2002) for an experiment study. They show that the absolute risk aversion decreases as income increases.
[18] We follow the precautionary labor supply concept of Netzer and Scheuer (2007). When individual wealth decreases, the policyholders increase their labor supply, and vice versa.

thereby changing the audit and fraud rates chosen by insurers and policy holders, respectively.

5. Optimal Redistribution Policies

As previously mentioned, redistributive instruments for the government include lumpsum transfers and social insurance, which are financed by a proportional income tax. Considering the second- and third-stage equilibria, the first-stage optimization problem of the government is

$$(\Gamma) \quad \max_{t,T,s} \quad \sum_{i=1}^{n} f_i V_i(t,T,s)$$
$$\text{s.t.} \quad \sum_{i=1}^{n} f_i t w_i l_i = \sum_{i=1}^{n} f_i (T + \pi_i s), \quad s \geq 0.^{19} \tag{8}$$

Equation (8) is the budget constraint of the government, where $\pi_i = (1-p_i)\sigma_i^*(1-\theta_i^*) + p_i$ is the probability for a policyholder i to receive social insurance benefits. The first term $(1-p_i)\sigma_i^*(1-\theta_i^*)$ is the probability of undetected fraud, and the second term p_i is the accidental rate.

Formulating the Lagrangean of problem (Γ), we have

$$\Omega = E(V_i(t,T,s)) + \mu E(t w_i l_i - T - \pi_i s),$$

where $E(V_i) = \sum_{i=1}^{n} f_i V_i$, $E(t w_i l_i - T - \pi_i s) = \sum_{i=1}^{n} f_i (t w_i l_i - T - \pi_i s)$, and μ is the Lagrange multiplier. The first-order conditions are

$$\frac{\partial \Omega}{\partial t} = E\left(\frac{\partial V_i}{\partial t} + \mu\left(t w_i \frac{\partial l_i}{\partial t} + w_i l_i - \frac{\partial \pi_i}{\partial t} s\right)\right) = 0, \tag{9}$$

$$\frac{\partial \Omega}{\partial T} = E\left(\frac{\partial V_i}{\partial T} + \mu\left(t w_i \frac{\partial l_i}{\partial T} - 1 - \frac{\partial \pi_i}{\partial T} s\right)\right) = 0, \tag{10}$$

$$\frac{\partial \Omega}{\partial s} = E\left(\frac{\partial V_i}{\partial s} + \mu\left(t w_i \frac{\partial l_i}{\partial s} - \frac{\partial \pi_i}{\partial s} s - \pi_i\right)\right) \leq 0, \quad s \geq 0, \quad s\frac{\partial \Omega}{\partial s} = 0, \tag{11}$$

where $\frac{\partial \pi_i}{\partial \Lambda} = (1-p_i)((1-\theta_i^*)\frac{\partial \sigma_i^*}{\partial \Lambda} - \sigma_i^* \frac{\partial \theta_i^*}{\partial \Lambda})$ and $\Lambda \in \{t, T, s\}$.

From Proposition 1, we know that

$$\frac{\partial \pi_i}{\partial t} > 0, \quad \frac{\partial \pi_i}{\partial T} < 0, \quad \frac{\partial \pi_i}{\partial s} > 0. \tag{12}$$

Denote Θ_i as the net marginal social benefit of tax as defined by Diamond (1975), which can be expressed as

$$\Theta_i = \frac{\partial V_i}{\partial T}\frac{1}{\mu} + t w_i \frac{\partial l_i}{\partial T}. \tag{13}$$

[19] We assume that the social welfare function is utilitarian, as noted by Boadway *et al*. (2003, 2006).

The first term on RHS of (13) denotes the marginal social benefit of the income of policyholder i, whereas the second term is the marginal tax revenue from the income of policy holder i. Next, combining Equations (10) and (13) results in

$$E\left(\Theta_i - \frac{\partial \pi_i}{\partial T} s\right) = 1. \tag{14}$$

We finally derive by Equations (6), (9), and (14)

$$\frac{t}{1-t} = \frac{-\mathrm{Cov}(w_i l_i, \Theta_i) - s(E(\partial \pi_i/\partial t) + E(w_i l_i)E(\partial \pi_i/\partial T))}{E(w_i \tilde{l}_i \varepsilon_i)}, \tag{15}$$ [20]

where $\tilde{l}_i$ is the compensated labor supply, and $\varepsilon_i > 0$ is the compensated elasticity of labor supply on net wage. Equation (15) is an important result in our model. First, from the RHS denominator of (15), when the labor supply elasticity of individual i is higher, the tax rate should be lower, which is the efficiency aspect as in conventional literature. Second, the covariance of $w_i l_i$ and Θ_i, which may be negative, denote the redistribution effect of taxation, which is identical to the standard case presented in Cremer and Pestieau (1996). Therefore, if the government is more egalitarian, then the tax rate should be higher. The second term on the RHS numerator of (15) is the effect of insurance fraud on optimal taxation. Equation (12) shows that $\partial \pi_i/\partial t > 0$ and $\partial \pi_i/\partial T < 0$. Therefore, the tax rate should be lower if the income tax system causes more insurance fraud. This is a brand new effect that is not explored in conventional literature.

For the optimal social insurance policy, substituting Equations (6) and (14) into (11) yields[21]:

$$\frac{1}{\mu}\frac{\partial \Omega}{\partial s} = \mathrm{Cov}(\pi_i, \Theta_i) + tE\left(\frac{\partial w_i l_i}{\partial s} - \pi_i \frac{\partial w_i l_i}{\partial T}\right) - s\left[E\left(\frac{\partial \pi_i}{\partial s}\right) - E(\pi_i)E\left(\frac{\partial \pi_i}{\partial T}\right)\right]$$
$$+\frac{1}{\mu}E(p_i U'(\omega_i^{a.3}) - \pi_i EU_i') \leq 0, \quad s \geq 0, \quad s\frac{\partial \Omega}{\partial s} = 0. \tag{16}$$

From (16), the welfare effects of s are decided by four elements: income redistribution effect, tax revenue effect, insurance fraud effect and risk transfer effect. We discuss these effects in the following paragraphs.

(i) The first term on the RHS of (16) represents the income redistribution effect, which is different from the argument of Cremer and Pestieau (1996) that emphasizes the covariance of p_i and Θ_i. In our model, π_i includes not only the probability of the accident (i.e., p_i), but also the probability of fraud $(1-p_i)\sigma_i^*(1-\theta_i^*)$. Cremer and Pestieau (1996) argued that if the covariance of p_i and Θ_i are positive, then social insurance can improve income distribution. In our model, it is the covariance of π_i and Θ_i rather than those of p_i and Θ_i that should be positive in order to improve income distribution.

(ii) The second term on the RHS of (16) is the tax revenue effect. By Lemma 2, $\partial l_i/\partial s < 0$ and $\partial l_i/\partial T < 0$; thus, the sign of the tax revenue effect is uncertain.

[20] See Appendix D.
[21] See Appendix E.

Cremer and Pestieau (1996) argued that this effect does not exist, because insurers offer full insurance to consumers if there is no fraud.[22] However, Netzer and Scheuer (2007) contended that it should be negative, because social insurance would reduce individual labor supply, thereby cutting tax revenue.

(iii) The third term on RHS of (16) is the effect of insurance fraud. As $\partial\pi_i/\partial s > 0$ and $\partial\pi_i/\partial T < 0$, this term is non-positive. Therefore, the insurance fraud effect negatively influences social insurance coverage s.

(iv) The last term on RHS of (16) denotes the risk transfer effect. Demonstrating $\pi_i > p_i$ as well as $EU_i' > U'(\omega_i^{a.3})$ is easy[23]; thereby, this term is negative. However, if there is no insurance fraud, then $\pi_i = p_i$ and $EU_i' = U'(\omega_i^{a.3})$, which make this term zero.

In sum, if there is no insurance fraud in the economy, then Equation (16) degenerates into $\partial\Omega/\partial s = \mu\mathrm{Cov}(p_i, \Theta_i)$, which is the result of Cremer and Pestieau (1996, 2014). Therefore, social insurance can transfer resources from high-ability individuals in low-risk state to low-ability individuals in high-risk state. This redistribution effect improves social welfare, at least regarding equity. However, if there exists insurance fraud, then the optimal social insurance s in (16) might be zero even though $\mathrm{Cov}(\pi_i, \Theta_i)$ is positive. Thus, we propose the following proposition.

Proposition 2. *In the presence of insurance fraud, we find that equity and efficiency effects of social insurance are conflicting rather than complementary with each other.*

The reason behind Proposition 2 is as follows. When there is no insurance fraud in the insurance market, insurers offer the insured full insurance without distortion. In this situation, Cremer and Pestieau (1996, 2014) proved that social insurance can improve welfare by redistributing income from high-ability individuals in a low-risk state to low-ability ones in a high-risk state. Once insurance fraud exists, over insurance prevails and causes inefficiencies such as tax revenue loss, increased insurance fraud and aggravated risk sharing. Therefore, the welfare-improving function of social insurance may be reversed by insurance fraud. In brief, we identify insurance fraud as a reason why the government may not provide social insurance. Taking insurance fraud into account, this paper obtains completely different results from Cremer and Pestieau (1996, 2014) and Boadway *et al.* (2003, 2006), as mentioned in the introduction.

6. Conclusion

This study examines the equity and efficiency effects of social insurance in the presence of insurance fraud and linear income taxes. Our main findings are as follows. (i) Under the commonly accepted assumption of DARA social insurance benefits may increase insurance fraud, whereas increasing the marginal tax rate (lumpsum transfer) of the linear

[22] If there is no insurance fraud ($\sigma_i^* = 0$), then insurers offer consumers full insurance and the second effect of (16) vanishes from the calculation in Appendix C.

[23] $\pi_i = (1-p_i)\sigma_i^*(1-\theta_i^*) + p_i > p_i$, as long as the first term of π_i is positive. Recall that $EU_i' = p_iU'(\omega_i^{a3}) + (1-p_i)U'(\omega_i^{na2}) > U'(\omega_i^{a3})$ since $U'(\omega_i^{na2}) > U'(\omega_i^{a3})$.

income tax also causes insurance fraud to rise (fall). (ii) Equity and efficiency effects of social insurance are conflicting rather than complementary with each other.

There are two possible extensions for future research. First, incorporating the adverse selection problem into our model is worthwhile. In other words, considering the interaction between adverse selection and fraud in the insurance market may influence the optimal social insurance policy in our model. Second, moral hazard can be integrated into this model to test the robustness of the proposed propositions in this paper.

Acknowledgments

The authors would like to thank two anonymous reviewers and an editor of this journal for their valuable comments.

Appendix A.

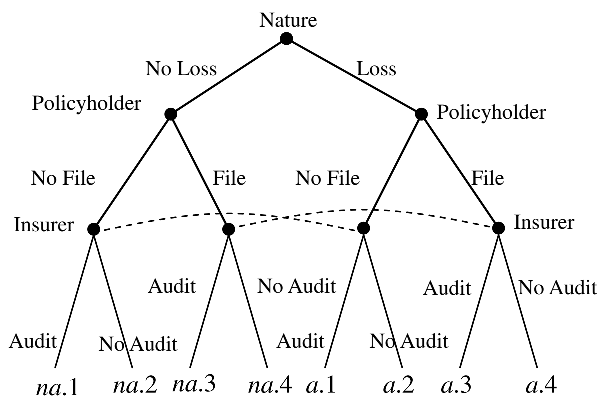

Figure A.1. The Game Tree

Appendix B.

A policyholder will apply for insurance payment when he has a loss d, and thus $\sigma_i^* = 1$ if the loss does occur. On the other hand, the insurer will not audit if there is no payment required; therefore, $\theta_i^* = 0$ at this situation. In equilibrium, the mixed strategy of an insurance company is to make policyholders be indifferent between cheating and not cheating — that is

$$U(\omega_i^{na.2}) = \theta_i U(\omega_i^{na.3}) + (1 - \theta_i) U(\omega_i^{na.4}). \tag{B.1}$$

Therefore, we state that

$$\theta_i^* = \frac{U(\omega_i^{na.4}) - U(\omega_i^{na.2})}{U(\omega_i^{na.4}) - U(\omega_i^{na.3})}. \tag{B.2}$$

By Bayes' rule, once the policyholders apply for payment, we denote the ex-post probability of no fraud as

$$\lambda_i = \frac{p_i}{p_i + (1 - p_i)\sigma_i}. \tag{B.3}$$

Similarly, in equilibrium, the mixed strategy of the policyholder is to make insurance companies' expected payment indifferent between auditing and not auditing, that is

$$-c - \lambda_i\beta_i = -\beta_i. \tag{B.4}$$

Therefore, we have

$$\lambda_i = \frac{\beta_i - c}{\beta_i}. \tag{B.5}$$

Substituting (B.5) into (B.3), we have

$$\sigma_i^* = \frac{p_i c}{(1 - p_i)(\beta_i - c)}. \tag{B.6}$$

Appendix C.

By the implicit function theory, from (4) and (5), we derive the marginal impact of governmental decision variable $\Lambda \in \{t, T, s\}$ on insurance coverage and labor supply as

$$\frac{\partial\beta_i}{\partial\Lambda} = \frac{\Phi_{\beta_i l_i}\Phi_{l_i\Lambda} - \Phi_{\beta_i\Lambda}\Phi_{l_i l_i}}{H}, \tag{C.1}$$

$$\frac{\partial l_i}{\partial\Lambda} = \frac{\Phi_{\beta_i l_i}\Phi_{\beta_i\Lambda} - \Phi_{l_i\Lambda}\Phi_{\beta_i\beta_i}}{H}. \tag{C.2}$$

Suppose that the second-order conditions are satisfied, i.e., $H > 0$. The signs of RHS of (C.1) and (C.2) are then determined by the numerators. From Equations (4) and (5), we derive

$$\Phi_{\beta_i l_i} = (1 - t)w_i p_i(1 - p_i\chi_i)U'(\omega_i^{a.3})[r(\omega_i^{na.2}) - r(\omega_i^{a.3})], \tag{C.3}$$

$$\Phi_{l_i l_i} = (1 - t)^2 w_i^2 EU_i'' - \varphi''(l_i) < 0, \tag{C.4}$$

$$\begin{aligned}\Phi_{\beta_i\beta_i} = {} & p_i(1 - p_i\chi_i)^2 U''(\omega_i^{a.3}) + (1 - p_i)(p_i\chi_i)^2 U''(\omega_i^{na.2}) \\ & - \frac{\partial\chi_i}{\partial\beta_i}[p_i^2 U'(\omega_i^{a.3}) + p_i(1 - p_i)U'(\omega_i^{na.2})] < 0,\end{aligned} \tag{C.5}$$

$$\Phi_{l_i t} = -w_i EU_i' - (1 - t)w_i^2 l_i EU_i'', \tag{C.6}$$

$$\Phi_{\beta_i t} = -w_i l_i p_i(1 - p_i\chi_i)U'(\omega_i^{a.3})[r(\omega_i^{na.2}) - r(\omega_i^{a.3})], \tag{C.7}$$

$$\Phi_{l_i T} = (1 - t)w_i EU_i'' < 0, \tag{C.8}$$

$$\Phi_{\beta_i T} = p_i(1 - p_i\chi_i)U'(\omega_i^{a.3})[r(\omega_i^{na.2}) - r(\omega_i^{a.3})], \tag{C.9}$$

$$\Phi_{l_is} = (1-t)w_ip_iU''(\omega_i^{a.3}) < 0, \tag{C.10}$$

$$\Phi_{\beta_is} = p_i(1-p_i\chi_i)U''(\omega_i^{a.3}) < 0, \tag{C.11}$$

where $r(\omega_i^{na.2}) = -U''(\omega_i^{na.2})/U'(\omega_i^{na.2})$ and $r(\omega_i^{a.3}) = -U''(\omega_i^{a.3})/U'(\omega_i^{a.3})$ are the absolute risk aversion coefficients, $EU_i' = p_iU'(\omega_i^{a.3}) + (1-p_i)U'(\omega_i^{na.2})$, $EU_i'' = p_iU''(\omega_i^{a.3}) + (1-p_i)U''(\omega_i^{na.2}) < 0$, $0 < \chi_i = \frac{\beta_i(\beta_i-2c)}{(\beta_i-c)^2} < 1$, and $\frac{\partial\chi_i}{\partial\beta_i} = \frac{2(\beta_i-c)c^2}{(\beta_i-c)^4} > 0$.

When there exists insurance fraud, consumers will over insure their loss; i.e., $\omega_i^{na.2} < \omega_i^{a.3}$. Therefore, $r(\omega_i^{na.2}) - r(\omega_i^{a.3}) > 0$ holds if the utility function exhibits DARA. We also know that (C.3) and (C.9) are both positives. Substituting Equations (C.3)–(C.11) into (C.1) and (C.2),[24] we can derive the results of $\partial\beta_i/\partial t < 0$, $\partial\beta_i/\partial T > 0$, $\partial\beta_i/\partial s < 0$, $\partial l_i/\partial t > 0$, $\partial l_i/\partial T < 0$ and $\partial l_i/\partial s < 0$.

Appendix D.

Substituting Equation (6) into (10) and using Equation (14), we can derive

$$\frac{1}{\mu}\frac{\partial\Omega}{\partial t} = E\left(\frac{-w_il_iEU_i'}{\mu} + tw_i\frac{\partial l_i}{\partial t} - \frac{\partial\pi_i}{\partial t}s\right) + E(w_il_i)E\left(\Theta_i - \frac{\partial\pi_i}{\partial T}s\right) = 0. \tag{D.1}$$

Rearranging the RHS of (D.1) by adding and subtracting $E(w_il_i\Theta_i)$ results in

$$\begin{aligned}\frac{1}{\mu}\frac{\partial\Omega}{\partial t} &= E\left(w_il_i\left(\frac{EU'}{\mu} + tw_i\frac{\partial l_i}{\partial T}\right)\right) + E\left(\frac{-w_il_iEU_i'}{\mu} + tw_i\frac{\partial l_i}{\partial t} - \frac{\partial\pi_i}{\partial t}s\right)\\ &\quad -\mathrm{Cov}(w_il_i,\Theta_i) - E(w_il_i)E\left(\frac{\partial\pi_i}{\partial T}s\right)\\ &= tE\left(w_i\frac{\partial\tilde{l}_i}{\partial t}\right) - \mathrm{Cov}(w_il_i,\Theta_i) - s\left[E\left(\frac{\partial\pi_i}{\partial t}\right) + E(w_il_i)E\left(\frac{\partial\pi_i}{\partial T}\right)\right] = 0,\end{aligned} \tag{D.2}$$

where $\tilde{l}_i$ is the compensated labor supply of individual i. Moreover, $\partial\tilde{l}_i/\partial t = \partial l_i/\partial t + w_il_i(\partial l_i/\partial T)$. Define the compensated elasticity of labor supply on net wage as

$$\varepsilon_i = \frac{\partial\tilde{l}_i}{\partial(1-t)w_i}\frac{(1-t)w_i}{\tilde{l}} > 0,$$

and then (D.2) can be rewritten as Equation (15).

Appendix E.

Substituting Equation (6) into Equation (12) and using Equation (14), we obtain

$$\frac{1}{\mu}\frac{\partial\Omega}{\partial s} = E\left(\frac{p_iU'(\omega_i^{a.3})}{\mu} + tw_i\frac{\partial l_i}{\partial s} - \frac{\partial\pi_i}{\partial s}s\right) - E(\pi_i)E\left(\Theta_i - \frac{\partial\pi_i}{\partial T}s\right) = 0. \tag{E.1}$$

[24] Readers interested in the calculation procedure can be provided with it upon request to the authors.

Rearranging the RHS of (E.1) by adding and subtracting $E(\pi_i\Theta_i)$ results in

$$\frac{1}{\mu}\frac{\partial\Omega}{\partial s} = -E\left(\pi_i\left(\frac{EU'}{\mu} + tw_i\frac{\partial l_i}{\partial T}\right)\right) + E\left(\frac{p_iU'(\omega_i^{a.3})}{\mu} + tw_i\frac{\partial l_i}{\partial s} - \frac{\partial\pi_i}{\partial s}s\right)$$
$$+\mathrm{Cov}(\pi_i,\Theta_i) - E(\pi_i)E\left(\frac{\partial\pi_i}{\partial T}s\right) = 0, \qquad \text{(E.2)}$$

from which we can derive Equation (16).

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