Credence Goods, Risk Averse, and Optimal Insurance

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Abstract

We analyze a credence goods market with risk averse consumers when the assumptions of both liability and verifiability hold. In the basic model, we show that the consumer's risk-aversion would induce expert's overtreatment behavior and thus cause social inefficiency. But the probability of overtreating deceases with the degree of consumer's risk-aversion or the coefficient of absolute risk aversion(CARA). Furthermore, we extend the basic model with insurance option. We assume there exists a perfectly competitive insurance market where the consumer could purchase insurance. Two sets of equilibria indexed by expert's pricing strategy could be specified. The equilibrium outcome shows that social efficiency could always be achieved and the expert could obtain all the social surplus in the equilibrium.

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1 Introduction

When the consumers need some repair services, the service providers have more information about the consumers' need and the corresponding treatments. The goods or services with this property that seller knows more about buyer's demand than the buyer himself is **credence goods** (See Darby and Karni (1973)). The consumers barely know what they need ex ante, and even can not verify whether their need is properly satisfied or not ex post. Typical credence services are medical services, repair services and education and consulting services.

The information superiority of service providers may induce three types of fraudulent behaviours by sellers: 1)*overtreatment*, providing unnecessarily high quality of goods or services, 2)*undertreatment*, providing insufficiently low quality and 3)*overcharging*, charging the price for quality actually unprovided. Ample anecdotes and empirical evidences show that these three types of frauds persist in credence goods market. For instance, Emons (1997) cite that Patterson (1992) finds that over 90% employees of Sears Automotive Centers in the test cases recommend unnecessary repairs for car owners in the United States[1].

This paper focuses on the impact of the consumer's risk-aversion on seller's incentive for overtreatment. We set up an otherwise credence goods model in which consumers are risk averse and assume that the expert is liable for the treatment outcome and the types of services provided by the seller are verifiable costlessly by consumers(Corresponding to the assumption of liability and verifiability in Dulleck and Kerschbamer (2006)). In our model, one risk-averse consumer has a either minor or major problem but she does not know exactly what her problem is, the monopolistic expert can accurately diagnose the nature of consumer's problem with no cost. The expert first posts a price list and then makes a take-it-or-leave-it treatment proposal for the consumer after diagnosis. We show that consumer's risk aversion could induce expert's overtreatment behaviour but the probability of overtreatment decreases with the degree of consumer's risk-aversion or the coefficient of absolute risk aversion(CARA). Extremely, when the consumer is absolutely risk-averse, the expert behaves honestly and the market efficiency can be reobtained.

We also extend the setup to a situation in which there exists a perfectly competitive insurance market. The consumer could purchase insurance after observing the expert's

[1]For more examples or evidence in details, see Emons (1997), Pesendorfer and Wolinsky (2003), Dulleck and Kerschbamer (2006), Bester and Dahm (2014)

price list and insurance scheme posted by the insurer. We study the consumer's optimal insurance choice and the effect on expert's overtreatment. Two sets of equilibria indexed by expert's pricing strategy could be specified. In both sets of equilibria, the consumers would purchase insurance while the expert always honestly offer to repair consumer's problem. The equilibrium outcome shows that social efficiency could always be achieved and the expert could obtain all the social surplus in the equilibrium.

Sulzle and Wambach(2005) is closely related to the problem under concern. They study the role of consumer's coinsurance rate on expert's overcharing behaviors by adding consumers' insurance into a simplified version of credence goods model in Pesendorfer and Wolinsky(2003). In their model, there exists many profit-maximizing experts in the market. The experts compete for consumers and can overcharge the consumers. Searching for second opinion is allowed for the consumer whenever he rejects an expert's offer. Thus the consumer's problem is always repaired and the social inefficiency comes from duplicately wasteful search cost. In contrast, this paper analyse a monopolistic expert who attempts to overtreat the consumer while the consumer disciplines the expert by rejecting expert's treatment offer. No second opinion is allowed and social inefficiency is due to consumer's unrepaired problems.

Furthermore, the price for treatments in their model is fixed and exogenously given. The expert's strategy is only one-dimension,i.e, deciding the probability of overcharging. As in Pesendorfer and Wolinsky(2003), they show there exists an *informational externality* between expert's strategy. If other experts prescribe relatively dishonestly, first offer for a high diagnosis is rejected pretty often and the chance is high that a consumer visiting a physician is already his second visit. Then the expert is more likely to prescribe a high diagnosis as well which may confirms the first diagnosis. In the other hand, if other experts acts pretty honestly, then the expert is also more likely to prescribe honestly. The key role of consumer's coinsurance rate in their model is affecting consumer's acceptance for first diagnosis.

But in our paper the expert decides both the prices for treatments and the probability of overtreatment, which interacts with each other. On the one hand, a relative higher price for major treatment create a stronger incentive for fraudulent behavior, which called *price effect*. But the higher price also makes dishonest behavior more intolerant, which renders less acceptance by the consumer, which called *quantity effect*. The expert decides optimal prices and optimal probability of dishonesty by balancing these two effects. Moreover, we assume the consumer is risk-averse and purchase insurance in a competitive insurance market. While in Sulzle and Wambach's model, the consumers are risk-neutral and their coinsurance rate is exogenously given.

In addition, Bonroy, et al (2013)analyse the impact of consumer's risk-aversion on expert's incentive to diagnosis. They show that the presence of risk aversion reduce expert's incentive to invest in diagnosis and thus cause mistreatment. This paper focuses on the role of risk aversion on expert's incentive for overtreatment and formally analyse the effect of insurance as well.

The remainder of the article is organized as follows. Section 2 presents the standard credence goods model with risk-averse consumer and analyses the equilibrium. Section 3 extends the basic model by introducing the insurance company and the equilibria are solved. Section 4 makes some discussions and then concludes.

2 Basic Model

2.1 Players and Payoff Function

There is a monopoly expert(she) and a consumer(he). The consumer has a problem r either being minor m or serious S, $r \in \{m, S\}$. $r = S$ with probability β, with $\beta \in (0, 1)$. If the consumer's problem $r \in \{m, S\}$ is resolved, the consumer could gain a gross of V_r, otherwise he gets 0. The consumer is risk-averse and his utility function follows a concave Von Neumann-Morgenstern form $U(x)$ which is twice differentiable with $U(0) = 0$, $U^{'}(\cdot) > 0$ and $U^{''}(\cdot) < 0$, where x being the consumer's net gain. So the consumer's utility is $U(V_b - P)$ if his problem b is resolved at price P, and $U(-P)$ if his problem is unresolved with treatment at price P. The reserve utility of the consumer is $\bar{U} > 0$.

The expert can privately learn the nature of the consumer's problem by costless diagnosis and then make a prescription d for the consumer: major treatment H or minor treatment L,i.e, $d \in \{L, H\}$. Prescription $d = H$ repairs both types of problems while prescription $d = L$ only repairs a minor problem. The cost of performing a treatment d for the expert are C_d. Suppose the expert is a profit maximizer and her utility from performing a treatment at price P is $P - C_d$, otherwise her payoff is 0. Meanwhile, we also assume that overtreatment will induce the same cost of treating the major problem for the expert[2].

[2]This assumption can be easily extended to the situation that overtreatment only induce a friction of cost for major treatment. overtreatment is actually the situation that the expert privately learns that the consumer's problem is minor, So the expert only need fix the consumer's problem whilst make the

Suppose that it is socially efficient to repair both problem with proper treatment while not efficient to repair minor problem by major treatment,i.e.,$0 < C_L < V_m < C_H < V_S$. Suppose major treatment is potentially more profitable than minor treatment for the expert[3]. Also, we assume that it is not optimal for the consumer to always accepting major treatment, i.e, $\beta U(V_S - C_H) + (1-\beta)U(V_m - C_H) < \bar{U}$[4]. Furthermore, we restrict any price list (P_L, P_H) to satisfy $P_d \geq C_d$ for all $d \in \{L, H\}$, which means that the expert can not cross-subsidise between the two treatment.

Following the literature, we define the following terms

Definition 1. ***Liability***: *The resolution of consumer's problem is verifiable costless ex post.* ***Verifiability***: *The type of treatment the consumer receives is verifiable costless.*

By Liability, if the consumer's problem is not resolved after treatment, the expert could be heavily fined. Then, the expert could not providing minor treatment for the consumer with major problem,i.e, undertreatment could be excluded. By Verifiability, the expert can not provide a minor (major) treatment while charging a price for major (minor) treatment,i.e, overcharging could be excluded. In the our model we assume both the assumptions of liability and verifiability hold.

Timing of the Game. The game proceeds as follows:

1. The expert posts a price list (P_L, P_H).
2. Nature draws the consumer's type. The consumer visits the expert. The expert performs a diagnosis and prescribes a treatment $d \in \{\varnothing, L, H\}$ for the consumer. $\varnothing$ here means the expert could reject to treat the consumer.
3. The consumer decides whether accept treatment d or not. If the consumer accepts, the treatment prescribed would be performed by the expert. If the problem is resolved, the expert receives her payment otherwise get nothing[5]. The game ends in other situations.

consumer believe that he have performed a major treatment. Therefore, overtreatment in some cases may be less costly than actually performing a major treatment.

[3]We would like use the minor treatment as the base line to study the expert's incentive to overtreatment. Since there are only two cases, then it is a symmetric problem to focus on the expert's incentive to undertreatment,i.e, provide insufficiently minor treatment for major problem, which could only be possible when the assumption liability defined below is not held.

[4]Other cases will be discussed in later sections.

[5]Here the payment for the expert is based on the resolution of the consumer's problem, so the liability holds. We think that it may be regarded as enough penalty for the expert's undertreatment behaviour.

2.2 Equilibrium

The perfect Bayesian equilibrium is analyzed below. An equilibrium consists of the expert's strategy, the consumer's strategy, and the consumer's beliefs over the nature of problem, which satisfy the following:

1. The consumer's strategy maximizes her expect payoff given her beliefs.
2. The expert's strategy maximizes his expected utility given the consumer's strategy.
3. The consumer's beliefs are correct on the equilibrium path.

The consumer's strategy specifies the acceptance probability regarding to the expert's recommendation. Note that as long as the assumption liability holds, undertreatment would be excluded as mentioned above. The expert would only recommend minor treatment for the consumer with minor problem. And the consumer would believe that his problem is indeed minor upon recommended minor treatment. Accepting the prescription at price P_L would bring the consumer with benefits of V_m, resulting in the consumer's utility being $U(V_m - P_L)$, while rejecting it retains the reserve utility $\bar{U}$.

Denote $\bar{P}_L^*$ and $\bar{P}_H^*$ that satisfy $U(V_m - \bar{P}_L^*) = \bar{U}$ and $U(V_S - \bar{P}_H^*) = \bar{U}$, respectively. Then $\bar{P}_L^*$ and $\bar{P}_H^*$ are the maximal prices at which the consumer would accept the treatment offer when he could make sure that his problem is minor and major, respectively. Any prices larger than the maximal prices would make the consumer reject and no transaction would be reached, which is suboptimal for the expert. So we restrict the prices with $P_L \leq \bar{P}_L^*$ and $P_H \leq \bar{P}_H^*$.

Then as long as $P_L \leq \bar{P}_L^*$ with $U(V_m - \bar{P}_L^*) = \bar{U}$, the consumer would accept the minor treatment prescription with probability one[6]. Denote λ as the probability of the consumer accepting major treatment.

The expert's strategy consists of posting a price list $\{P_L, P_H\}$ and a prescription strategy $d \in \{\varnothing, L, H\}$. For the consumer with serious problem,i.e, $r = S$, the expert has to prescribe major treatment ($d = M$) since the consumer's payment is based on the resolution of his problem and only major treatment could repair serious problem. Let ρ be the probability of prescribing major treatment for the consumer with minor problem,i.e.attempt to overtreat the consumer.

[6]Assume that the consumer would accept the prescription when he is indifferent between accepting and rejecting the offer.

Lemma 1. *There exists no equilibrium where the expert posts a single price $P_L = P_H = \bar{P}$ or a price list $\{P_L, P_H\}$ with $P_H \in [C_H, C_H + P_L - C_L)$.*

Proof. The proof can be divided into two parts: the first part shows that there exists no equilibrium with a single price $P_L = P_H = \bar{P}$ and the second part proves that a price list $\{P_L, P_H\}$ with $P_H \in [C_H, C_H + P_L - C_L)$ can not be optimal for the expert.

1. Assume that there is indeed a equilibrium where the expert posts a single price $P_L = P_H = \bar{P}$. If $\bar{P} < C_H$, then the expert would reject the consumer with serious problem. The consumer updates his belief that the expert would offer to treat him only when his problem is minor. Then for the expert's offer at such a single price, the consumer believe that his problem is minor with probability one and expected gain from the treatment is V_m. Therefore, the consumer would only accept the treatment at price $\bar{P} \leq \bar{P}^*$ and reject any treatment at price $\bar{P} > \bar{P}^*$. So the expert's maximal profits $\pi_m = (1-\beta)(\bar{P}^* - C_L)$. However, the expert can always post a price list $\{P_L, P_H\}$ with $P_L = \bar{P}^*$ and $P_H = C_H + \xi$ ($\xi \to 0$). Overtreatment is not profitable for the expert under such a price list, then the consumer would accept both major and minor treatment prescriptions with probability one. The expert's profits are $\beta\xi + (1-\beta)(\bar{P}^* - C_L) > \pi_m$. Therefore, the single price list $\bar{P} < C_H$ is suboptimal.

   If $\bar{P} \geq C_H$, although the expert would offer to treat the consumer in both states but no information about the consumer's problem could be updated from the price list and expert's recommendation, the consumer maintains his prior belief and the expected utility from treatment is $\beta U(V_M - P_H) + (1-\beta)U(V_m - P_H) < \bar{U}$, then the consumer would reject the treatment with probability one. Then the market breaks down and the expert make no profits, which makes the price suboptimal.

2. For the price list $\{P_L, P_H\}$ with $P_H \in [C_H, C_H + P_L - C_L)$, it is strictly dominated strategy for the expert because the expert could strictly increase his profits by posting a price list $\{P_L, C_H + P_L - C_L\}$. This is because the consumer holds the belief that the expert would honestly treat him as long as $P_H \leq C_H + P_L - C_L$ and both liability and verifiability holds[7], so the consumer would accept the expert's recommendation, either major or minor treatment, with probability one. Then the expert's profits are $\beta(P_H - C_H) + (1-\beta)(P_L - C_L)$. The profits under any price list $\{P_L, P_H\}$ with $P_H \in [C_H, C_H + P_L - C_L)$ are $\beta(P_H - C_H) + (1-\beta)(P_L - C_L) < P_L - C_L$,

[7] Assume that the expert would honestly treat the consumer when he is indifferent between honestly treating and overtreating.

the profits under price list $\{P_L, P_H\}$ with $P_H = C_H + P_L - C_L$. Therefore, such a price list is also suboptimal.

□

Lemma 1 shows that some constraints can be put on the equilibrium price. Firstly, a single price is not feasible on the equilibrium. If the single price is too low to compensate the expert's cost of major treatment, the expert would reject treating the consumer with major problem at the price. Then the consumer learns that only minor problem would be repaired at the price based on this observation, so the consumer would only accepting a maximal price that leave him reserve utility. The expert can get all the rents from the consumer with minor problem but give up all the possible rents from the consumer with major problem, but such a price can not be optimal because the expert could always post a price list that get extra rents by treating the consumer with major problem. While if the single price can cover the cost of major treatment. The price is too high to make the consumer always reject the offer. Therefore, a single price is not optimal.

On the other hand, if the price list satisfies that the margin from major treatment is no bigger than that from minor treatment, then the expert would behave honestly and the consumer would accept the offer for certain. Given the consumer always accepting expert's offer, expert's profits is increasing in both prices. Then any price lists that makes the margin from major treatment smaller than that from minor treatment is dominated by that equals the price margin.

From the two points, we could focus our attention on the price list $\{P_L, P_H\}$ with $P_H \geq C_H + P_L - C_L$ in the equilibrium analysis below.

Lemma 2 (Fully Overtreatment). *Given the price list $\{P_L, P_H\}$ with $P_L - C_L \leq P_H - C_H$, there exists no equilibrium where*

$$\rho = 1, \qquad \lambda = 1. \tag{1}$$

Proof. We shows the result by contradiction. If $\rho = 1$, no information is updated and the consumer retains his prior belief that his problem is major with probability β. The expected utility from accepting the treatment is $\beta U(V_M - P_H) + (1-\beta)U(V_m - P_H)$. Given the price $P_L - C_L \leq P_H - C_H$ and $\beta U(V_M - C_H) + (1-\beta)U(V_m - C_H) < \bar{U}$, then $\beta U(V_M - P_H) + (1-\beta)U(V_m - P_H) < \bar{U}$. Optimally, the consumer should reject the treatment offer with probability one,i.e, $\lambda = 0$. □

The lemma 2 establishes that the fully overtreatment could not be a equilibrium. Since fully overtreatment provides no information updating for the consumer about the nature of the problem, the consumer retains his prior belief and his acceptance for price of major treatment is constrained by such belief. As the price for major treatment is too high, the consumer should reject such a offer with probability one[8].

We next direct our attention to mixed strategy equilibrium. Given the price list $\{P_L, P_H\}$ with $P_L - C_L \le P_H - C_H$, we compute the consumer's optimal acceptance strategy λ at stage 3. Upon being recommending major treatment, the consumer would update his belief about the nature of his problem and weigh the price of the treatment and expected valuation from treatment. The expert would recommend major treatment in two situations: one where the consumer's problem is serious; the other where the expert overtreats the consumer with minor problem, and the probability of the two situations is β and $(1-\beta)\rho$, respectively. According to Bayes' rule, the consumer nurture the belief that his problem is minor with probability $\frac{(1-\beta)\rho}{\beta+(1-\beta)\rho}$ and major with probability $\frac{\beta}{\beta+(1-\beta)\rho}$. If the consumer rejects the expert's recommendation, he would receive his reserve utility which is $\bar{U}$, while if he accepts, his expected utility is

$$EU = \frac{(1-\beta)\rho U(V_m - P_H)}{\beta + (1-\beta)\rho} + \frac{\beta U(V_S - P_H)}{\beta + (1-\beta)\rho} \tag{2}$$

Assume that $\hat{\rho}$ be the probability which makes $EU = \bar{U}$, so $\hat{\rho}$ makes the consumer indifferent between accepting and rejecting the expert's recommendation. By simple calculations, $\hat{\rho} = \frac{\beta(U(V_S-P_H)-\bar{U})}{(1-\beta)(\bar{U}-U(V_m-P_H))}$. Given the price list $\{P_L, P_H\}$ with $P_L - C_L \le P_H - C_H$, the consumer should choose his acceptance probability $\lambda = 1$ if $\rho < \hat{\rho}$ and $\lambda = 0$ if $\rho > \hat{\rho}$. And if $\rho = \hat{\rho}$, any $\lambda \in [0, 1]$ is optimal for the consumer.

Backward, we consider the expert's recommendation strategy at stage 2. For the consumer with minor problem, the expert could either prescribe minor or major treatment,i.e. overtreat or not. Given the price list $\{P_L, P_H\}$, if the expert treats the consumer honestly,i.e, prescribe a minor treatment, she could make a profit of $\pi(H) = P_L - C_L$ for sure, while if she overtreats the consumer,i.e, prescribe a unnecessary major treatment, her expected profit is $\pi(F) = \lambda(P_H - C_H)$. So the expert would always overtreats the consumer if $\pi(F) > \pi(H)$ while honestly repair the consumer's problem if $\pi(F) < \pi(H)$, and he is indifferent between overtreatment and honest treatment if $\pi(F) = \pi(H)$.

[8] This argument holds because $\beta U(V_M - C_H) + (1-\beta)U(V_m - C_H) < \bar{U}$ and $P_H \ge C_H$. $P_H \ge C_H$ because the expert lack of the commitment to provide major treatment by make a negative profit.

LEMMA 3 (Partial Overtreatment). *Given the price list $\{P_L, P_H\}$ with $P_L - C_L \leq P_H - C_H$, there exists a equilibrium where*

$$\lambda^* = \frac{P_L - C_L}{P_H - C_H}, \qquad \rho^* = \frac{\beta(U(V_S - P_H) - \bar{U})}{(1-\beta)(\bar{U} - U(V_m - P_H))} \tag{3}$$

and the expert's expected payoff $\pi = (P_L - C_L)$

Proof. 1. Suppose the posted price list satisfies $P_L - C_L \leq P_H - C_H$. Given $r = m$, the expert receives $\pi(H) = P_L - C_L$ by recommending $d = L$ and $\pi(F) = \lambda(P_H - C_H)$ by recommending $d = H$. Given the consumer's strategy, $\pi(H) = \pi(F)$, then $\rho \in [0, 1]$ is optimal.

   Given the expert's strategy, the consumer who decline $d = H$ would retain his reserve utility $\bar{U}$ and accept $d = H$ would receive a utility

$$\begin{aligned} U(d = H, accept) &= \left(\frac{(1-\beta)\rho^* U(V_m - P_H)}{\beta + (1-\beta)\rho^*} + \frac{\beta U(V_S - P_H)}{\beta + (1-\beta)\rho^*} \right) \\ &= \bar{U} = U(d = H, reject). \end{aligned} \tag{4}$$

   Then any $\lambda \in [0, 1]$ is an optimal strategy for the consumer. Therefore, for the given price list, the strategies of the expert and the consumer are mutually best responses.

2. Suppose the strategies in (3) form an equilibrium. For $\lambda \in [0, 1]$, it must hold that $P_H > C_H$ and $P_H - C_H \geq P_L - C_L$. For $\hat{\rho} \in [0, 1]$, it is necessary that $P_H \leq \bar{P}_H^*$.

3. Note that a prescription of $d = H$ is rejected with probability λ. The ex ante payoffs of the expert are

$$\Pi = \beta(P_H - C_H)\frac{P_L - C_L}{P_H - C_H} + (1-\beta)(P_L - C_L) = P_L - C_L \tag{5}$$

□

The lemma 3 shows that there indeed exists a mixed strategy equilibrium in which the consumer's strategy makes the expert indifferent between overtreating and honestly treating, whilst the expert's strategy makes the consumer indifferent between accepting and rejecting major treatment recommendation.

Lastly, we study the optimal pricing strategy for the expert given the optimal strategies of both players in continuation game and the following equilibria could be found.

PROPOSITION 1. *Under the assumption of liability and verifiability, there exists a continuum of equilibria where the expert posts the price list* $\{\bar{P}_L^*, P_H^*\}$ *with* $P_H^* \in [\bar{P}_L^* + C_H - C_L, \bar{P}_H^*]$. *The expert would honestly treat the consumer with major problem while attempt to overtreat the consumer with minor problem with probability* $\frac{\beta(U(V_S - P_H^*) - \bar{U})}{(1-\beta)(\bar{U} - U(V_m - P_H^*))}$ *and honestly treat the consumer with minor problem with probability* $1 - \frac{\beta(U(V_S - P_H^*) - \bar{U})}{(1-\beta)(\bar{U} - U(V_m - P_H^*))}$. *The consumer would accept minor treatment prescription with probability one and major one with* $\frac{\bar{P}_L^* - C_L}{P_H^* - C_H}$.

Proof. In lemma 3, the expert's expected payoff $\pi = (P_L - C_L)$. Obviously, the expert's expected profits are strictly increasing in P_L while constant at P_H. Then the expert should choose the price for minor treatment P_L as large as possible while decide the price for major treatment as long as the consumer would accept.

Since the consumer would accept any price$P_L \leq \bar{P}_L^*$ for minor treatment, thus the optimal price for minor treatment $P_L^* = \bar{P}_L^*$. While for the price of major treatment, $P_L - C_L \leq P_H - C_H$ gives that $P_H^* \geq C_H + P_L - C_L$. Moreover, the highest price that the consumer is willing to pay for his serious problem repaired is $\bar{P}_H^*$, then $P_H^* < \bar{P}_H^*$. In brief, $P_H^* \in [\bar{P}_L^* + C_H - C_L, \bar{P}_H^*]$. Therefore, the optimal price list is $\{\bar{P}_L^*, P_H^*\}$ with $P_H^* \in [\bar{P}_L^* + C_H - C_L, \bar{P}_H^*]$. □

In proposition 1, both the expert and the consumer play mixed strategy and their strategies are mutual best responses. The probability of overtreatment by the expert makes the consumer indifferent between accepting or rejecting the treatment offer, whilst the consumer's acceptance probability equate the expert's profits from overtreamtent and honest treatment. Notice that the expert would still overtreat the consumer with strictly positive probability even when the price margin of the two treatments is equal, which indicates that "equal price margin principle" proposed in Dulleck and Kerschbamer (2006) fail when the consumer is risk-averse. Dulleck and Kerschbamer (2006) also show that the assumption of liability and verifiability can ensure social efficiency but the equilibrium outcome in proposition 1 shows that this prediction fails as well with risk-averse consumer in the market.

Next, we could investigate how the degree of consumer's risk-aversion *ceteris paribus* affects the expert's fraudulent behaviours.

Corollary 1. *Given the price list* $\{\bar{P}_L^*, P_H^*\}$ *with* $P_H^* \in [\bar{P}_L^* + C_H - C_L, \bar{P}_H^*)$ *in the equilibrium*[9]*, the optimal overtreatment probability* ρ^* *decreases with the coefficient of absolute*

[9]Except the case with the price list $\{\bar{P}_L^*, \bar{P}_H^*\}$ because the expert would honestly treat the consumer

risk aversion (CARA). Extremely, when CARA tends toward infinity, $\rho^* = 0$[10].

Proof. Given some price list $\{\bar{P}_L^*, P_H^*\}$ posted by the expert, the optimal probability of overtreatment for the expert

$$\begin{aligned}\rho^* &= \frac{\beta(U(V_S - P_H^*) - \bar{U})}{(1-\beta)(\bar{U} - U(V_m - P_H^*))} = \frac{\beta U(V_S - P_H^*) + (1-\beta)U(V_m - P_H^*) - \bar{U}}{(1-\beta)(\bar{U} - U(V_m - P_H^*))} + 1 \\ &= \frac{U(\beta V_S + (1-\beta)V_m - P_H^* - \gamma) - \bar{U}}{(1-\beta)(\bar{U} - U(V_m - P_H^*))} + 1 \end{aligned} \tag{6}$$

where γ denote the certain equivalence that make $U(\beta V_S + (1-\beta)V_m - P_H^* - \gamma) = \beta U(V_S - P_H^*) + (1-\beta)U(V_m - P_H^*)$.

It is proved that a larger coefficient of absolute risk aversion (CARA) means larger certainty equivalence[11]. It is not hard to notice that ρ^* decreases in γ, and therefore ρ^* decreases with CARA.

For the extreme case, when the coefficient of absolute risk aversion tends toward infinity, the consumer's expected utility function takes a form of maximin[12]. Then given the expert's recommendation for major treatment, the consumer's utility $U(P_H, \mathit{accept}) = \min\{U(V_m - P_H), U(V_S - P_H)\} = U(V_m - P_H))$ if the expert overtreats the consumer with positive probability, while $U(P_H, \mathit{accept}) = U(V_S - P_H)$ if the expert honestly treats. Given our assumption $V_m < C_H$, then the consumer would always reject the expert's offer if the expert overtreats the consumer with any, even extremely small, probability because $U(V_m - P_H) < \bar{U}$ holds for any $P_H \geq C_H$. And the expert's expected profits from the strategy $\pi_1 = (1-\beta)(1-\rho^*)(\bar{P}^* - C_H)$.

On the other hand, if the expert honestly repairs the consumer's problem with $U(V_S - P_H) \leq \bar{U}$ and $P_H > C_H$, the consumer would accept the offer with probability one. Then the expert's expected profits $\pi_2 = (1-\beta)(\bar{P}^* - C_H) + \beta(P_H^* - C_H)$. Obviously, $\pi_2 > \pi_1$ and honest treatment is optimal for the expert. □

This result is quite interesting but intuitive. The expert's overtreatment behaviors impose uncertainties on the consumer. When the consumer becomes more risk-averse, he would obtain less utilities from accepting a major treatment offer and become more likely to reject it. Therefore, a more risk-averse consumer is less tolerant with the expert's

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regardless to the degree of consumer's risk aversion in that case.

[10]the result still holds when the coefficient of absolute risk aversion is replaced by the coefficient of relative risk aversion(CRRA).

[11]See THEROEM 1 in Pratt (1964) for the proof in details.

[12]See the Maximin Criterion in chapter 2(Laffont (1989)).

fraud behaviours, which in turn on the equilibrium discipline the expert and result in less overtreatments. And if the consumer is extremely risk-averse and worries about the worst situation, then his utility function takes a form of max-min, and he would show zero tolerance for the expert's overtreatment behaviours, which would lead zero acceptance probability for major treatment if the expert overtreats the consumer with any, even very small, possibilities. Given the consumer's strategy, the expert would optimally choose not to overtreat the consumer because honestly prescribing major treatment at least brings positive profits whilst cause no decrease of the profits from minor treatment. Therefore, the expert would behave honestly if visited by a extremely risk-averse consumers.

In the next sections, we extend the basic model by entitling the consumer with insurance option.

3 Analysis with Insurance Option

In the previous section, we have shown that the consumer's utility differs in different states on the equilibrium. If the problem is minor, he would obtain the reserve utility $\bar{U}$. If the problem is a major one, the consumer is honestly treated with probability $1-\rho^*$ and receive a utility of $U(V_M - P_H) > \bar{U}$ whilst he is overtreated with probability ρ^* and gain a utility of $U(V_m - P_H) < \bar{U}$. Therefore, the consumer would obtain a expected utility $\rho^* U(V_m - P_H) + (1-\rho^*)\bar{U} < \bar{U}$ in the state of minor problem while $U(V_M - P_H) > \bar{U}$ if his problem is major. Therefore, the consumer is not fully insured by the expert and have an incentive to purchase insurance from a third party.

As the consumer would obtain a utility below the reserve utility in states of minor problem while one above reserve utility with major problem, then the problem being minor is the "bad thing" for the consumer while a major problem is the "good thing". However, since both the insurer and the consumer can not learn exactly whether the consumer's problem is minor or major, the insurance could not be based on the states. But the price list posted by the expert is common knowledge for all, then the insurance can be based on the price list.

In this section, we assume that there exists a perfectly competitive insurance market. After the expert posts the price list, the insurer posts the insurance scheme. The consumer can purchase some insurances before he visits the expert[13]. The insurer pro-

[13]Here we assume that the price list posted by the expert is common knowledge, which can be well justified by the reality. Besides, in our setting, we assume that the consumer must have a problem, being

vides a insurance plan with (k, α), k denote the price of the insurance or the amount of insurance with unit price and α means the compensation to the consumer. The insurer determine the insurance scheme (k, α) after the expert posts the price list. If the consumer is charged with the price for a minor treatment, the insurer should pay a compensation of α to the consumer, while pay nothing if the consumer being charged with the price for major treatment.

Timing of New Game. The game proceeds as follows:

1. The expert posts a price list (P_L, P_H).
2. The insurance company provide a actually fair insurance plan (k, α). The consumer decide to buy k amount of insurance with $k \geq 0$.
3. Nature draws the consumer's type. The consumer visits the expert. The expert performs a diagnosis and prescribes a treatment $d \in \{L, H\}$ for the consumer.
4. The consumer decides whether accept treatment d or not. If $d = m$ and the consumer accepts, the treatment prescribed would be performed by the expert, the consumer receive a compensation of α from the insurer and pay the treatment price to the expert based on the resolution of his problem. If $d = M$ and the consumer accepts, the treatment is performed and the consumer get no compensation and pay the expert if his problem is repaired. The game ends if the consumer rejects expert's offer.

The notation in the previous section will be retained in the following analysis. As before, there exists no equilibrium with single price due to the same argument in Lemma 1. Therefore, only price list should be under our concern. We subdivide the analysis into two cases, one with $P_L - C_L \leq P_H - C_H$ and the other with $P_L - C_L > P_H - C_H$

3.1 $P_L - C_L \leq P_H - C_H$

Firstly, we study the consumer's optimal acceptance strategy at stage 4. Given the price list $\{P_L, P_H\}$ with$P_L - C_L \leq P_H - C_H$ and $\hat{k}$ amount of insurance purchased in previous

minor or major. It can be easily extended to the case with healthy consumer but does not change the essence of the problem under concern.

stage, upon recommended minor treatment, accepting the offer would bring a utility

$$U(d=L, accept) = U(V_m - \hat{k} - P_L + \hat{\alpha}), \tag{7}$$

while rejecting will reserve $\bar{U}$.

On the other hand, the consumer would update his belief about the nature of his problem as before upon recommended a major treatment. The expert would recommend major treatment in two situations: one where the consumer's problem is serious; the other where the expert overtreats the consumer with minor problem, and the probability of the two situations is β and $(1-\beta)\rho$, respectively. According to Bayes' rule, the consumer forms the belief that his problem is minor with probability $\frac{(1-\beta)\rho}{\beta+(1-\beta)\rho}$ and major with probability $\frac{\beta}{\beta+(1-\beta)\rho}$. If the consumer accepts the offer, his expected utility is

$$U(d=H, accept) = \frac{(1-\beta)\rho U(V_m - \hat{k} - P_H)}{\beta + (1-\beta)\rho} + \frac{\beta U(V_S - \hat{k} - P_H)}{\beta + (1-\beta)\rho}, \tag{8}$$

and,again, rejecting will bring $\bar{U}$.

Denote $\hat{\rho}'$ that satisfy $U(d=H, accept) = U(d=H, reject)$,i.e,

$$\frac{(1-\beta)\hat{\rho}' U(V_m - \hat{k} - P_H)}{\beta + (1-\beta)\hat{\rho}'} + \frac{\beta U(V_S - \hat{k} - P_H)}{\beta + (1-\beta)\hat{\rho}'} = \bar{U}, \tag{9}$$

then simple calculations lead to $\hat{\rho}' = \frac{\beta((V_S - \hat{k} - P_H) - \bar{U})}{(1-\beta)(\bar{U} - U(V_m - \hat{k} - P_H))}$. Optimally, the consumer would choose his acceptance probability $\lambda = 1$ if $\rho < \hat{\rho}'$, $\lambda \in [0,1]$ if $\rho = \hat{\rho}'$, and $\lambda = 0$ if $\rho > \hat{\rho}'$.

Backward, the expert's prescription strategy at stage 3 is the same as that in the analysis of previous section.

Lemma 4 (Partial Overtreatment). *Given the price list* $\{P_L, P_H\}$ *with* $P_L - C_L \leq P_H - C_H$ *and* $0 \leq \hat{k} \leq \bar{P}_H^* - P_H$, *there exists a equilibrium where*

$$\lambda_1^* = \frac{P_L - C_L}{P_H - C_H}, \qquad \rho_1^* = \frac{\beta(U(V_S - \hat{k} - P_H) - \bar{U})}{(1-\beta)(\bar{U} - U(V_m - \hat{k} - P_H))} \tag{10}$$

and the expert's expected payoff $\pi_1 = (P_L - C_L)$

Proof. 1. Suppose the posted price list satisfies $P_L - C_L \leq P_H - C_H$. Given $r = m$, the expert receives $\pi(H) = P_L - C_L$ by recommending $d = L$ and $\pi(F) = \lambda_1(P_H - C_H)$ by recommending $d = H$. Given the consumer's strategy, $\pi(H) = \pi(F)$ because

$\theta > 1$, then $\rho \in [0, 1]$ is optimal.

Given the strategies of the expert, declining $d = H$ gets reserve utility $\bar{U}$ while accepting $d = H$ brings a utility

$$U(d = H, accept) = \left(\frac{(1-\beta)\rho_1^* U(V_m - \hat{k} - P_H)}{\beta + (1-\beta)\rho_1^*} + \frac{\beta U(V_S - \hat{k} - P_H)}{\beta + (1-\beta)\rho_1^*} \right)$$
$$= \bar{U} = U(d = H, reject).$$

Then any $\lambda \in [0, 1]$ is an optimal strategy for the consumer. Therefore, for the given price list, the expert's strategy and the consumer's strategy are mutual best responses.

2. Suppose the strategies in (10) form an equilibrium. For $\lambda \in [0, 1]$, it must hold that $P_H > C_H$ and $P_H - C_H \geq P_L - C_L$. For $\rho_1^* \in [0, 1]$, it is necessary that $\hat{k} \leq \bar{P}_H^* - P_H$.

3. Note that a prescription of $d = H$ is rejected with probability λ. The expert's expected payoffs are

$$\Pi_1 = \beta(P_H - C_H)\frac{P_L - C_L}{P_H - C_H} + (1-\beta)(P_L - C_L) = P_L - C_L \tag{11}$$

□

Lemma 5 (Optimal Insurance Choice). *Given the price list* $\{P_L, P_H\}$ *with* $P_L - C_L \leq P_H - C_H$ *and players' strategy in* (10)*, the consumer's optimal insurance choice*

$$k_1^* = \bar{P}_H^* - P_H \tag{12}$$

and then $\rho_1^* = 0$ *under the consumer's optimal insurance choice.*

Proof. In lemma 5, the consumer's expected utility is

$$EU(\hat{k}, P_L, P_H) = \lambda_1^* \left(\beta U(V_S - \hat{k} - P_H) + (1-\beta)\rho_1^* U(V_m - \hat{k} - P_H) \right)$$
$$+ (1 - \lambda_1^*)(\beta + (1-\beta)\rho_1^*)\bar{U} + (1-\beta)(1-\rho_1^*)U(V_m - \hat{k} - P_L + \hat{\alpha})$$
$$= (\beta + (1-\beta)\rho_1^*)\bar{U} + (1-\beta)(1-\rho_1^*)U(V_m - \hat{k} - P_L + \hat{\alpha}) \tag{13}$$

The second equation holds by using definitions of ρ_1^*. As the insurance market is perfectly competitive, zero expected profits condition ensures that,

$$k - (1-\beta)(1-\rho_1^*)\alpha = 0 \tag{14}$$

then $\alpha = \frac{k}{(1-\beta)(1-\rho_1^*)}$.

Therefore, the consumer's maximization program subject to the insurer's zero expected profit is reduced to

$$\begin{aligned} &\arg max \qquad EU(\hat{k}, P_L, P_H) \\ &s.t. \quad \alpha = \frac{k}{(1-\beta)(1-\rho_1^*)}, \quad \rho_1^* = \frac{\beta(U(V_S - \hat{k} - P_H) - \bar{U})}{(1-\beta)(\bar{U} - U(V_m - \hat{k} - P_H))} \end{aligned} \tag{15}$$

Take both $\hat{\alpha}$ and ρ_1^* as a function of $\hat{k}$, denoted as $\hat{\alpha}(\hat{k})$ and $\rho_1^*(\hat{k})$, respectively. Note that $EU(\hat{k}, P_L, P_H)$ is differentiable. By taking partial derivative with respect to $\hat{k}$, we get

$$\frac{\partial EU}{\partial \hat{k}} = (1-\beta)\left(\rho_1^{*'}[\bar{U} - U(V_m - \hat{k} - P_L + \hat{\alpha})] + (1-\rho_1^*)(\hat{\alpha}' - 1)U'(V_m - \hat{k} - P_L + \hat{\alpha})\right) \tag{16}$$

Due to $\bar{U} - U(V_m - \hat{k} - P_L + \hat{\alpha}) < 0$ and $\rho_1^{*'}(\hat{k}) < 0$, then the first term in equation (16) is positive. Moreover, $\hat{\alpha}' - 1 = \frac{1-\rho_1^* + k\rho_1^*}{(1-\beta)(1-\rho_1^*)} - 1 > 0$ and $U'(\cdot) > 0$, the second term is also positive. Therefore, $\frac{\partial EU}{\partial \hat{k}} > 0$. So the consumer's expected utility is strictly increasing in the amount of insurance $\hat{k}$ purchased. Since $0 \leq \hat{k} \leq \bar{P}_H^* - P_H$, the optimal amount of insurance $k_1^* = \bar{P}_H^* - P_H$. □

Lemma 6 (Pricing Strategy). *Given the price list $\{P_L, P_H\}$ with $P_L - C_L \leq P_H - C_H$ and players' strategies in lemma 4 and 5, the optimal price list for the expert $\{P_L^*, P_H^*\}$ is*

$$P_L^* = \beta\bar{P}_H^* + (1-\beta)\bar{P}_L^* - \beta(C_H - C_L), \qquad P_H^* = \beta\bar{P}_H^* + (1-\beta)\bar{P}_L^* + (1-\beta)(C_H - C_L) \tag{17}$$

and $\lambda_1^* = 1$ and the expert's maximal profit $\pi^* = \beta\bar{P}_H^* + (1-\beta)\bar{P}_L^* - \beta C_H - (1-\beta)C_L$ under the price list.

Proof. We study the optimal pricing strategy for the price list $\{P_L, P_H\}$ with $P_L - C_L \leq P_H - C_H$, the expert's profit $\pi = P_L - C_L$, which is strictly monotonically increasing in P_L while invariant to P_H.

To ensure that the consumer accepts minor treatment prescription, $U(d = m, accept) = U(V_m - k^* + \alpha^* - P_L) \geq U(d = m, reject) = \bar{U}$. Then the optimal P_L should make that

$U(V_m - k^* + \alpha^* - P_L^*) = \bar{U}$. Recall that $U(V_m - \bar{P}_L^*) = \bar{U}$, then $U(V_m - k^* + \alpha^* - P_L^*) = U(V_m - \bar{P}_L^*)$. It follows that $P_L^* + k^* - \alpha^* = \bar{P}_L^*$. Given k_1^* chosen by the consumer, the expert's optimal overtreatment strategy in lemma 4

$$\rho_1^* = \frac{\beta(U(V_S - k^* - P_H) - \bar{U})}{(1-\beta)(\bar{U} - U(V_m - \hat{k} - P_H))} = \frac{\beta(U(V_S - \bar{P}_H^*) - \bar{U})}{(1-\beta)(\bar{U} - U(V_m - \hat{k} - P_H))} = 0 \tag{18}$$

It follows that $\alpha_1^* = \frac{\bar{P}_H^* - P_H}{(1-\beta)(1-\rho_1^*)} = \frac{\bar{P}_H^* - P_H}{(1-\beta)}$. Plugging $k^* = \bar{P}_H^* - P_H$ and $\alpha^* = \frac{\bar{P}_H^* - P_H}{(1-\beta)}$,

$$P_L^* = \bar{P}_L^* + \frac{\beta}{1-\beta}(\bar{P}_H^* - P_H). \tag{19}$$

Furthermore, $P_L^* - C_L \leq P_H^* - C_H$. To maximize P_L, P_H^* should take the lower bound, and $P_H^* = P_L^* + C_H - C_L$. Substituting P_H^* into equation 19, then $P_L^* = \beta\bar{P}_H^* + (1-\beta)\bar{P}_L^* - \beta(C_H - C_L)$ and $P_H^* = \beta\bar{P}_H^* + (1-\beta)\bar{P}_L^* + (1-\beta)(C_H - C_L)$.

Given the optimal price list, $\lambda^* = \frac{P_L^* - C_L}{P_H^* - C_H} = 1$. The expert's maximal profits $\pi^* = P_L^* - C_L = \beta\bar{P}_H^* + (1-\beta)\bar{P}_L^* - (\beta C_H + (1-\beta)C_L)$.

□

3.2 $P_L - C_L > P_H - C_H$

LEMMA 7 (Efficient Outcome). *Given the price list $\{P_L, P_H\}$ with $P_L - C_L > P_H - C_H$, there exists a equilibrium where*

$$\lambda_2^* = 1, \qquad \rho_2^* = 0, \tag{20}$$

and the expert's expected payoff $\pi_2 = (1-\beta)(P_L - C_L) + \beta(P_H - C_H)$.

Proof. 1. Suppose the posted price list satisfies $P_L - C_L > P_H - C_H$. since overtreatment is not profitable for the expert, then honest treatment is optimal for the expert,i.e, $\rho_2^* = 0$.

   Given that the expert always honestly offer the treatment, the consumer would always accept the offer, i.e, $\lambda_2^* = 1$.

   Therefore, under the given price list, the expert's strategy and the consumer's s-trategy are mutual best responses.

2. Suppose the strategies in (3) form an equilibrium. For $\lambda = 1$, it must hold that $P_L \leq \bar{P}_L^* + \hat{\alpha} - \hat{k}$ and $P_H \leq \bar{P}_H^*$. For $\rho = 0$, it is necessary that $P_L - C_L > P_H - C_H$.

3. Since the consumer would always accept the recommendation, the expert's expected payoffs are

$$\Pi_2 = \beta(P_H - C_H) + (1-\beta)(P_L - C_L) \tag{21}$$

□

Lemma 8 (Optimal Insurance Choice). *Given the price list $\{P_L, P_H\}$ with $P_L - C_L > P_H - C_H$ and players' strategy in (20), the optimal insurance choice for the consumer*

$$k_2^* = (1-\beta)(V_S - V_m + P_L - P_H) \tag{22}$$

Proof. In lemma 8, the consumer's expected utility is

$$EU = \beta U(V_S - \hat{k} - P_H) + (1-\beta)U(V_m - \hat{k} - P_L + \hat{\alpha}) \tag{23}$$

As the previous case, given the expert's optimal overtreatment probability ρ_2^* on the equilibrium path, zero expected profit in competitive equilibrium would ensure that

$$k = (1-\beta)(1-\rho_2^*)\alpha. \tag{24}$$

therefore $\alpha = \frac{k}{(1-\beta)(1-\rho_2^*)} = \frac{k}{1-\beta}$. Optimally, the consumer maximize his expected utility subject to the insurer's zero expected profits constraint. As the insurance is actually fair, the consumer would fully insure for the risk. Then the consumer's optimal insurance choice is given by

$$V_S - k_2^* - P_H = V_m - k_2^* - P_L + \alpha_2^* \tag{25}$$

Solving k_2^* by combining this condition and equation (24), $k_2^* = (1-\beta)(V_S - V_m + P_L - P_H)$ and $\alpha_2^* = V_S - V_m + P_L - P_H$. □

Lemma 9 (Pricing Strategy). *Given the optimal strategy of both consumer and expert in lemma 7 and 8, the expert's optimal pricing strategy $\{P_L^*, P_H^*\}$ should satisfy*

$$\beta P_H^* + (1-\beta)P_L^* = \beta \bar{P}_H^* + (1-\beta)\bar{P}_L^*, \qquad P_L^* - C_L > P_H^* - C_H \tag{26}$$

and the expert's maximal profit $\pi_2^* = \beta \bar{P}_H^* + (1-\beta)\bar{P}_L^* - \beta C_H - (1-\beta)C_L$.

Proof. The expert's profits $\pi_2 = \beta P_H + (1-\beta)P_L - \beta C_H - (1-\beta)C_L$, which are strictly increasing in both P_L and P_H. Then the pricing strategy should make the consumer indifferent between accepting and rejecting the recommendation and leave no rents for the consumer, which gives rise to

$$P_L = \alpha_2^* - k_2^* + \bar{P}_L^* \qquad\qquad P_H = \bar{P}_H^* - k_2^* \tag{27}$$

Plugging k_2^* and α_2^* into the equations, we get $\beta P_H + (1-\beta)P_L = \beta\bar{P}_H^* + (1-\beta)\bar{P}_L^*$. Essentially, the two conditions in equation 27 are the same. Since the consumer would always purchase fully insurance, the consumer would retain the same utility in both states and the difference of utility between the two states under the price list would be cancelled out by insurance. Also, the optimal price list should meet the precondition, that is, $P_L^* - C_L > P_H^* - C_H$. The expert's profit follows. □

PROPOSITION 2. *Under the assumption of liability and verifiability, there exists two sets of equilibria where*

1. *the expert post a price list* $\{P_L^*, P_H^*\}$ *with* $P_L^* = \beta\bar{P}_H^* + (1-\beta)\bar{P}_L^* - \beta(C_H - C_L)$, $P_H^* = \beta\bar{P}_H^* + (1-\beta)\bar{P}_L^* + (1-\beta)(C_H - C_L)$, *and the consumer purchase a mount of insurance* $k_1^* = (1-\beta)(\bar{P}_H^* - \bar{P}_L^* - C_H + C_L)$.
2. *the expert posts the price list* $\{P_L^*, P_H^*\}$ *with* $\beta P_H^* + (1-\beta)P_L^* = \beta\bar{P}_H^* + (1-\beta)\bar{P}_L^*$ *and* $P_L^* - C_L > P_H^* - C_H$, *the consumer would purchase a mount of insurance* $k_2^* = (1-\beta)(V_S - V_m + P_L - P_H)$.

In both sets of equilibria, the expert would honestly treat the consumer in both states, and the consumer would accept both minor and major treatment with probability one.

Proof. Comparing the expert's payoffs in lemma 6 and 9, the expert would achieve the same maximal amount of profits, which is $\beta\bar{P}_H^* + (1-\beta)\bar{P}_L^* - \beta C_H - (1-\beta)C_L$. Furthermore, the expert would always honestly treat the consumer and the consumer always accept the expert's offer,i.e, $\lambda_1^* = \lambda_2^* = 1$ and $\rho_1^* = \rho_2^* = 0$. Therefore, both optimal pricing strategies in lemma 6 and 9 with corresponding optimal strategy in the continuation game form a equilibrium of the game. And the social efficiency could be achieved, the expert would obtain all the social surplus from the transaction. □

From the proposition 2, we show that the social efficiency could be achieved under both situations when the consumer could buy insurance in a competitive insurance market. The expert's profits is maximized and the consumer's problem is resolved with probability one. The logic behind the preferable result is that the consumer would fully insure himself in a competitive market, and then the consumer could always adjust his utility between the two treatment recommendation. Essentially, the consumer now have only one states and one utility under whatever the expert recommendation. Then anticipating that the consumer would buy full insurance, the expert would post the price list that make the consumer in the state indifferent between accepting or rejecting his recommendation, repair the consumer's problem honestly and grab all surplus at the same time. Therefore, the equilibrium ends up with the social efficiency outcome.

Without insurance option, the consumer could not cross-subsides himself under minor treatment and major treatment, then his decision under minor treatment and major treatment is separated, and he would only accept the recommendation with expected utility no lower than his reserve utility under each separate case. While with insurance option, the consumer could align the two choice into one and save in the good situation for case of the "bad thing" happening, which induce the consumer not restricted within acceptance strategy with respect to the expert's recommendation. the consumer could accept a treatment with expected utility lower than reserve utility and then receive compensation from the insurance company.

When the price list gives rise to more profits from major treatment than minor treatment, corresponding to first case in the proposition, the expert's profits equal to the price margin from minor treatment due to the consumer's optimal acceptance probability on the equilibrium. Then, the expert would charge as much as possible for minor treatment. If the consumer purchase no insurance, the price for minor treatment maximizes at the price that leave the consumer with reserve utility after having minor problem repaired. While now the consumer could buy insurance and he would purchase as much amount insurance as he can because the insurance could not only alleviate the risk he face but also mitigate the expert's fraud problem. So the consumer now could receive compensation from the insurance company when he accept minor treatment, then the price for minor treatment could be bigger and maximize at the price which makes the consumer indifferent between accepting or rejecting the offer with minor problem resolved and receiving the compensation from the insurance company. Then the expert's optimal price for minor treatment is that price. But, the amount of insurance the consumer could purchase in insurance market is constrained by the residuals from having his problem repaired with major treatment and paying the price for major treatment. In other word, the money that the consumer could save for the "bad thing" is restricted by the money that he left when the "good thing" happens. Therefore, the expert could use the insurance that the consumer purchase as the tool that grab the surplus from major treatment by minor treatment. Since the consumer would fully insurance himself, then the consumer put aside all his surplus from having major problem repaired for minor treatment. As the compensation is based on the price paid, then the consumer could not get compensation even when he is overtreatment, but at same time he has already used all the surplus from having major problem repaired to purchase insurance, and then the consumer has no tolerance of overtreatment. The results follows.

As to the second case in the proposition, the argument is similar. The insurance acts as the tunnel by which the expert could transit the surplus from major treatment to minor treatment, and then the expert captures all the surplus with only minor treatment. Since now all the surplus goes to the expert's pocket, the expert's incentive is aligned with social efficiency and he would post the price list and prescribe to ensure that the consumer always accepts the treatment. Therefore, social efficiency could be realised.

4 Discussions and Conclusions

In the previous sections, we assume that $\beta U(V_S-C_H)+(1-\beta)U(V_m-C_H) < \bar{U}$, then fully overtreatment is not possible in the equilibrium. While if $\beta U(V_S - C_H) + (1-\beta)U(V_m - C_H) \geq \bar{U}$, the expert could post a single price $\bar{P} > C_H$ to provide fully insurance for the consumer. Specifically, assume that the expert post a single price $\bar{P} > C_H$, the expert would repair consumer's problem, either minor or major, under the single price. The optimal single price could be set such that $\beta U(V_S - \bar{P}^*) + (1-\beta)U(V_m - \bar{P}^*) = U(\beta V_S + (1-\beta)V_m - \bar{P}^* - \gamma) = \bar{U}$, with γ being the certainty equivalence. Then $\bar{P}^* = \beta V_S + (1-\beta)V_m - \gamma$. Under the optimal single price, the consumer would always accept the expert's recommendation and the expert's profits are maximized as the transaction could be reached with probability one and all surplus from the transaction is captured by the expert.

Therefore, cutting down the expert's cost of treatment or improving the expert's productivity of treatment to some threshold could avoid the social inefficiency induced by the risk-aversion of consumer when the assumptions of both liability and verifiability hold. However, the expert's cost may differ from each other, some experts are efficient enough while others may be not[14]. Furthermore, there always exists some treatments that the

[14]We study the impact of expert's private information about its treatment cost on the market perfor-

expert is not efficient enough and then the expert can not provide fully insurance for the consumer. Thus, the situation under concern in this paper is pretty general.

Conclusion In this paper, we study the impact of consumer's risk-aversion on the expert's incentive for overtreatment and the efficiency of credence goods market when both liability and verifiability holds in the basic model. Then, we extend the model by introducing a competitive insurance company, and investigate the consumer's optimal insurance choices and its effect on the expert's fraud behaviour and social welfare on the equilibrium.

In the basic model, we show that the consumer's risk aversion would induce expert's overtreatment behaviours and thus lead to social inefficiency even when both liability and verifiability holds. But the frequency of overtreatment by the expert decreases with the degree of consumer's risk-aversion or the coefficient of absolute risk aversion. When the consumer is extremely risk-averse and the consumer's utility function takes a form of max-min, the expert would always honestly treat the consumer and the market is socially efficient.

In the extensive model with a competitive insurance company, we show that the expert would always behave honestly and social efficiency can always be achieved. Two sets of equilibrium outcomes divided by expert's pricing strategy could be specified. When the expert posts a price list with price margin from major treatment being larger than that from minor treatment, the expert's equilibrium profits equal to the price margin from minor treatment and the consumer would purchase as much insurance as possible. Interestingly, the expert could grab all the social surplus facilitated by the insurance purchased by the consumer, acting as the tunnel that transports the consumer's surplus from major problem repaired to minor treatment. Optimally, the consumer's insurance choice would make the expert honestly treat his problem, and in turn the expert post a optimal price list to capture all the social surplus, and the social efficiency is implemented in the equilibrium.

The other equilibrium outcome relates to the situation where the experts posts a price list with profits from major treatment being smaller than that of minor treatment. Under such a price list, the expert credibly commits to honestly repair consumer's problem, and then the consumer would purchase full insurance and ends up with the same utility level no matter which type his problem may be. Again, the insurance is a surplus-grabbing

mance in another paper.

device. Since the consumer would always purchase full insurance, then obtaining all the surplus in one situation(e.x.minor problem) means getting all the surplus in these two situation. Therefore, the expert only need post a price list that make the consumer with minor problem is indifferent between accepting and rejecting the treatment offer, and then obtains all possible surplus. More importantly, the expert indeed has the incentive to post such a price list as a honesty signal because all possible surplus could be captured under the price list.

Nevertheless, the results is based on some assumptions. In the model, we assume that the insurance market is completely competitive, and then the insurance is actually fair. We anticipate that the market may be not socially efficient any more if the insurance company have some monopoly power. Intuitively, the consumer would not purchase full insurance even in the second set of equilibrium outcome above and he would be under-insured. Although the insurance could still acts as tunnel for the experts, there exists loss of surplus in the transportation since the insurance company would obtain some consumer's surplus. Depending on the share captured by the insurance company, committing to honestly treatment may be not optimal for the expert and the equilibrium outcome is uncertain.

On the other hand, the consumer may be heterogeneous with respect to risk-aversion. Our basic model have show that the expert's probability of overtreatment decreases with the degree of consumer's risk-aversion. With consumer's risk-heterogeneity, the less risk-averse consumer would have the incentive to pretend to be more risk-averse. This may give rise to screening problem for the expert. While if the insurance company is in position, then risk-heterogeneity may also bring about selection problem for the insurance company. And it might be interesting to study the fraud problem of expert mingled with the selection problem. All these problems are interesting while remains unanswered in the literature, which point out the direction for future researches.

References

BESTER, H., AND M. DAHM (2014): "Credence Goods, Costly Diagnosis, and Subjective Evaluation," *Mimeo*, Free University Berlin.

DARBY, M., AND E. KARNI (1973): "Free Competition and the Optimal Amount of Fraud," *Journal of Law and Economics*, 16, 67–88.

DULLECK, U., AND R. KERSCHBAMER (2006): "On Doctors, Mechanics, and Computer Specialists: The Economics of Credence Goods," *Journal of Economic Literature*, XLIV, 5–42.

EMONS, W. (1997): "Credence Goods and Fraudulent Experts," *Rand Journal of Economics*, 28, 107–19.

LAFFONT, J.-J. (1989): *The Economics of Uncertainty and Information.* The MIT Press, Translated by John P.Bonin and Hlne Bonin.

PATTERSON, G. (1992): "Sears' Brennan Accepts Blame for Auto Flap," *Wall Street Journal*, p. B1 and B14.

PESENDORFER, W., AND A. WOLINSKY (2003): "Second Opnions and Price Competition: Inefficiency in the Market for Expert Advice," *Review of Economic Studies*, 70, 417–437.

PRATT, J. W. (1964): "Risk Aversion in the Small and in the Large," *Econometrica*, 32(1/2), 122–136.