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Abstract

Undertreatment, i.e., providing a minor treatment for a serious problem, may provide a partial benefit or may further worsen the actual condition. This paper studies the implications of undertreatment on a credence goods expert's pricing and treatment strategies and on the social welfare under two different liability regimes: strict liability rule and no liability rule. We characterize conditions under which a no liability rule is more socially efficient compared to a strict liability rule. When an expert's diagnosis is accurate, a no liability rule is efficient compared to a strict liability rule unless the cost of serious treatment is relatively low or there is sufficient loss from undertreatment. Consequently, if undertreatment increases the loss from the serious problem, the strict liability rule results in higher social welfare than the no liability rule. In the presence of diagnosis errors, the strict liability rule leads to no trade, and the no liability rule is more efficient than the strict liability rule when the probability of the serious problem is low. This holds irrespective of whether undertreatment results in benefit or harm to the serious problem.

Keywords: Credence Goods; Undertreatment; Diagnosis Error; Liability Rule; Social Welfare

JEL Code: D40, D80, D82, D83, L10

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1 Introduction

Credence goods markets are characterized by information asymmetry, where sellers, often referred to as experts, possess better knowledge about the consumers' needs than the consumers themselves. Even after receiving a service, consumers typically cannot verify whether the treatment provided was appropriate. This paper examines the consequences of undertreatment—where a minor treatment is given for a serious problem—under two legal regimes: a strict liability rule and a no liability rule. While much of the existing literature (for example, Wolinsky (1993); Fong (2005); Liu (2011); Fong and Liu (2018)) assumes that such undertreatment leaves the consumer's condition unchanged-neither improved nor worsened-empirical evidence from sectors like healthcare suggests otherwise[1]. Undertreatment may sometimes lead to partial improvement or, in some cases, exacerbate the underlying condition. We extend the standard framework to capture both of these outcomes by allowing undertreatment to either reduce or increase the consumer's loss.

Existing theoretical literature (for example, Fong (2005); Liu (2011); Fong et al. (2024); Ogawa (2024)) has primarily focused on the case of perfect diagnosis by an expert. However, there exist several instances of diagnosis errors in credence goods markets such as healthcare [2]or mechanic markets[3] where serious problems can be diagnosed as minor ones or vice versa. In our analysis, we consider two distinct diagnostic settings: one with perfect diagnosis, as assumed in most of the existing literature (e.g., Pitchik and Schotter (1987); Emons (2001); Fong (2005); Fong et al. (2014, 2022); Wu and Tsai (2025)), and another with diagnosis errors, where the expert may misclassify a serious problem as minor or a minor problem as serious with certain probabilities. We mention here that Wolinsky (1993) introduces diagnosis error in an extension of their model, but restricts the error probabilities below 50% and limits their study to the strict liability regime. Unlike Wolinsky (1993), we do not impose any such restriction on the error probabilities, keeping our model more general. Further, we also allow for both the strict liability and no liability regimes. As in Fong and Liu (2018), we also consider that under the strict liability rule, the expert is held accountable for completely treating the consumer's problem if the consumer accepts his recommendation. On the other hand, under the no liability rule, the expert must deliver a service upon acceptance but bears no responsibility for treating the consumer's problem.

[1]See Kearney et al. (2017) for effects of suboptimal care on patients in healthcare market.

[2]See WebM&M Case Studies by US Patient Safety Network (https://psnet.ahrq.gov/webmm-case-studies) for various such cases.

[3]See the thread "Diagnosis errors by mechanics & service centres" by Team BHP (https://www.team-bhp.com/forum/technical-stuff/189467-diagnosis-errors-mechanics-service-centres-share-your-stories-here-2.html) that reports several such cases in India.

This paper yields two key insights that contrast with the existing literature. Under the standard assumption of perfect diagnosis and no implication of undertreatment, Fong and Liu (2018) show that trade takes place in a static setting under both the strict liability and no liability rules. In contrast, in the presence of diagnosis errors, we show that the strict liability rule leads to a complete breakdown of trade[4], while no liability rule still permits trade when the likelihood of a serious condition is low. Secondly, our result demonstrates that when diagnosis is perfect, a no liability rule can outperform a strict liability rule in terms of efficiency, especially when serious treatment is costly and undertreatment brings some partial benefit to the serious problem, resulting in sufficiently less amount of loss. In the presence of diagnosis errors, the no liability rule is more efficient compared to the strict liability rule when the probability of occurrence of the serious problem is sufficiently low. When the likelihood of the serious problem is relatively higher, both the liability rules result in equal amount of social loss.

The rest of the paper is organized as follows. Section 2 demonstrates the model. Section 3 presents the equilibrium analysis under perfect diagnosis for the two liability regimes, i.e., strict liability and no liability. Section 4 investigates the equilibrium analysis under diagnosis errors for the strict and no liability regimes. Section 5 concludes the paper.

2 Model

Consider a risk-neutral expert and a risk-neutral consumer who interact with each other. The consumer faces a problem that is either serious ($i = s$) or minor ($i = m$). While the consumer is unaware of the true nature of her problem, common knowledge is that the problem is serious with probability α and minor with probability $1-\alpha$, where $\alpha \in (0, 1)$. If the problem $i \in \{m, s\}$ remains unresolved, the consumer incurs a loss of $l_i > 0$, where $0 < l_m < l_s$.

The expert performs a costless diagnosis to assess the nature of the consumer's problem and subsequently, provide a costly treatment that can be either minor ($t = m$) or serious ($t = s$). The cost of treatment $i \in \{m, s\}$ is c_i , with $0 < c_m < c_s$. A minor (respectively, serious) treatment fully recovers the loss from a minor (respectively, serious) problem.

We assume that undertreatment, i.e., providing the minor treatment for the serious problem, results in a net loss of $L = l_s - kl_m \geq l_s - l_m$, where $k \leq 1$ is common knowledge. Here, $0 < k \leq 1$ represents scenarios where the minor treatment offers partial recovery from the serious problem, reducing the total loss from l_s. Note that the maximum recovery possible by the minor treatment is l_m. $k < 0$ captures the scenario where the minor treatment for a serious

[4]According to Fong (2005), trade always takes place under a strict liability rule in a static environment with perfect diagnosis and no implication of undertreatment.

problem worsens the condition, increasing the loss beyond the original l_s. The case of $k = 0$ corresponds to the standard models in the literature, where undertreatment leaves the serious problem unchanged, neither improving nor worsening the serious condition.

When the consumer's problem $i \in \{m, s\}$ remains unresolved, her utility is $-l_i$, and when the problem is completely treated for a price p, she gets a utility of $-p$. However, if she has the serious problem but is given the minor treatment for a price p, her utility is $-p - L$.

We assume that it is cost-efficient to treat both the problems completely, i.e., $c_i < l_i$ for $i \in \{m, s\}$. Further, in line with the existing literature (for example, Liu (2011), Fong and Liu (2018)), we assume that the prior expected loss $E(l) = \alpha l_s + (1 - \alpha) l_m < c_s$[5].

Following Fong and Liu (2018), we consider the following two liability regimes:

Strict Liability: The expert bears full responsibility for resolving the consumer's problem upon acceptance of the recommended treatment. Failure to treat the consumer completely results in an infinite penalty ($-\infty$ payoff) for the expert.

No Liability: The expert needs to provide some treatment, but there is no restriction on the treatment he provides when the consumer accepts his recommendation, i.e., he is not held accountable for the undertreatment. Failure to resolve the problem does not affect the expert's payoff.

We distinguish the following two scenarios of the expert's diagnosis to assess and compare the implications of the liability rules under each of them:

No Diagnosis Error: When the expert can accurately diagnose the consumer's problem.

Diagnosis Error: When the expert's diagnosis (d) can be subject to error. Although the diagnosis outcome remains the expert's private information, it is common knowledge that the diagnosis error follows the following conditional distribution:

$$Pr(d = m | i = s) = e_s, \text{ and } Pr(d = s | i = s) = 1 - e_s,$$
$$Pr(d = s | i = m) = e_m, \text{ and } Pr(d = m | i = m) = 1 - e_m,$$

with $0 < e_m, e_s < 1$. Here, e_s (respectively, e_m) denotes the probability that the serious (respectively, minor) problem is misdiagnosed as the minor (respectively, serious) one, i.e., "$i = s$ but $d = m$" (respectively, "$i = m$ but $d = s$").

The timeline of events is as follows:

[5]For $E(l) \geq c_s$, a trivial equilibrium exists where the expert can charge a price $E(l)$ for both the treatments.

- Stage 1: Nature determines the type of the consumer's problem, $i \in \{m, s\}$, and the probability α.
- Stage 2: Expert posts a price list (p_m, p_s), with $p_m \leq p_s$; where p_i is the price charged for recommending treatment $i \in \{m, s\}$.
- Stage 3: The consumer visits the expert, and the expert performs the diagnosis. The diagnosis result is only known to the expert. The expert either refuses to treat the consumer or offers treatment at a price $p_i \in \{p_m, p_s\}$.
- Stage 4: The consumer forms beliefs over the nature of her problem depending upon the expert's recommendation, and decides to accept or reject the treatment offer. If accepted, she pays the recommended price.
- Stage 5: If the consumer accepts his recommendation, the expert decides which treatment $(t \in \{m, s\})$ to perform.

We use the solution concept of *Perfect Bayesian Equilibrium*(PBE). The expert's strategy consists of posting a price list (p_m, p_s); a recommendation strategy $\{\rho_d, \beta_d, 1-\beta_d-\rho_d\}$, where ρ_d is the probability that the expert refuses to treat the consumer given the diagnosis $d \in \{m, s\}$, and β_d is the probability that the expert recommends serious treatment given the diagnosis d; a treatment strategy $\{\tau_{rd}, 1-\tau_{rd}\}$ given the diagnosis $d \in \{m, s\}$ and recommendation $r \in \{m, s\}$, where τ_{rd} is the probability that the expert provides serious treatment given the diagnosis d and recommendation r. The consumer's strategy consists of her acceptance probability $\{\gamma_r\}$ given the expert's recommendation $r \in \{m, s\}$.

3 Analysis: No Diagnosis Error

3.1 Strict Liability

It is intuitive that under the rule of strict liability, the expert always provides the true treatment needed by the consumer. Deviating from this would be suboptimal: undertreatment of a serious problem would expose the expert to a large negative payoff, while serious treatment for a minor problem would result in unnecessarily high costs. Given this, and knowing the liability regime in place, the consumer can correctly anticipate that her problem will be fully resolved if she accepts the treatment. Consequently, the assumption regarding the possibility of undertreatment for serious problem does not affect the consumer's expected payoff. Therefore, the "no-cheating" equilibrium result established by Fong (2005) holds regardless of whether undertreatment impacts the actual loss or not. We restate this result below[6].

Proposition 1 (Fong, 2005). *Suppose the expert's diagnosis is accurate. Under the rule of strict liability, the expert posts a price list* $(p_m, p_s) = (l_m, l_s)$. *He always gives honest recommendation for the treatment, i.e.,* $\beta_m = 0, \beta_s = 1$, *and never refuses to treat, i.e.,* $\rho_m = 0 = \rho_s$. *The consumer accepts the minor treatment recommendation at price* p_m *with probability* $\gamma_m = 1$, *and the serious treatment recommendation at price* p_s *with probability* $\gamma_s = \frac{p_m - c_m}{p_s - c_m}$. *The maximum profit the expert earns is* $\pi_L^{max} = \alpha(l_s - c_s)\frac{l_m - c_m}{l_s - c_m} + (1-\alpha)(l_m - c_m)$.

3.2 No Liability

When the expert is not liable to solve the consumer's problem, he always provides the low-cost minor treatment if the consumer accepts his recommendation[7]. Since the consumer is aware of the no liability rule in place, she correctly anticipates this. A minor treatment completely recovers the consumer's loss if she has a minor problem (which is with probability $1-\alpha$), but causes a loss of $L = l_s - kl_m$ if she has a serious problem (which is with probability α). As a result, the consumer's expected utility on accepting the minor treatment for price p is $-\alpha L - p = -\alpha(l_s - kl_m) - p$, and the expected utility on rejecting it is $-E(l) = -(1-\alpha)l_m - \alpha l_s$. Clearly, the consumer's maximum willingness to pay is $E(l) - \alpha L = (1 - \alpha + \alpha k)l_m$. Since the expert's cost of treatment is c_m, the feasible price range is $[c_m, (1-\alpha+\alpha k)l_m]$ and trade occurs iff $0 < c_m \leq (1-\alpha+\alpha k)l_m \implies \alpha \leq \frac{l_m - c_m}{(1-k)l_m}$(for $k < 1$). For $k = 1$, we have $c_m < (1-\alpha+\alpha k)l_m = l_m$ and trade certainly occurs. Therefore, the following proposition follows immediately.

Proposition 2. *Suppose the expert's diagnosis is accurate and the no liability rule is in order. Providing minor treatment for the serious problem results in a loss* $L = l_s - kl_m$ *where* $k \leq 1$. *When (i)* $k = 1$ *or, (ii)* $(k < 1; \alpha \leq \frac{l_m - c_m}{(1-k)l_m})$, *there are pooling equilibria in which a single price* $p \in [c_m, (1-\alpha+\alpha k)l_m]$ *is charged by the expert for any type of problem. The expert doesn't refuse to treat the consumer, i.e.,* $\rho_d = 0$ *and* $\beta_d, 1 - \beta_d \in [0,1]$ *for* $d \in \{m, s\}$ *and always provides the minor treatment. The consumer always accepts the treatment recommendation, i.e.,* $\gamma_m = \gamma_s = 1$. *The expert's maximum possible profit is* $\pi_{NL}^{max} = (1-\alpha+\alpha k)l_m - c_m$. *For* $(k < 1; \alpha > \frac{l_m - c_m}{(1-k)l_m})$, *there is no trade.*

[6]See Fong (2005) for the proof and detailed explanation.

[7]Note that, following the literature (Fong and Liu (2018), Fong et al. (2014)), here we don't allow the case where the expert can get away with providing no treatment at all even after the consumers accepts the price he offers. Because in that case, the consumer will correctly anticipate that the expert will provide no treatment and hence there will be no trade, resulting in zero profit for the expert. Therefore, once the consumer accepts the price offered by the expert, the expert provides some treatment if he can make a profitable trade.

Note that Proposition 2 closely parallels Proposition 2 in the no-liability analysis of Fong and Liu (2018). Depending on the sign of k, the maximum feasible price in our setting, given by $(1-\alpha+\alpha k)l_m$, may be higher or lower than the corresponding maximum price $(1-\alpha)l_m$ in the no liability analysis of Fong and Liu (2018). This is fairly intuitive since for $k > 0$, undertreatment yields partial benefit, increasing the consumer's willingness to pay; whereas when $k < 0$, undertreatment worsens the condition, thereby reducing the consumer's willingness to pay.

3.3 Social Welfare

Proposition 3. *Suppose the expert's diagnosis is accurate, and providing minor treatment for the serious problem results in loss $L = l_s - kl_m$. Under the expert's optimal pricing strategy, in equilibrium, the no liability rule is more efficient compared to the strict liability rule if and only if the following two conditions hold: (a) the cost of serious treatment is sufficiently high, i.e., $c_s > c_m \frac{l_s-c_m}{l_m-c_m}$, and (b) undertreatment causes partial benefit to a serious problem, i.e., $k > 0$ and the resulting loss is sufficiently low i.e., $L = l_s - kl_m < c_s \frac{l_m-c_m}{l_s-c_m} - c_m$. In all other cases, the strict liability rule is more efficient compared to the no liability rule.*

Proof: See Appendix.

Under the strict liability rule, the expert always provides the actual treatment needed by the consumer. However, under the no liability rule, the expert always provides the minor treatment regardless of the problem type. Therefore, the expert incurs a higher expected cost under strict liability due to the high expense of serious treatment, c_s; while under no liability, the cost remains lower. However, under no liability, undertreatment of the serious problem imposes a net loss $L = l_s - kl_m$ on the consumer. Therefore, the no liability regime results in lower overall social loss compared to strict liability when the serious-treatment cost c_s is higher and the net loss from undertreatment L is sufficiently low. Note that under the standard setting, where a minor treatment has no implication for a serious problem (i.e., $k = 0$), or when undertreatment causes further harm to the serious condition (i.e., $k < 0$), by the cost-efficiency assumption of the model, we have $L|_{k\leq 0} = l_s - kl_m > l_s > c_s > c_s \frac{l_m-c_m}{l_s-c_m} - c_m$. This implies that in the standard models of the literature (where $k = 0$), a strict liability rule is always more efficient compared to a no liability rule. In our model, the efficiency of the strict liability rule over the no liability rule continues to hold when $k < 0$, i.e., when undertreatment causes further harm to the serious condition. However, when $k > 0$, i.e., when undertreatment for serious problem brings some partial benefit, the no liability rule proves to be more efficient than the strict liability rule unless the resulting net loss is sufficiently high or the serious treatment is relatively cheap. The following corollary immediately follows.

Corollary 1. *Under perfect diagnosis, if undertreatment further worsens the serious condition or leaves it unchanged, the strict liability results in higher social welfare compared to the no liability rule.*

4 Analysis: Diagnosis Error

In this section, we assume that the expert's diagnosis may be erroneous, occurring with known probabilities as outlined in the description of the model.

4.1 Strict Liability

When there are diagnosis errors, under strict liability, the expert always provides a serious treatment to avoid a large negative payoff due to undertreatment. Therefore, the expert has to bear a cost of c_s for the treatment. The consumer correctly anticipates that her problem is going to be completely treated. and hence her maximum willingness to pay is $E(l)$. However, by our assumption $E(l) < c_s$. Therefore, there is no feasible price that is profitable for the expert as well as acceptable by the consumer, resulting in no trade. The following proposition is immediate.

Proposition 4. *Suppose there are probable nonzero diagnosis errors for either type of problem (i.e., $0 < e_s, e_m < 1$). Under the strict liability rule, there is no trade in equilibrium.*

4.2 No Liability

Under the no liability rule, the expert provides the minor treatment for any diagnosis outcome. Therefore, the consumer's maximum willingness to pay remains the same as in the case no diagnosis error in section 3.2. The subsequent equilibrium also remains the same, and Proposition 2 continues to hold in this case.

4.3 Social Welfare

Proposition 5. *Suppose there are probable nonzero diagnosis errors for either type of problem (i.e., $0 < e_s, e_m < 1$), and providing minor treatment for the serious problem results in loss $L = l_s - kl_m$. Under the expert's optimal pricing strategy in equilibrium, for $\alpha \leq \frac{l_m - c_m}{(1-k)l_m}$, the no liability rule is more efficient compared to the strict liability rule. For $\alpha > \frac{l_m - c_m}{(1-k)l_m}$, both the liability rules result in equal amount of social loss.*

Proof: See Appendix.

When there are possible diagnosis errors, there is no trade in case of a strict liability rule and hence the consumer's problem remains unresolved. Under the no liability rule, trade doesn't occur for $\alpha > \frac{l_m - c_m}{(1-k)l_m}$. Therefore, the social loss is equal to the prior expected loss to the consumers under both of these liability rules. However, for $\alpha \leq \frac{l_m - c_m}{(1-k)l_m}$, trade occurs under a no liability rule and the expert always provides minor treatment. Therefore, the consumer's minor problem recovers, and the no liability rule results in lower social loss than the strict liability. It is easy to note that the above proposition holds irrespective of whether $k \leq 0$ or $k > 0$.

Corollary 2. *When there are diagnosis errors, irrespective of whether undertreatment results in benefit or harm to the serious condition, the no liability rule is more efficient than the strict liability rule when* $\alpha \leq \frac{l_m - c_m}{(1-k)l_m}$.

5 Conclusion

Departing from the existing literature, we consider the possibility where undertreatment, i.e., providing a minor treatment for a serious problem, can either offer partial benefit or worsen the condition by increasing the amount of loss. We show that the efficiency of liability rules in credence goods markets critically depends on treatment costs and the extent of loss from undertreatment. Under perfect diagnosis, a no liability rule outperforms the strict liability rule when serious treatment is expensive and undertreatment brings some partial benefit to the serious problem and the resulting loss from the serious problem is sufficiently low. Clearly, this result stands in contrast with the literature which assumes undertreatment has no value to the consumer as it leaves the serious problem unchanged, resulting in the full original loss. Notably, in our analysis, the strict liability rule is more efficient compared to the no liability rule even when undertreatment further worsens the consumer's loss from the serious problem. Our results demonstrate that in the presence of diagnosis errors, the strict liability rule leads to a complete breakdown of trade, while the no liability rule permits market activity when serious problems are less likely. This result holds true irrespective of whether undertreatment results in additional benefit or harm to the serious problem. These findings underscore the importance of accounting for suboptimal treatment in expert markets when designing liability policies, as a less stringent legal framework can, in some cases, lead to maximum social efficiency.

For future research, it would be interesting to explore the implications of a credence goods expert's reputation concern (a la Fong (2005); Fong et al. (2022); Ogawa (2024)) in the present context. In particular, it would be worthwhile to examine whether our findings regarding the expert's pricing and treatment strategies continue to hold when the expert cares about building or maintaining a reputation. Additionally, such an extension could reveal whether reputation concerns enable the no-liability rule to achieve efficiency under a broader set of conditions than those identified in the present analysis.

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Appendix

Proof of Proposition 3.

Under the strict liability rule, the social welfare is $SW^L = \pi^L + (1-\alpha)(-p_m) + \alpha\gamma_s(-p_s)$.

According to the expert's profit-maximization strategy, putting $p_m = l_m, p_s = l_s, \gamma_s = \frac{l_m - c_m}{l_s - c_m}$ and the profit π^L_{max} in the above expression, we get:

$SW^L = \alpha(l_s - c_s)\frac{l_m-c_m}{l_s-c_m} + (1-\alpha)(l_m - c_m) + (1-\alpha)(-l_m) + \alpha\frac{l_m-c_m}{l_s-c_m}(-l_s) = -\alpha c_s\frac{l_m-c_m}{l_s-c_m} - (1-\alpha)c_m$

Under the no liability rule, when $\alpha \leq \frac{l_m-c_m}{(1-k)l_m}$, the expert always provides a minor treatment at price $p = (1-\alpha+\alpha k)l_m$. It completely treats the minor problem but for a serious problem, the consumer suffers a loss of $L = l_s - kl_m$. Therefore the social welfare is $SW^{NL} = (p - c_m) + \alpha(-L-p) + (1-\alpha)(-l_m + l_m - p) = -c_m - \alpha L$.

$SW^L - SW^{NL} = \alpha(L + c_m - c_s\frac{l_m-c_m}{l_s-c_m})$. Clearly, $SW^L - SW^{NL} > 0$ for $L > c_s\frac{l_m-c_m}{l_s-c_m} - c_m$.

When $L < c_s\frac{l_m-c_m}{l_s-c_m} - c_m$, we have $SW^L - SW^{NL} < 0$. However, since $L = l_s - kl_m > 0$ for all $k \leq 1$, we need to ensure $c_s\frac{l_m-c_m}{l_s-c_m} - c_m > 0$, i.e., $c_s > c_m\frac{l_s-c_m}{l_m-c_m}$

When $\alpha > \frac{l_m-c_m}{(1-k)l_m}$, there is no trade and hence, $SW^{NL} = -\alpha l_s - (1-\alpha)l_m$. Therefore, $SW^L - SW^{NL} = (1-\alpha)(l_m - c_m) + \alpha(l_s - c_s\frac{l_m-c_m}{l_s-c_m}) > 0$

It follows that $SW^{NL} > SW^L$ for $c_s > c_m\frac{l_s-c_m}{l_m-c_m}$ and $L < c_s\frac{l_m-c_m}{l_s-c_m} - c_m$.

Note that when $k \leq 0$, $L = l_s - kl_m > c_s\frac{l_m-c_m}{l_s-c_m} - c_m$ since by the cost-efficiency assumption, $c_s\frac{l_m-c_m}{l_s-c_m} - c_m < c_s < l_s$. Therefore, $SW^{NL} < SW^L$ when $k \leq 0$. □

Proof of Proposition 5.

Under the strict liability rule, there is no trade, and hence, the consumer's problem remains completely untreated. Therefore, the social welfare is $SW^L = \alpha(-l_s) + (1-\alpha)(-l_m) = -l_m - \alpha(l_s - l_m)$.

In case of a no liability rule, for $\alpha < \frac{l_m - c_m}{(1-k)l_m}$, the expert's optimal strategy is to always provide a minor treatment. The social welfare is the same as in the case of proposition 3, i.e., $SW^{NL} = -c_m - \alpha L$.

Therefore, $SW^{NL} - SW^{L} = l_m - c_m - \alpha(L - l_s + l_m) = l_m - c_m - \alpha(1-k)l_m > 0$ since $\alpha < \frac{l_m - c_m}{(1-k)l_m}$. When $\alpha > \frac{l_m - c_m}{(1-k)l_m}$, there is no trade and hence, $SW^{NL} = SW^{L}$. $\square$