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The Direct Incidence of Product Liability on Wages

https://doi.org/10.1515/rle-2024-0120
Received October 22, 2024; accepted November 15, 2024; published online February 10, 2025

Abstract: This paper shows that changes in the product-liability regime influence workforce welfare via an adjustment of the wage resulting from firm-union bargaining. Shifting more losses to consumers increases (decreases) equilibrium wages when consumers underestimate (overestimate) product risk. We highlight an important yet unexplored link between product liability and worker welfare relevant to policy-making.

Keywords: product liability; unions; wages; safety; misperceptions

JEL Classification: K41

1 Introduction

Product liability (i.e. the liability of producers for the harm they cause to their consumers) is a significant legal institution in Europe and the United States. The objectives policymakers pursue when using product liability include (i) improving product safety, (ii) causing product prices to reflect the products' risks, and (iii) compensating consumers (e.g. Polinsky and Shavell 2010). Importantly, product liability rules also have consequences for other important economic outcomes. For example, empirical studies have shown that liability rules are relevant for businesses' organizational designs (e.g. Ringleb and Wiggins 1990) and their level of R&D expenditures (e.g. Viscusi and Moore 1993). When deciding which liability rule to impose, policymakers must acknowledge that product liability rules influence various outcomes.

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Shepherd (2013) uses data from 1977 to 1997 to study how product liability reforms influence employment and other measures of economic activity. Her findings, particularly on the positive effect of statutes of repose on employment, underscore the practical implications of liability rules. Shifting more losses to consumers can raise employment. Understanding the relationship between product liability and worker welfare is crucial for policymakers when formulating optimal liability policy.

This paper combines a classic setup from labor economics and a standard model from the law-and-economics literature to study the link between product liability on the one hand and wages and employment on the other. After negotiating with a trade union about the wage, a monopolist invests in product safety and chooses employment. Consumers' willingness to pay is biased by a misperception of product risk (Spence 1977). In reality, consumers often misperceive product risk (e.g. Jolls 1998; Marino 1988; Viscusi 2012), and this behavioral bias affects the performance of liability rules (Baniak and Grajzl 2016; Miceli and Segerson 2013; Miceli, Segerson, and Wang 2015).[1]

We find that how the equilibrium wage reacts to allocating a greater share of losses to the firm via liability depends on consumers' product-risk misperception. Intuitively, marginally increasing the wage during firm-union negotiations always reduces employment and the firm's profits independent of the liability rule's loss allocation. However, the toll that a higher wage takes on both employment and profits *relative* to these indices' total levels is greater when fewer losses are allocated to risk-underestimating consumers. As a result, the equilibrium wage is lower when fewer losses are allocated to risk-underestimating consumers. When consumers overestimate product risk, we obtain the opposite results.

Maybe counterintuitively, how product liability influences equilibrium employment is ambiguous. Shifting losses to risk-underestimating consumers motivates output when all else is held equal because this shift reduces the per-unit cost as internalized by the firm. Yet, the countervailing effect via equilibrium wage and product safety complicates the analysis. For example, when consumers' underestimation of risk is not so severe, making consumers bear more losses reduces safety level and raises the wage, two changes that discourage output. Nevertheless, we show that shifting more losses to risk-underestimating consumers tends to raise the union's and the firm's equilibrium payoffs.

1 Risk misperceptions may stem from limited knowledge about the objective harm probability (e.g., Teitelbaum 2007). However, for example, Kahneman and Tversky (1979) suggest that, even if the objective harm probabilities are known, choices will be based on probability weights differing from objective probabilities.

By showing how wages respond to changes in product liability, this paper makes a novel contribution to two strands of the literature. First, it adds to the literature on the determinants of wages (e.g. Arulampalam, Devereux, and Maffini 2012; Goerke 2022). Second, it is related to contributions analyzing the various effects of liability on economic variables outside of the narrow focus on activity and safety levels. For example, Dari-Mattiacci and Franzoni (2014) analyze incentives to adopt new technologies, and Requate, Friehe, and Sengupta (2023) consider incentives to acquire information about harm.

Section 2 presents the model, and Section 3 presents the analysis of it. In Section 4, we discuss how product liability influences equilibrium payoffs and how it would relate to wages under a different cost structure. Section 5 concludes.

2 Model

Our model comprises a monopolist, a representative consumer, workers, and a trade union.

The *firm* produces output q using a linear production technology $q(L) = L$, where L denotes the number of the firm's employees.[2] The firm incurs wage w per employee. With probability $r(x) = 1 - x$, the consumer suffers product-related harm h, where x denotes the firm's product safety, which costs $c(x) = K\frac{x^2}{2}$.[3] The safety cost can be understood as R&D investment into product safety before production occurs and is thus independent of output (e.g. Daughety and Reinganum 2006; Polinsky 1980).[4]

The representative *consumer* perceives expected harm per output unit as $\lambda hr(x)$. The parameter λ, $\lambda \in [\underline{\lambda}, \bar{\lambda}]$ with $\underline{\lambda} < 1 < \bar{\lambda}$, indicates the consumer's perception of product risk (e.g. Spence 1977). She overestimates the product risk when $\lambda > 1$ and underestimates it when $\lambda < 1$. The consumer is unaware of her misperception while it is transparent to the firm.[5] Our assumptions are similar to those in Polinsky and Rogerson (1983) and the subsequent literature

2 For example, Corneo and Lucifora (1997) and Chongvilaivan, Hur, and Riyanto (2013) also assume a linear production technology.

3 We assume specific functional forms for tractability. For similar setups with strictly convex safety costs and a linear accident probability, see Baumann, Friehe, and Rasch (2018) and Schmitz (2000). The specific cost function is widely used in the context of quality competition (see, e.g., Motta 1993).

4 We comment on the analysis of the case with proportional safety cost in Section 4.

5 This assumption of consumers' naivety is standard in the behavioral industrial organization literature. See, for example, Köszegi and Heidhues (2018).

(e.g. Miceli, Segerson, and Wang 2015). The consumer's inverse demand function reads:

$$p = a - bL - g\lambda hr(x), \tag{1}$$

where g denotes the consumer's share of harm, $g \in [0,1]$. This variation of the liability system's allocation of losses between the firm and the consumer is in the spirit of Daughety and Reinganum (1995). When the share g equals one (zero), the relevant liability rule is akin to no (strict) liability.

We can state the firm's profits as

$$\pi = \big(a - bL - \gamma hr(x) - w\big)L - c(x), \tag{2}$$

where

$$\gamma = 1 - g + g\lambda$$

denotes the *perceived total harm burden*. It increases with the consumer's share of losses g if consumers overestimate product risk and decreases with it otherwise. Given the bounds on λ, it holds that $\gamma \in [\underline{\lambda}, \bar{\lambda}]$. In the special case where $\lambda = 1$, the consumer correctly anticipates the expected harm, and the loss allocation is thus no longer relevant to the firm's activities (Landes and Posner 1985; Shavell 1980).

The utilitarian *union* has M members, where L are employed by the firm. Members not employed by the firm obtain a fixed payoff $\bar{w}$. We assume that the utility of risk-neutral workers can be stated as $u(w) = w$, and that trade-union utility can be expressed as (Oswald 1982):[6]

$$V = u(w)L + u(\bar{w})(M - L) = Mu(\bar{w}) + L(u(w) - u(\bar{w})). \tag{3}$$

The timing of the model is as follows: In Stage 1, the wage is determined by Nash bargaining between the firm and the union. The monopolist chooses safety and employment in Stages 2 and 3.

3 Analysis

We proceed using backward induction, starting in Stage 3.

6 The assumption of utility linear in the wage is quite standard in the literature (see, e.g., Chongvilaivan, Hur, and Riyanto 2013; Leahy and Montagna 2012).

3.1 Stage 3: Choice of Employment

The firm seeks to

$$\max_{L} \pi(L; x, w, \gamma) = \big(a - bL - \gamma h(1-x) - w\big)L - \frac{Kx^2}{2} \tag{4}$$

given the safety level it assessed in Stage 2. The profit-maximizing level of employment conditional on safety reads

$$L(x; w, \gamma) = \frac{a - \gamma h(1-x) - w}{2b}. \tag{5}$$

A higher wage and a higher perceived total harm burden raise the marginal cost per output unit and induce lower output for fixed safety.

3.2 Stage 2: Choice of Safety

In Stage 2, the firm anticipates its third-stage employment choice as a function of safety and seeks to

$$\max_{x} \pi(x; w, \gamma) = \big(a - bL(x; w, \gamma) - \gamma h(1-x) - w\big)L(x; w, \gamma) - \frac{Kx^2}{2}, \tag{6}$$

The profit-maximizing level of safety for a given L follows as

$$x(w, \gamma) = \frac{\gamma h}{K} L(x; w, \gamma).$$

A higher perceived total harm burden raises the level of safety which is proportional to the level of output. Using $L(x;\ w, \gamma)$ and $x(w, \gamma)$, we get the optimal safety and employment levels as[7]

$$L^*(w, \gamma) = \frac{K(a - w - \gamma h)}{2bK - \gamma^2 h^2} = \frac{K}{\gamma h} x^*(w, \gamma). \tag{7}$$

A higher wage reduces employment and safety. The marginal effects from a higher wage are moderated by the liability rule represented by γ:

$$\frac{\partial^2 L^*}{\partial w \partial \gamma} = -\frac{2h^2 K\gamma}{(2bK - \gamma^2 h^2)^2} < 0 \tag{8}$$

$$\frac{\partial^2 x^*}{\partial w \partial \gamma} = -\frac{h(2bK + \gamma^2 h^2)}{(2bK - \gamma^2 h^2)^2} < 0. \tag{9}$$

7 Necessary conditions for $L^*(w, \gamma) > 0$ and $x^*(w, \gamma) \in (0, 1)$ are $\gamma^2 h^2 < \gamma h(a - w) < 2bK$ for all levels of w.

The negative employment implications from a higher wage are more significant when the liability rule signifies a higher γ (i.e. shifts fewer losses to underestimating consumers or more losses to overestimating consumers). This suggests that the union may be less aggressive in the wage-bargaining process when γ is high because a wage increase signifies a more significant employment loss.

3.3 Stage 1: Wage Bargaining

The firm and the trade union anticipate how the firm decides about safety and employment in Stages 2 and 3. Their payoffs as functions of γ result as:

$$\pi^*(w,\gamma) = \big(a - bL^*(w,\gamma) - \gamma hr(x^*(w,\gamma)) - w\big)L^*(w,\gamma) - c(x^*(w,\gamma))$$
$$V^*(w,\gamma) = M\bar{w} + L^*(w,\gamma)(w - \bar{w}).$$

As is standard in the literature, we assume that the wage is determined through Nash bargaining between the firm and the union. Thus, when bargaining about the wage, the firm and the union seek to

$$\max_w N(w;\gamma) = (\pi^*)^\delta (V^* - \bar{w}M)^{1-\delta},$$

as π^* and $V^* - \bar{w}M$ represent the gains from reaching an agreement from the firm's and the union's standpoint. The first-order condition for the equilibrium wage can be stated as:

$$(1-\delta)\left(\frac{\pi^*}{V - \bar{w}M}\right)^\delta \frac{\partial V^*}{\partial w} = -\delta\left(\frac{V^* - \bar{w}M}{\pi^*}\right)^{1-\delta} \frac{\partial \pi^*}{\partial w},$$

which balances out the marginal decrease in firm profits and the marginal increase in union payoffs:

$$\frac{\partial \pi^*}{\partial w} = -L^* < 0 \text{ and } \frac{\partial V^*}{\partial w} = (w - \bar{w})\frac{\partial L^*}{\partial w} + L^* = \frac{K(a - 2w + \bar{w} - \gamma h)}{2bK - \gamma^2 h^2} > 0.$$

Using this condition, we derive the equilibrium wage as well as equilibrium employment and safety; and document the results in:

Lemma 1. *In equilibrium, the wage resulting from the Nash bargaining between the firm and the union amounts to*

$$w^{**}(\gamma) = \frac{(1-\delta)(a - \gamma h) + (1+\delta)\bar{w}}{2}.$$

The equilibrium levels of employment and safety read

$$L^{**}(\gamma) = \frac{(1+\delta)K}{2}\frac{a - \gamma h - \bar{w}}{2bK - \gamma^2 h^2} = \frac{K}{\gamma h}x^{**}(\gamma).$$

Our research question concerns the relationship between the wage and the liability rule represented by γ. It can be seen from Lemma 1 that a higher γ reduces the equilibrium wage. In order to better understand the effect, we transform the first-order condition for the wage into

$$\delta \frac{\frac{\partial \pi^*}{\partial w}}{\pi^*} + (1-\delta)\frac{\frac{\partial L^*}{\partial w}}{L^*} + (1-\delta)\frac{1}{w-\bar{w}} = 0,$$

of which only the first two terms are influenced by the liability rule. Note that

$$\frac{\frac{\partial \pi^*}{\partial w}}{\pi^*} = -\frac{L^*}{\pi^*} = -\frac{2}{a-w-\gamma h} \quad \text{and} \quad \frac{\frac{\partial L^*}{\partial w}}{L^*} = -\frac{1}{a-w-\gamma h}$$

represent the *relative* marginal profit loss from the firm's side and the *relative* marginal employment loss from the union's side, respectively. A higher level of γ makes both marginal cost terms larger, and thus decreases the equilibrium wage.

The comparative statics of equilibrium employment concerning γ is less straightforward. The sign of the marginal employment change

$$\frac{dL^{**}}{d\gamma} = \frac{(1+\delta)Kh}{2}\frac{2\gamma h(a-\bar{w}) - 2bK - \gamma^2 h^2}{(2bK-\gamma^2 h^2)^2}$$

depends on parameter specifications. When K is sufficiently high, increasing the total perceived harm burden via a higher γ lowers employment. When consumer's risk-underestimation is mild, there exist levels of K such that shifting losses away from underestimating consumers could increase equilibrium employment. In this case, the offsetting effects from a higher safety level and a lower wage dominate the direct effect of γ on the per-unit output cost.

We summarize our main results in:

Proposition 1. *Shifting more losses to consumers increases (decreases) equilibrium wages when consumers underestimate (overestimate) product risk. The effect of product liability on equilibrium employment depends on parameters.*

Proof. See Appendix A.1. □

4 Discussion

We first explore how a change in the liability rule influences equilibrium payoffs, then comment on the liability rule's implications for social welfare, and finally discuss the role of the fixed-cost assumption for our results.

4.1 Product Liability and Equilibrium Payoffs

A higher perceived total harm burden lowers both equilibrium payoffs. Starting from

$$\pi^{**} = K(1+\delta)^2 \frac{(a-\gamma h-\iota\bar{w})^2}{8(2bK-\gamma^2 h^2)} \tag{10}$$

$$V^{**} = M\iota\bar{w} + K(1-\delta^2)\frac{(a-\gamma h-\iota\bar{w})^2}{4(2bK-\gamma^2 h^2)}, \tag{11}$$

we find that

$$\frac{d\pi^{**}}{d\gamma} = K(1+\delta)^2 h \frac{(\gamma h+\iota\bar{w}-a)(2bK-\gamma h(a-\iota\bar{w}))}{4(2bK-\gamma^2 h^2)^2} < 0, \tag{12}$$

$$\frac{dV^{**}}{d\gamma} = K(1-\delta^2) h \frac{(\gamma h+\iota\bar{w}-a)(2bK-\gamma h(a-\iota\bar{w}))}{2(2bK-\gamma^2 h^2)^2} < 0. \tag{13}$$

The perceived total harm burden increases when losses are shifted away from (towards) consumers underestimating (overestimating) product risks. The scenario in which consumers underestimate product risk is the benchmark in the literature (e.g. Polinsky and Rogerson 1983; Spence 1977) and is considered by many to be more relevant in reality (see, e.g. Landes and Posner 1987). In this scenario, the firm loses profits when more losses are reallocated from consumers to the firm. As a result, the firm has incentives to push for lower damage payments via lobbying or political influence on judicial appointments, for example. Business groups are indeed active in this field. For the US, it is argued that business groups guided legislative changes to tort law, such as introducing damage award caps or statutes of repose (Rubin 2005; Runbin, Curran, and Curran 2001). In our model, the trade union would welcome any attempts by the firm to politically induce that consumers' compensation decreases, as seen in (13).

4.2 Social Welfare

Polinsky and Rogerson (1983) focus on consumers underestimating product risk and explain that this misperception can be exploited to improve welfare in Cournot markets with significant market power. The intuition is that shifting losses to risk-underestimating consumers lessens the scarcity of output at the cost of distorted product safety. We want to revisit this trade-off using our framework, which includes wage bargaining. To do so, we employ the welfare function used by Polinsky and Rogerson (1983) and augment it by the union's payoff. Using the equilibrium levels of wage, employment, and safety in Lemma 1, we have:

$$SW = \left(a - \frac{1}{2}bL^{**} - h(1-x^{**})\right)L^{**} - \frac{Kx^{**2}}{2} + (M-L^{**})\bar{w}. \tag{14}$$

Note that wage payments are pure monetary transfers from the firm to employees and, thus, only appear implicitly in equilibrium employment and safety. Raising the perceived total harm burden implies the following marginal change in welfare:

$$\begin{aligned}\frac{dSW}{d\gamma} &= \frac{\partial SW}{\partial L^{**}}\frac{\partial L^{**}}{\partial \gamma} + \frac{\partial SW}{\partial x^{**}}\frac{\partial x^{**}}{\partial \gamma} \\ &= \left(a - bL^{**} - h(1-x^{**}) - \bar{w}\right)\frac{\partial L^{**}}{\partial \gamma} + (hL^{**} - Kx^{**})\frac{\partial x^{**}}{\partial \gamma}. \qquad (15)\end{aligned}$$

Under strict liability, $\gamma = 1$ holds and output and safety levels are insulated from consumer's misperception of risks. In this case, the firm chooses socially optimal safety conditional on output, implying that the second term in (15) is zero. In contrast, the monopolist induces artificial output scarcity, implying that the term in the first parentheses is positive. Whereas shifting losses to consumers underestimating product risk raises output in Polinsky and Rogerson (1983), this may not hold in our framework. In other words, we may find that strict liability is socially optimal in the monopoly setting, contrary to Polinsky and Rogerson (1983) if they allowed a continuous shifting of losses.[8]

4.3 Safety Cost

We assumed that the firm incurs a safety cost independent of the output level. In a framework in which the safety cost arises per unit of output, the equilibrium wage results as[9]

$$\hat{w} = w^{**} + (1-\delta)\frac{h^2\gamma^2}{4K}.$$

This means that the finding about the relationship between product liability and the equilibrium wage is robust to this framework change. In contrast to what we presented above, employment always decreases in the perceived harm burden. Moreover, how it changes with the wage is independent of the liability rule.

5 Conclusions

Product liability aims at improving product safety, causing product prices to reflect the products' risks, and compensating consumers. However, product liability simultaneously impacts other critical economic outcomes. This paper uses

8 Polinsky and Rogerson (1983) consider no liability ($g = 1$) and strict liability ($g = 0$) besides negligence, but no intermediate levels of g.

9 Derivations are contained in Appendix A.2.

a simple framework to show that product liability rules can influence wages and employment.

Shifting more losses to consumers increases the equilibrium wage when consumers underestimate product risk but decreases it when consumers overestimate product risk. In addition, shifting more losses to underestimating consumers tends to raise equilibrium employment and the union's and the firm's equilibrium payoffs.

This note describes the relationship between product liability and wages, relying on the most widely used firm-union bargaining protocol and a very standard product liability model. Considering other frameworks (e.g. efficient bargaining between the firm and the union) and analyzing how the relationship between product liability and wages bears on socially optimal liability law is left for future research.

Appendix

A.1 Proof of Proposition 1

(i) For the first claim, we use:

$$\frac{d\omega^{**}}{d\gamma} = -\frac{(1-\delta)h}{2} < 0.$$

(ii) For the second claim, consider:

$$\frac{dL^{**}}{d\gamma} = \frac{(1+\delta)Kh}{2}\frac{2\gamma h(a-\iota\bar{w}) - 2bK - \gamma^2h^2}{(2bK-\gamma^2h^2)^2}.$$

Because $2\gamma h(a-\iota\bar{w}) - \gamma^2h^2$ increases in γ, the marginal employment change is negative for all γ when

$$K > \frac{2\bar{\lambda}h(a-\iota\bar{w}) - \bar{\lambda}^2h^2}{2b} = \bar{K}.$$

The necessary condition for $x^{**} < 1$ is fulfilled with all levels of K in this range since

$$2bK > 2\bar{\lambda}h(a-\iota\bar{w}) - \bar{\lambda}^2h^2 > \bar{\lambda}h(a-\iota\bar{w}) \geq \gamma h(a-\iota\bar{w}).$$

Similarly, when

$$K < \frac{2\underline{\lambda}h(a-\iota\bar{w}) - \underline{\lambda}^2h^2}{2b} = \underline{K},$$

we have that $dL^{**}/d\gamma$ is positive for all γ. In this case, however, the equilibrium safety may exceed 1 due to the very low level of K. For consumers who underestimate risks (i.e. $\gamma \in [\underline{\lambda}, 1]$), the critical level $\underline{K}$ and the neighborhood on its left fulfill the necessary condition for $x^{**} < 1$ when $h(a - \bar{\iota w}) < 2b\underline{K}$ or:

$$h(a - \bar{\iota w}) < 2\underline{\lambda}\, h(a - \bar{\iota w}) - \underline{\lambda}^2 h^2 \Leftrightarrow (2\underline{\lambda} - 1)(a - \bar{\iota w}) - \underline{\lambda}^2 h > 0,$$

which is true when $\underline{\lambda}$ is sufficiently close to 1 (i.e. when the underestimation is mild).

Regarding the marginal change of safety w.r.t γ, we have:

$$\frac{dx^{**}}{d\gamma} = \frac{(1+\delta)h}{2} \frac{(2bK + \gamma^2 h^2)(a - \bar{\iota w}) - 4\gamma hbK}{(2bK - \gamma^2 h^2)^2}.$$

When $K < \underline{K}$ such that $2\gamma h(a - \bar{\iota w}) - 2bK - \gamma^2 h^2 > 0$, we have:

$$(2bK + \gamma^2 h^2)(a - \bar{\iota w}) - 4\gamma hbK > \frac{(2bK + \gamma^2 h^2)^2}{2\gamma h} - 4\gamma hbK \geq 0$$

since $(2bK - \gamma^2 h^2)^2 \geq 0$. In this case, a higher γ leads to higher equilibrium employment and equilibrium safety. The positive indirect effects of γ via product safety and wage level sufficiently offset its negative direct effect on employment, which thus leads to a higher overall equilibrium employment.

A.2 The Case with a Proportional Cost of Safety

Assume that safety is associated with a per-unit cost instead of a one-time investment before production. The firm's profit follows as:

$$\pi = \left(a - bL - \gamma h(1 - x) - \frac{Kx^2}{2} - w\right)L.$$

The equilibrium level of safety is $\hat{x} = \gamma \frac{h}{K}$ and thus independent of employment. The first-order condition for the level of employment results as:

$$\frac{\partial \pi}{\partial L} = a - 2bL - \gamma h(1 - \hat{x}) - \frac{K\hat{x}^2}{2} - w = 0,$$

which gives rise to

$$\hat{L} = \frac{2K(a - w - \gamma h) + \gamma^2 h^2}{4bK}.$$

How labor changes with the wage is independent of the liability rule. The firm's equilibrium profits in this case are:

$$\hat{\pi} = \frac{(2K(a - w - \gamma h) + \gamma^2 h^2)^2}{16bK^2}.$$

Similar to what is presented in the main text, the Nash solution results from the equation:

$$\delta \frac{\frac{\partial \hat{\pi}}{\partial w}}{\hat{\pi}} + (1 - \delta) \frac{\frac{\partial \hat{L}}{\partial w}}{\hat{L}} + (1 - \delta) \frac{1}{w - \bar{w}} = 0.$$

The condition can be transformed into:

$$\frac{1 - \delta}{w - \bar{w}} = \frac{2K(1 + \delta)}{2K(a - w - \gamma h) + \gamma^2 h^2}$$

which yields the equilibrium wage

$$\hat{w} = w^{**} + \frac{1 - \delta}{4K} \gamma^2 h^2.$$

Considering the marginal change of equilibrium wage in the perceived harm burden, we have that

$$\frac{\partial \hat{w}}{\partial \gamma} = \frac{(1 - \delta)h(\gamma h - K)}{2K} < 0$$

because $x^* < 1$ requires $\gamma h < K$. The equilibrium employment, evaluated at the equilibrium wage, is

$$\hat{L}(\hat{w}) = \frac{(1 + \delta)(2aK + \gamma^2 h^2 - 2K(\gamma h + \bar{w}))}{8bK},$$

which always decreases in γ:

$$\frac{d\hat{L}(\hat{w})}{d\gamma} = \frac{(1 + \delta)h(\gamma h - K)}{4bK} < 0.$$

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