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Moral Hazard and Agency Relationship in Sequential Litigation

Christian At* Yannick Gabuthy†

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Abstract

The aim of this paper is to determine the optimal fee contract between a plaintiff and his lawyer in a trial process where liability and damages are treated sequentially: the court determines liability at the first stage and chooses damages at the second one. The plaintiff-lawyer relationship is embedded in a dynamic principal-agent setup where the lawyer's effort is unobservable by her client. It is shown that such a sequential process induces an interesting spillover effect for the plaintiff: the prospect of payment at the second period acts as carrot for the first period by inciting the lawyer to make effort in the liability stage in order to enjoy the reward in case of winning when damages are litigated. This effect implies a particular contractual design where the lawyer gets no transfer from the plaintiff at the first period.

Keywords: Sequential trials, Moral hazard.

JEL codes: D82, K41.

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1. INTRODUCTION

The moral hazard problem is common in litigation since the plaintiff does not have the ability or the expertise to directly observe how much time his lawyer is spending on the case and how hard she is working during those hours.¹ Absent concerns for reputation or long-run relationship, paying the lawyer by the hour would clearly induce shirking. In this context, there is a large literature which shows that contingent fees may be a response to this problem by tying the attorney's pay on the outcome of litigation. Typically, the contingent fee mechanism implies that the lawyer gets a share of the judgement if her client wins and nothing if he loses. This mechanism is widely used in the U.S., where the typical contract involves a percentage of 33%, while several European countries are considering to allow such payment schemes (which are currently forbidden).² Overall, contingent fees are shown to be better than fixed fees because the individual with more information becomes residual claimant (see, *e.g.*, Halpern and Turnbull, 1983; Danzon, 1983; Hay, 1996; Wang, 2008).

Though this literature has generated insightful results, it is also limited by considering litigation only as a unitary/one-shot process while legal systems often feature a sequence of decisions before a final judgment is reached. In criminal procedures, conviction and sentencing are indeed frequently treated sequentially: the jury first decides whether the defendant committed the crime while the judge sentences him. This division finds an analogue in the tort law where civil proceedings may imply a separation between liability and damages. For example, when Polaroid successfully sued Kodak for infringing its patents on instant photography, the questions of liability and damages were litigated in different trials (Landes, 1993). In the same way, the New York law encourages judges to separate liability and damages issues into sequential proceedings in any action for personal injury. More precisely, it presumptively assigns the determination of liability to the first stage and determination of damages to the second stage, unless the court orders otherwise (De Mot *et al.*, 2013).³ Overall, sequential trials are common in antitrust

¹We use the pronon 'she' to refer to the lawyer and 'he' to refer to the client.

²*Pactum cuota litis* is not allowed by the ethical code of the European association of lawyers. However, as explained by Emons and Garoupa (2006), market pressure has led some countries (*e.g.* the U.K., Belgium and the Netherlands) to allow *conditional* fees in which the lawyer receives an upscale premium – unrelated to the amount adjudicated – in case of winning.

³In practice, a so-called 'sequential litigation' is not limited to separating liability and damages, and refers to any situation where the issues of disagreement are adjudicated sequentially by the court. In contrast, in 'unitary litigation', the distinct issues of a dispute are bundled together in a single proceeding.

litigation, employment litigation, and complex litigation such as mass tort cases where a very important sphere of application is related to asbestos claims.⁴ In this context, several legal systems specify the courts' option of conducting separate trials. For example, in U.S. federal courts, Rule 42(b) of the Federal Rules of Civil Procedure allows the court to separate liability and damages "in furtherance of convenience or to avoid prejudice". Likewise, in the U.K., Rule 3.1(2) of the Civil Procedure Rules states that the court may "direct a separate trial of any issue". Finally, in Canada, procedure rules are determined independently by each jurisdiction and most jurisdictions allow sequential litigation.

The aim of our paper is then to determine the optimal fee contract arising between the plaintiff and his lawyer in such a sequential litigation, considering that the lawyer's effort is unobservable by her client. Following this objective, we broaden the discussion of attorneys' fee arrangements in mainly two ways.

First, as mentioned above, the law and economics literature examined the moral hazard problem exclusively in the situation of unitary trials while many cases of sequential litigation are observed in practice. Our approach considers such cases by modelling the plaintiff-lawyer relationship as a dynamic principal-agent setup under moral hazard where the agent is protected by limited liability. This relationship may be then considered as a particular problem of repeated moral hazard (see, *e.g.*, Bierbaum, 2002; Ohlendorf and Schmitz, 2012).

Second, we consider that the lawyer and her client are unrestricted in the contracts they can make, and we then try to highlight what types of fee arrangements arise in equilibrium. This approach contrasts sharply with most of the existing literature which restricts attention *a priori* to percentage fees, without worrying about the additional and important issue of what type of payment mechanism might be more efficient.⁵ The argument behind such a restriction is based on the fact that some of the proposed alternatives would not be allowed by existing laws, following the champerty doctrine in the U.S. and the forbidden *pactum cuota litis* in continental Europe. However, this does not mean that these alternatives will never be allowed in any jurisdictions at any time. Furthermore, we argue that a normative perspective may be useful to provide insightful recommendations/guidelines to alter some inefficiencies of the existing legal systems.

Our paper complements also the previous literature on sequential litigation which ignores the issue of lawyer-client relationship by focusing the analysis on the parties' strategic

⁴See White (2002) for some quantitative data.

⁵Some notable exceptions are Rubinfeld and Scotchmer (1993), and Polinsky and Rubinfeld (2003).

interactions. Landes (1993) presents the first formal study of the incentives to file, settle, and spend in sequential *versus* unitary trials, while there is a related informal discussion in the pioneering paper of Schwartz (1967). It is shown that separating liability and damages tends to lower the expected cost of litigating a given dispute because the cost of litigating damages will be saved if the plaintiff loses liability. This expected cost reduction increases his incentive to sue and decreases his willingness to settle. Therefore, even though the litigation costs per case will fall, the number of cases will rise so that the overall effect on the total litigation costs is uncertain.⁶ Chen *et al.* (1997) extend the analysis by considering asymmetric information: the defendant is privately informed about both the probability that he will found liable and the damages, conditional upon a finding for liability. The Landes' results are challenged due to the information revealing effect of sequential litigation: the information produced in the first stage of a sequential dispute may increase the likelihood of settlement between the litigants, relative to a unitary trial. Following this argument, Gensler (2000) encourages federal courts to favor sequential proceedings. Finally, interesting results are obtained when the costs of litigation are assumed to be a choice variable for the conflicting parties. De Mot *et al.* (2013) analyze endogenous litigation expenditures, by using a rent-seeking model, and show that the optimal trial process (*i.e.* unitary or sequential) depends on the strength of the plaintiff's case. In fact, separating issues incentivizes the defendant to front-load his expenditures in order to avoid the costs associated with the second step of the trial. This front-loading will promote expenditures by the plaintiff if his case is sufficiently strong (*viz.* if the returns on his investment is sufficiently high). The opposite effect is obtained when the plaintiff has a weak case. This result provides a theoretical foundation to procedural rules that give courts discretion on whether to join or separate issues.

Considering the plaintiff-lawyer relationship, our analysis shows that the optimal – second-best – contract exhibits a particular design. Indeed, the separation between liability and damages in sequential litigation implies an interesting spillover effect for the plaintiff which enables him not to reward his lawyer at the liability stage. In fact, the transfer provided at the second period acts as carrot for the first period by inciting the lawyer to make effort in the liability stage in order to get this transfer in case of victory when damages are litigated.

The remainder of the paper is organized as follows. Section 2 lays down the model, and

⁶See also De Mot (2012) who considers the effects of sequential trials in conjunction with the English fee-shifting rule (inducing that the losing party bears all litigation costs).

derives our main results concerning the optimal fee contracts. Section 3 concludes and suggests some possible extensions. Proofs are relegated to the appendix.

2. THE MODEL

2.1. Framework. A plaintiff has been a victim of an accident or a breach of contract, and sues the defendant to be paid damages following a sequential litigation process. In this context, the lawyer and plaintiff enter into a contractual relationship for the lawsuit, which implies the following timing of events.⁷ At date 0, the plaintiff makes a take-it-or-leave-it contract offer to the lawyer. Having accepted the offer, at date 1 the lawyer chooses an unobservable first-period effort level $h_1 \in [0, 1]$, incurring disutility $c_1(h_1)$. At date 2, the verifiable result $y \in \{0, 1\}$ is realized, where $y = 0$ denotes failure (*viz.* the defendant is not found liable) and induces that the litigation process is aborted, while $y = 1$ denotes success (*viz.* the defendant is found liable) and implies that the game goes on. The probability of success is normalized to equal the effort level (*i.e.* $Pr\{y = 1|h_1\} = h_1$). In case of winning, the relationship continues to date 3 where the lawyer chooses an unobservable second-period effort level $h_2 \in [0, 1]$, incurring disutility $c_2(h_2)$. Finally, at date 4, the plaintiff gets the verifiable damages $J \in \{0, J_H\}$, where $Pr\{J = J_H|h_2\} = h_2$.⁸ In other words, the attorney's efforts affect the winning probability of the plaintiff at the first period and the level of compensation awarded by the court at the second one. The effort cost functions satisfy $c'_i > 0$, $c''_i > 0$, $c'''_i \geq 0$, $c_i(0) = 0$, $c'_i(0) = 0$ and $c'_i(1) \geq J_H$ (with $i = 1, 2$). We also assume that c''_i is high enough to ensure the concavity of the objective functions. The sequence of events is illustrated in Figure 1.

Before analyzing the main question of interest, several comments on the framework and its main assumptions are in order. First, this paper deals with the lawsuit only, ignoring the possibility of pre-trial settlement or considering that this attempt has failed. This assumption may seem somewhat puzzling given that, in practice, a large number of disputes do not rise the level of a lawsuit and end in settlement. However, as mentioned by Hay (1996), in most situations the settlement amount reflects the expected value the claim would have if it went to trial. Therefore, the optimal lawyer-client contract in a world

⁷To simplify the exposition, we neglect discounting and assume that the plaintiff incurs no fixed cost in filing the suit. In real-world cases, such an amount includes the cost of preparing a complaint and making the fact of the lawsuit known to the defendant.

⁸The assumption that $J_L = 0$ is made to alleviate notations and could be relaxed without altering the gist of our arguments.

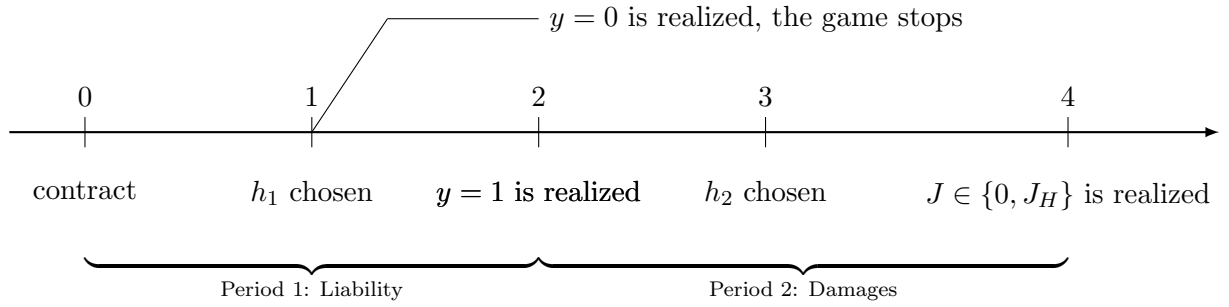


Figure 1: The sequence of events.

in which cases settle should not be very different from the optimal contract in which all cases go to trial. Second, we consider a full commitment situation, where the principal can commit not to renegotiate the contract that is written at date 0. This feature has been deliberately chosen to develop our main insights in a tractable manner, and could be relaxed in an extended version of the model. In the same way, we assume that the agent cannot be replaced at the end of the liability stage. While this assumption is restrictive, it seems reasonable to consider that the first-period relationship induces learning and specific training, which make replacement unprofitable for the principal and imply that the parties are ‘locked-in’ as a bilateral monopoly. Finally, while litigation generates external costs and benefits (including administrative costs and deterrence of harmful activities), we abstract from the complex problem of the social optimality by analyzing the contractual arrangement that maximizes the client’s – private – welfare in litigation.⁹

2.2. Optimal Contracting. As a benchmark, we briefly consider the first-best situation where the effort levels maximize the expected total surplus:

$$S(h_1, h_2) = h_1(h_2 J_H - c_2(h_2)) - c_1 h_1. \quad (1)$$

where $h_2 J_H - c_2(h_2)$ is the expected total surplus of the damages’ game, which occurs with the probability h_1 of winning the liability’s game. The first-best effort levels h_1^{FB} and h_2^{FB} are then the unique solutions to the following first-order conditions:

$$h_2^{FB} J_H - c_2(h_2^{FB}) = c_1'(h_1^{FB}), \quad (2)$$

$$J_H = c_2'(h_2^{FB}). \quad (3)$$

⁹See Kaplow (1994) and Shavell (1997) for discussions on the divergence between the private and the social value of litigation.

The left-hand sides of these expressions define the marginal aggregate benefits of the first- and second-periods' efforts. Efficiency requires that such marginal returns be equated to the corresponding marginal costs (which are characterized in the right-hand sides of (2) and (3)). Furthermore, since $c_i(0) = 0$, $c'_i(0) = 0$ and $c'_i(1) \geq J_H$, we get interior solutions (*i.e.* $h_1^{FB} \in (0, 1)$ and $h_2^{FB} \in (0, 1)$).

Let us now turn to the asymmetric information situation where the lawyer's effort choices are not observable by her client. A contract specifies a recommended effort level h_i and a transfer payment t_i from the plaintiff to his lawyer at each period i . The lawyer is assumed to be protected by limited liability which implies that the transfers must always be non-negative:

$$t_1 \geq 0, \tag{4}$$

$$t_2 \geq 0. \tag{5}$$

We thus rule out contracts with payments from the attorney to the client. This assumption restricts the class of feasible contracts, however it is commonly used in law and economics literature (see, *e.g.*, Emons and Garoupa, 2006; Emons, 2006, 2007), and it is consistent with the champerty doctrine in the U.S. and the forbidden *pactum cuota litis* in continental Europe: the lawyer cannot buy the lawsuit from the client or incur penalties if the case is lost.¹⁰ Furthermore, the condition stated in (5) implies that the lawyer cannot be forced to refund payments that he received in the past. In fact, this assumption is made without loss of generality and we could easily relax the constraint by considering only $t_2 \geq -t_1$.

Moreover, the recommendations formulated by the plaintiff must satisfy suitable incentive compatibility constraints. Following the standard principal-agent approach, we consider that the lawyers' payments are made contingent on the results of the trial (*viz.* the lawyer will never be rewarded for a failure). Moving backward, conditional on a success arising at the first period, the lawyer chooses her effort level h_2 at the second period such that:

$$h_2 = \arg \max_{h_2 \in [0,1]} U_2 = h_2 t_2 - c_2(h_2). \tag{6}$$

¹⁰Furthermore, without such limited-liability conditions, the – risk-neutral – agent could become the residual claimant and the moral-hazard problem would disappear. In other words, the plaintiff could costlessly structure the lawyer's payments so that the first-best effort levels would be implemented: the contract would imply negative (positive) transfers from the plaintiff to his lawyer in case of failure (success) in both periods. See, *e.g.*, Laffont and Martimort (2002) who analyze this issue in a more simple and general setup.

The first-order condition of the second-period lawyer's optimization problem is then given by:

$$t_2 = c'_2(h_2). \quad (7)$$

This condition implies that the marginal benefit from an increase in the second-period effort (*i.e.* t_2) is equated with its marginal cost (*i.e.* $c'_2(h_2)$).

Anticipating her future expected payoffs, the lawyer chooses h_1 at the first period such that:

$$h_1 = \arg \max_{h_1 \in [0,1]} U_1 = h_1 (t_1 + U_2) - c_1(h_1). \quad (8)$$

The first-order condition of the first-period lawyer's optimization problem is then given by:

$$t_1 + h_2 t_2 - c_2(h_2) = c'_1(h_1). \quad (9)$$

This expression can be interpreted like the condition in (7), except that an increase in the first-period effort will be not only rewarded by the immediate transfer t_1 , but also by the possibility to continue the litigation process and, then, the prospect to get the second-period transfer in case of winning (which implies a net – *ex-ante* – expected payment of U_2).

Finally, the contract must ensure the lawyer's participation. Assuming a competitive market for attorneys so that they expect zero profit or normalizing to zero their outside opportunity wages, the individual rationality conditions are:

$$U_1 \geq 0, \quad (10)$$

$$U_2 \geq 0. \quad (11)$$

The maximization problem of the plaintiff may then be written as:

$$\begin{aligned} \max_{h_i, t_i} \quad & \Pi = h_1 (-t_1 + h_2(J_H - t_2)) \\ \text{s.t.} \quad & t_1 \geq 0, t_2 \geq 0, U_1 \geq 0, U_2 \geq 0 \\ & \text{and } t_1 + h_2 t_2 - c_2(h_2) - c'_1(h_1) = 0, t_2 - c'_2(h_2) = 0. \end{aligned}$$

The next result follows.

Proposition 1 *When the lawyer's efforts are unobservable, the second-best contract $\{h_i^{SB}, t_i^{SB}\}$ entails:*

$$0 < h_i^{SB} < h_i^{FB} \ (\forall i = 1, 2), \ t_1^{SB} = 0 \ \text{and} \ t_2^{SB} = c_2'(h_2^{SB}).$$

Proof. See Appendix ■

The intuition behind these results is the following. First, the prospect of a second-period payment (*i.e.* $t_2^{SB} > 0$) following a first-period success motivates the lawyer to exert effort in the first period, which enables the client not to reward it (*i.e.* $t_1^{SB} = 0$). In other words, the separation between liability and damages in sequential trial creates a desirable spillover effect for the principal: the incentives provided in the second period act as carrot for the first period since the agent works hard in the liability stage in order to enjoy the reward in case of winning when damages are litigated.¹¹

Furthermore, more classically, the second-best contract exhibits a conflict between the limited liability and the incentive constraints, implying a downward distortion of the first-period effort. Punishment being infeasible, the client is restricted to use only rewards to induce effort from the lawyer. This restriction of the principal's incentive instrument implies that he must give up some *ex-ante* rent to the agent. Following (6), (8) and (9), this expected limited liability rent is given by:

$$U_1^{SB} = h_1^{SB}(t_1^{SB} + h_2^{SB}t_2^{SB} - c_2(h_2^{SB})) - c_1(h_1^{SB}) = h_1^{SB}c_1'(h_1^{SB}) - c_1(h_1^{SB}) \geq 0. \quad (12)$$

Hence, the client distorts the first-period effort level below to its first-best value (*i.e.* $h_1^{SB} < h_1^{FB}$) in order to reduce the cost of this rent.¹² In the same way, the plaintiff implements $h_2^{SB} < h_2^{FB}$ because the second-period transfer is increasing in the lawyer's effort level (*i.e.* $t_2^{SB'} = c_2''(h_2^{SB}) > 0$). Overall, the conjunction of moral hazard and limited liability induces a trade-off between rent extraction and efficiency which prevents the principal to implement the first-best effort levels.

¹¹Notice that our model treats the outcome of the two stages of the trial as independent, while it would be relevant to consider that the probability to win at the damages stage increases when the effort chosen at the liability stage is higher (*viz.* $Pr\{J = J_H|h_2, h_1\}$ is increasing in h_1). This restriction enables us to develop our main results in a focused and tractable manner. Furthermore, we conjecture that such a modification would not alter the gist of our arguments. Indeed, assuming that $Pr\{J = J_H|h_2, h_1\}$ is increasing in h_1 would create only an expected additional benefit for the lawyer to exert effort h_1 in the first period. Therefore, the main insight of our analysis should not be impacted: the plaintiff should pay nothing for success in the liability stage, and should reward the lawyer in the damages stage in case of victory.

¹²It is straightforward to show that there is no liability rent in the first-best situation: $t_i^{FB} = c_i(h_i^{FB})/h_i^{FB} \Rightarrow U_1^{FB} = 0$.

3. CONCLUSION

This paper studies the plaintiff-lawyer contractual relationship when the litigation process implies a separation between liability and damages. This relationship is then considered as a particular problem of repeated moral hazard which induces a specific fee arrangement: following the spillover effect highlighted in the analysis, the prospect of payment at the damages stage induces the lawyer to provide effort at the liability stage, which implies no transfer at the first period. As noted in Introduction, this is, to our knowledge, the first paper that analyzes the moral hazard problem between a lawyer and her client within the specific context of sequential litigation, whereas this context is common in practice.

However, our analysis has only just scratched the surface of the various matters that impinge on this issue, and some extensions and generalizations suggest themselves. First, as mentioned in the paper, we consider a full commitment regime by ruling out the possibility of renegotiation after the liability stage and before the damages one. In other words, we assume that the plaintiff can *ex-ante* commit not to renegotiate the contract after the first period is over. A further step toward realism would be to embed the present framework in a more general setup implying renegotiation-proof contracts.¹³

In the same way, the analysis has been deliberately restricted to the case where the damages may take only two values (*i.e.* $J \in \{0, J_H\}$), which enables us to consider t_2 as a fixed payment. Following some analytical developments in the literature on contract theory (see, *e.g.*, Innes, 1990; Poblete and Spulber, 2012), it would be interesting to extend our framework by considering that both effort and output (*i.e.* damages) are continuous. Such an analysis would be significantly more intricate, but would provide a more complete and robust approach of the moral hazard problem in sequential litigation. It would certainly allow to develop new insights on the optimal payment scheme arising in this context.

Furthermore, we restrict our attention to the case of separation between liability and damages, while the sequentiality of the litigation process may refer to any situation where the issues of disagreement are treated successively by the court. In such a context, the parties litigate ‘issue 1’ after which the court makes a decision about ‘issue 1’. Then, the parties litigate ‘issue 2’ after which the court makes a decision about ‘issue 2’, and so forth. As mentioned by De Mot (2012), courts have opportunities to separate issues at trial in many countries, and it would be then interesting to extend our framework in order

¹³See, *e.g.*, Wang (2000) and Zhao (2006) who analyze renegotiation problems in more general frameworks.

to embed such – more general – situations. For example, in the U.K., according to Rule 3.1(2)e of the Civil Procedure Rules, the court may order that part of any proceedings (such as counterclaim) be dealt with separate proceedings. Similar possibilities may be found in the U.S. Federal Rules of Civil Procedure.

APPENDIX. PROOF OF PROPOSITION 1

The maximization problem of the plaintiff may be written as:

$$\begin{aligned}
 & \max_{\{h_1, h_2, t_1, t_2\}} \Pi = h_1(-t_1 + h_2(J_H - t_2)) \\
 & \text{s.t.} \\
 & t_1 \geq 0 \quad (LL_1) \\
 & t_2 \geq 0 \quad (LL_2) \\
 & U_1 = h_1(t_1 + U_2) - c_1(h_1) \geq 0 \quad (IR_1) \\
 & U_2 = h_2 t_2 - c_2(h_2) \geq 0 \quad (IR_2) \\
 & t_1 + h_2 t_2 - c_2(h_2) - c'_1(h_1) = 0 \quad (IC_1) \\
 & t_2 - c'_2(h_2) = 0 \quad (IC_2)
 \end{aligned}$$

Furthermore, recall that the effort cost functions satisfy $c'_i \geq 0$, $c''_i > 0$, $c'''_i \geq 0$, $c_i(0) = 0$, $c'_i(0) = 0$ and $c'_i(1) \geq J_H$ (with $i = 1, 2$). Moreover, we assume that c''_i is high enough to ensure the concavity of the objective function.

Let us show that (IR_1) , (IR_2) and (LL_2) are satisfied:

- From (IC_1) we get $t_1 = -h_2 t_2 + c_2(h_2) + c'_1(h_1)$. Replacing t_1 and U_2 by their values in U_1 gives $U_1(h_1) = h_1 c'_1(h_1) - c_1(h_1)$. Since $U_1(0) = 0$ and $U'_1(h_1) = h_1 c''_1(h_1) \geq 0$, we have $U_1(h_1) \geq 0$, which implies that (IR_1) is satisfied.
- Replacing t_2 (obtained from (IC_2)) in U_2 gives $U_2(h_2) = h_2 c'_2(h_2) - c_2(h_2)$. Since $U_2(0) = 0$ and $U'_2(h_2) = h_2 c''_2(h_2) \geq 0$, we get $U_2(h_2) \geq 0$ and (IR_2) is satisfied.
- (LL_2) is induced by (IC_2) since $c'_2(0) = 0$ and $c''_2 > 0$.

After substituting for the values of t_1 and t_2 (obtained from (IC_1) and (IC_2)) into the plaintiff's objective function, we get the following reduced program:

$$\begin{aligned}
 & \max_{h_1, h_2} \Pi = h_1(-c'_1(h_1) - c_2(h_2) + h_2 J_H) \\
 & \text{s.t. } t_1 = c'_1(h_1) + c_2(h_2) - h_2 c'_2(h_2) \geq 0 \quad (LL_1)
 \end{aligned}$$

The Lagrange function is given by:

$$\mathcal{L} = h_1(-c'_1(h_1) - c_2(h_2) + h_2 J_H) + \lambda(c'_1(h_1) + c_2(h_2) - h_2 c'_2(h_2)),$$

where λ is the Lagrange multiplier.

The first-order conditions are then:

$$-h_1 c_1''(h_1) - c_1'(h_1) - c_2(h_2) + h_2 J_H + \lambda c_1''(h_1) = 0, \quad (\text{A.1})$$

$$h_1 (-c_2'(h_2) + J_H) - \lambda h_2 c_2''(h_2) = 0, \quad (\text{A.2})$$

$$\lambda (c_1'(h_1) + c_2(h_2) - h_2 c_2'(h_2)) = 0, \quad (\text{A.3})$$

First, consider that $\lambda = 0$. In this case, we get $J_H = c_2'(h_2)$ from (A.2). Replacing J_H in (A.1) gives $-h_1 c_1''(h_1) - c_1'(h_1) = c_2(h_2) - h_2 c_2'(h_2)$. The constraint (LL_1) may be rewritten as $c_1'(h_1) + c_2(h_2) - h_2 c_2'(h_2) = -h_1 c_1''(h_1) < 0$. Hence, $\lambda = 0$ cannot be a solution.

Now, assuming that $\lambda > 0$, the constraint (LL_1) is binded (*i.e.* $t_1^{SB} = 0$). Considering $h_1 = 0$, the condition (A.2) is satisfied if and only if $h_2 = 0$ (since $c_2'' > 0$). However, in this case, the condition (A.1) cannot be satisfied since $\lambda c_1'' > 0$. Hence, $h_1 = 0$ cannot be a solution. Considering $h_2 = 0$, the condition (A.2) becomes $h_1 J_H = 0$ and it cannot be satisfied since $h_1 > 0$.

We conclude that $h_2^{SB} \in (0, h_2^{FB})$ since:

$$\left. \frac{\partial \mathcal{L}}{\partial h_2} \right|_{h_2=h_2^{FB}} = -\lambda h_2 c_2''(h_2) < 0 \quad (\text{A.4})$$

$$\text{and } \frac{\partial^2 \mathcal{L}}{\partial h_2^2} = -h_1 c_2''(h_2) - \lambda (c_2''(h_2) + h_2 c_2'''(h_2)) < 0 \quad (\text{A.5})$$

Following (A.3), we know that $c_1'(h_1) = U_2(h_2)$ in both first- and second-best situations, where $U_2(h_2) = h_2 c_2'(h_2) - c_2(h_2)$. Since $h_2^{SB} < h_2^{FB}$ and $U_2'(h_2) > 0$, we get $c_1'(h_1^{FB}) = U_2'(h_2^{FB}) > c_1'(h_1^{SB}) = U_2'(h_2^{SB})$. Following $c_1'' > 0$, we conclude that $h_1^{SB} \in (0, h_1^{FB})$.

Finally, the optimal value of t_2 is induced by the constraint (IC_2), such that $t_2^{SB} = c_2'(h_2^{SB})$.

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