REGULATING PRICE-LIABILITY COMPETITION TO IMPROVE WELFARE

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Abstract

This paper examines regulation in markets where firms choose price-liability combinations. Our setting (which differs from the insurance model in assuming symmetric information) is inspired by the demand for delicate medical procedures even when the possibility of catastrophe is common knowledge. Our work implies that a recently suggested regulatory rule, restricting the maximum liability that can be assumed, does not increase consumer welfare. In fact, such regulation may result in a Pareto inferior market outcome, leaving firms as well as consumers worse off. We also study a rule inspired by the German audit market, in which maximum liability is restricted but only as a multiple of the price. This reduction in the dimensionality of firm's strategy space is shown to reduce consumer welfare, if the liability-price multiple is smaller than the multiple observed under no regulation. However, even larger liability-price multiples could leave consumers worse off.

I. Introduction

This paper focuses on a particular class of markets, viz. one in which competition among firms takes place via choices of price and maximum liability level. It is inspired mainly by the market for very delicate medical procedures (though in what follows we argue that a segment of the audit market also exhibits some of the same characteristics). Our model is different from the standard insurance model chiefly in not assuming asymmetric information which generates an adverse selection problem.

Our motivation stems from a consideration of contemporary arguments for regulation, and for regulation of a particular variety, in these markets. A fundamental problem arises in these markets even without asymmetric information. A delicate medical procedure is often intensely desired, even when the probability of success is (commonly) understood to be small. A failure can often result in a malpractice suit, and possible damages can be very large.

The risk is best classified as "catastrophic" in nature, and insurance is typically not available, either because the cost is prohibitive, or because the ethics of supporting such practices are still a matter of debate[1]. Nevertheless, there are some who advocate the adoption of such delicate medical procedures, when they are freely demanded by people who would otherwise be considered to be of sound mind.

It is felt that the current unregulated environment permits the few doctors who have the financial capacity to accept the risks to charge "exploitative"

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1. In other words, we model a market with an insurance "availability" problem (see for example Nye and Hofflander, 1987).

fees. In this context it has been argued that if legislation limited the maximum liability that could attach to a physician, more physicians would enter the market, and fees would become more "reasonable".

One goal of this paper is to show that there is a fallacy in this argument (even if we take as given the desirability of encouraging such procedures). For one thing, consumers are also affected by maximum liability legislation: ceteris paribus, they would desire more liability coverage. For another, this type of market exhibits a property similar to one found in "contestable markets": restricting the advantage of the superior or stronger firm cannot possibly improve consumer welfare, which is determined by the "marginal" firm, the firm which is just outcompeted away in the battle for the consumer, i.e. by the firm which does NOT participate in the market. We show that the "opposite" kind of legislation, which would strengthen the hand of the weakest doctor, could improve consumer welfare.

These results can be applied to the audit market as well. Recent events (e.g. the DeLorean scandal in the UK) have renewed the debate about whether audit firms should have limited liability (currently, most countries do not allow limited liability). This debate has recognised that even with full adherence to due process by an auditor, there will remain at least a small probability of a major catastrophe, simply because audit technology is imperfect[2]. In a related context, Francis (1984) and Palmrose (1986) and others, have studied the relationship between audit firm size and audit fees. One hypothesis put forward by these studies is that the "Big Eight"[3] charge higher audit fees because of market power or higher quality[4]. This

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2. Note that this imperfection is different from and independent of the moral hazard concerns that have dominated the theoretical literature in auditing.
3. The "Big Eight" refers to the largest eight auditing firms.
4. There is also the competing hypothesis that larger firms charge lower prices because of economies of scale (see Simunic, 1980, for evidence).

paper suggests that "big" firms (in unregulated markets) charge higher audit fees because they can offer higher (effective) liability levels, thereby outcompeting others. Furthermore, this paper argues that regulation that imposes maximum liability levels does not benefit the consumer, and may hurt the "Big Eight".

We also consider another type of regulatory regime, in which the regulator is not required to identify candidates for selective assistance. It is inspired by observation of an actual market, the German audit market, where (in contrast to audit markets elsewhere) liability is limited, but only as a multiple of the audit fee. In other words, it imposes a different restriction on the price-liability strategy space -- it reduces its dimensionality -- by allowing only "standardized contracts". We analyze the effect of such a rule on prices and welfare. It is shown that the "German Rule" reduces consumer welfare, if the liability-price multiple is smaller than the multiple observed under no regulation. However, even larger liability-price multiples could leave consumers worse off.

II. The Model

The model we use is a simple sequential game of four stages[5]. There are two firms (i=1,2) competing for one customer by choosing a level of liability, l_i, and a price, p_i, for a single homogeneous product or

5. Given the clear possibility of knowing the identity of the consumer (patient) in these markets, and discriminating accordingly, it turns out that the order of the first two stages is immaterial to our results -- and they could even be simultaneous.

service[6]. Each firm has an endowment of initial wealth, w_i. We capture asymmetry between the two firms by letting firm 1 have a larger initial endowment, $w_1 > w_2$.

The sequential rules are as follows. In stage 1, the larger firm, i.e. firm 1, chooses a liability-price combination. In stage two, firm 2 chooses its price-liability combination, (l_2, p_2). Stage three has the customer choose one of the two firms to perform the service. In the final stage, nature chooses a damage level, $d=\tilde{d}$, where d has the probability density function f(d). Both firms and the customer are risk averse. The customer's preferences are defined over end of period wealth, H, by a utility function U(H), such that $U'(H)>0$ and $U''(H)<0$. At stage three, the customer maximizes her expected payoff by choosing one of the two firms, i.e. she solves the following program,

$$(1) \qquad \max_i E(U) = \int_0^{l_i} U(-p_i)f(d)dd + \int_{l_i}^{\infty} U(-p_i-d+l_i)f(d)dd$$

The first term relates to the event of all damages being covered by the liability limit, and the second term relates to the event when damages are higher than liabilities. As is shown in the appendix, E(U) is increasing in l_i and decreasing in p_i.

To complete the formal description of the model we define the firm's payoff functions, V(H), such that $V'(H)>0$ and $V''(H)<0$. To capture the fact that richer firms are more willing to shoulder risk, firms are assumed to have decreasing absolute risk aversion. The expected payoff is then,

6. We restrict attention to the case with a single customer, because this is the simplest setting in which we can examine contemporary arguments for regulation. With more customers, we need to worry about extraneous issues, such as whether the risks are correlated, which are irrelevant given the focus of the paper.

$$(2) \qquad E(V_i) = \int_0^{l_i} V(w_i+p_i-d)f(d)dd + \int_{l_i}^{\infty} V(w_i+p_i-l_i)f(d)dd,$$

if firm i "wins" the contract and,

$V(w_i)$, the reservation value, if firm i "loses".

Similarly, the first term in E(V) relates to the event of all damages being covered, whereas the second term relates to the event when damages are not covered. Again, $E(V_i)$ is increasing in p_i and decreasing in l_i (see the appendix).

We focus on the **subgame-perfect** equilibrium. The fact that firm 1 has a higher resource allocation (i.e. $w_1 > w_2$), and that both firms are risk averse, implies from (2) that firm 1 enjoys higher expected profits over its reservation value at any given point in price-liability space. Since only one firm will "win" the customer, it is clear that firm 1 will offer price-liability combinations that cannot be undercut by firm 2. In other words, firm 1 will always "win" the customer.

This allows us to substantially simplify the computation of the equilibrium. Firm 1 will offer just enough to make the customer indifferent between its price-liability offer and firm 2's best offer. Thus firm 1 will compute the following maximum level of utility the customer can obtain from firm 2,

$$(3) \qquad \max_{p_2, l_2} E(U) = \int_0^{l_2} U(-p_2)f(d)dd + \int_{l_2}^{\infty} U(-p_2-d+l_2)f(d)dd$$

s.t.

$$E(V_2) = \int_0^{l_2} V(w_2+p_2-d)f(d)dd + \int_{l_2}^{\infty} V(w_2+p_2-l_2)f(d)dd \geq V(w_2)$$

Normalizing $V(w_2)$ at zero and using the fact that V is monotonic in p_2 and l_2 (see the appendix), we can write the constraint as,

$$(4) \qquad F(l_2) = 1 + \int_0^{l_2} \frac{V(w_2+p_2-d)}{V(w_2+p_2-l_2)} f(d)dd$$

where F(.) denotes the distribution function of d. Substituting (4) back into (3) gives us,

$$(5) \quad \max_{p_2, l_2} \quad V(-p_2) \left[1 + \int_0^{l_2} \frac{V(w_2+p_2-d)}{V(w_2+p_2-l_2)} f(d)dd \right] + \int_{l_2}^{\infty} U(-p_2-d+l_2)f(d)dd$$

Denote the solution to (5) by p_2^*, l_2^* and the associated maximum level of utility $\bar{U}$. Thus, a subgame perfect equilibrium is a liability-price choice (p_1^{**}, l_1^{**}) that will maximize firm 1's payoff subject to the customer's utility of at least $\bar{U}$. Hence we get the following remark.

<u>**Remark**</u>: (p_1^{**}, l_1^{**}) is a subgame perfect equilibrium if and only if it maximizes (2) s.t. $E(U) = \bar{U}$.

This result is demonstrated graphically in Figure 1. The iso-payoff curves for each firm (i.e. the implicit relationships l(p), defined by (2) holding $E(V_i)$ constant), are increasing and concave[7], as drawn in Figure 1. Furthermore, since firm 1 has higher initial wealth, it follows from decreasing absolute risk aversion that its iso-payoff curves have a steeper slope in general, representing the fact that firm 1 is willing to accept more liability (relative to firm 2) for any given price increase.

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7. See the appendix for conditions sufficient for $l'(p)>0$ and $l''(p)<0$.

Similarly, the consumers indifference curves are increasing and convex[8], as drawn in Figure 1.

Insert Figure 1 about here

Given that the iso-payoff curves for the two firms and the customer are shaped as in Figure 1, it is clear that the price-liability choice offered by firm 2 (i.e. point A in Figure 1, which is the solution to (5)) is smaller than the price-liability choice of firm 1 (i.e. point B in Figure 1).

III. Maximum Liability Rules (MLR) and Subsidies

In this section we investigate the effects of MLR on consumer welfare. The MLR rule is imposed on the above equilibrium via the additional two constraints, $\bar{l} \geq l_i$, i=1,2, where $\bar{l}$ denotes the liability limit. Depending on the magnitude of $\bar{l}$ there are two distinct cases to be considered in turn[9]. First, the case of maximum liability limits below the larger firm's offer, yet still above the smaller firm's offer, i.e. $l_1^{**} > \bar{l} \geq l_2^{*}$. In this case, as can be seen in Figure 2, the solution to (5), is unchanged by

8. See appendix for conditions to ensure $l'(p)>0$ and $l''(p)>0$.
9. There is of course a third case where the constraints are non-binding, i.e. $\bar{l} \geq l_1^{**} \geq l_2^{*}$, resulting in the identical equilibrium as in the previous section.

Insert Figure 2 about here

the additional constraints. Hence, consumer welfare ($\bar{U}$) is unchanged. However, the price-liability contract will change, since firm 1's optimal unconstrained solution (point B) is infeasible. Given the monotonicity properties, it is apparent that the new contract is at point $C=(\bar{p}_1,\bar{I})$, resulting in a payoff reduction for firm 1 to $\overline{E(V_1)}$. Thus the overall result of such liability rules is a price decrease as well as a liability coverage reduction to the legislated level. The consumer, however, does not benefit. Furthermore, due to the lower payoff to firm 1, the MLR results in a overall welfare loss, moving the market to a Pareto inferior outcome. This is demonstrated graphically in figure 2, where Pareto improvements from point C are indicated by the shaded area.

Second, we consider the case of maximum liability limits below both firms optimal offers, i.e. $l_2^* > \bar{I}$. Graphically, this is demonstrated in Figure 3.

Insert Figure 3 about here

Now firm 2's optimal offer is constrained and consequently the solution to program (5), which is denoted $C=(\bar{p}_2,\bar{I})$, results in a utility reduction for the consumer to $\tilde{U}$. Given the monotonicity property and decreasing absolute risk aversion, it is clear that firm 1's offer must be the same as firm 2's. The effect on firm 1's payoff, however, is ambiguous. On one hand, firm 1 gains by having to satisfy a lower utility level $\tilde{U}$, on the other hand firm

1's liability space is constrained. The effect on firm 1's payoff, as well as on overall welfare, thus depends on the precise parametrization of the model. To summarize, it can be stated that the impact of MLR is not to increase competition and increase consumer welfare, but more likely to result in the opposite effect.

There is, however, a different policy instrument that will have the desired positive effect on consumer welfare. A subsidy, (s), to the smaller firm[10], if added to the initial wealth endowment, will improve the position of firm 2 relative to firm 1. Since the consumers utility, $\bar{U}$, is determined by firm 2's ability to compete it follows that the consumer must benefit from the subsidy. To see this consider the solution to (5), which is the consumer's utility $\bar{U}$. Let (p_2^*,l_2^*) denote the solution to (5) without any subsidy. Substituting w_2+s for w_2, (p_2^*,l_2^*), as well as the reservation value $V(w_2+s)$ into (5) yields,

$$V(-p_2^*)\left[1+\int_0^1 \frac{V(w_2+s+p_2^*-d)}{V(w_2+s+p_2^*-l_2^*)} f(d)dd + \frac{V(w_2)}{V(w_2+s+p_2^*-l_2^*)}\right] + \int_{l_2^*}^{\infty} U(-p_2^*-d+l_2^*)f(d)dd$$

which is increasing in s, for s in $(0,w_1-w_2)$. Thus the consumer's maximum utility $\bar{U}$ is higher under the subsidy. Firm 1, however, is clearly worse off under the subsidy system, since a more "competitive" price liability offer is needed to win the contract. The overall welfare effect is dependent on the precise magnitudes of this payoff loss to firm 1 and the welfare increase to the customer[11].

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10. This selective assistance requires, of course, identification of the smaller firm.
11. Note that firm 2 is not affected by the subsidy. Also note that the subsidy is never paid in equilibrium and consequently no welfare distortions arise.

IV. The German Rule

Finally, we consider a third legislative action. The "german rule" restricts the strategy space from two dimensions into one by requiring that the liability is a multiple of the price charged, i.e. $l_i = np_i$. The presumed rationale behind such a rule is that it is "fair" to the customer and therefore improves consumer welfare, especially so if n is relatively large. As we will demonstrate next, it is not true that consumers always benefit under the german rule, even if n is "large".

Since firm 2's strategy space is now constrained by the german rule and the consumers preferences are unchanged, it follows that the solution to (3), i.e. $\bar{U}$, will generally be lower. Denote this new level of consumer utility by $\tilde{U}$. This reduction in consumer welfare is however counterbalanced by the constraint on firm 1's strategy space, i.e. the german rule as it applies to firm 1. The combined outcome on consumer welfare is thus dependent on which effect dominates. In particular, we can get the following two results.

Proposition 1: If $n > l_1^{**}/p_1^{**}$ (i.e. n is larger than under no regulation), then consumer welfare may still decrease under the german rule.

Proof: by graphical example, see Figure 4.

Insert Figure 4 about here

The original equilibrium (l_1^{**}, p_1^{**}) is at point B, with the associated utility $\bar{U}$. Under the german rule the maximum level of consumer utility from firm 2 changes to $\tilde{U}$. This implies that firm 1 maximizes $E(V_1)$ over the segment (R1,R2). If the maximum is on the line segment (T1,T2), for instance at point C, then consumer welfare increases relative to B. On the other hand, if firm 1 optimizes on the line segment (R1,T1), for instance at point D, consumers are worse off. The same scenario is possible with line segment (R2,T2).q.e.d.

The reason why consumer surplus decreases even for large n is that the constraint on firm 1's strategy space via the german rule forces the incumbent to maximize at a point which reduces consumer welfare. In fact, since firm 1's payoff may decreases as well, it follows that total welfare may decrease, leaving everybody worse off.

Proposition 2: If $n < l_1^{**}/p_1^{**}$ (i.e. n is smaller than under no regulation), then consumer welfare decreases under the german rule.

Proof: Recall that any equilibrium price-liability choice must give the consumer at least $\tilde{U}$ and satisfy the german rule, $l_i = np_i$. Consider two cases corresponding to Figures 5.1 and 5.2. Case 1 (Figure 5.1): the iso-profit

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Insert Figure 5.1 and 5.2 about here

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line $\bar{U}$ does not intersect the line $l = np$. In this case, it is clear that any price-liability choice which gives the consumer a higher utility than $\bar{U}$ does not satisfy the german rule. Equilibrium must be on the segment (R1,R2) with lower utility for the consumer. Case 2 (Figure 5.2): the iso-profit line $\bar{U}$ does intersect the line $l = np$. We must show that equilibrium can not occur on the line segment (T1,T2). Let l_1^{**}/p_1^{**} be at point B. Thus, point B is a point of tangency, i.e. we can draw a separating hyperplane (in our case simply a tangent) which will separate the "preference sets" of consumer and firm 1. This tells us that firm 1's entire set of more preferred (p,l) combinations, except for point B, lie completely separate with the consumer's preference set bounded by the iso-utility curve $\bar{U}$. So when constrained by l=np, firm 1's optimum, which must lie in its "preferred set" must be outside (T1,T2). q.e.d.

To conclude this section, it can be stated that it is far from obvious what the effect of the german price-liability rule is. Even for the case of a relatively large n (relative to the free market equilibrium of section II), consumers may be harmed. In fact, the highest welfare losses are likely to occur for large n, leading to a Pareto inferior market outcome.

V. Conclusion

This paper examines regulation in markets where firms choose price-liability combinations. The basic findings point towards the fact that any of the suggested regulatory actions intended to improve consumer welfare, may very well have the opposite effect. Furthermore, in some cases, not only is the consumer worse off, but so is the firm supplying the service, leading to a Pareto inferior market outcome. On the other hand, it is argued that subsidies to the smaller firm improve consumer welfare.

Appendix-Monotonicity and Iso-Payoff Curves

In this section (in what follows we drop the firm specific subscript) we show that the firm's iso-payoff curves, l(p), defined by (2) are increasing in p, list the condition for l to be concave in p, and show that E(V) is monotonically increasing in p and decreasing in l. Similarly, we show that the customer's indifference curves, l(p), defined by (1) are increasing in p, list the condition for l to be convex in p, and show that E(U) is monotonically decreasing in p and increasing in l.

First, we show that the firm's iso-payoff curves, i.e. l(p) holding E(V) constant, is increasing in p, i.e. $l'(p)>0$. Holding E(V) constant, we implicitly differentiate (2) w.r.t p. Using Leibniz's Rule we obtain,

$$E[V'(w+p-d)|d\leq l] + V'(w+p-l)\ [1-l'(p)]\ [1-F(l)] = 0.$$

Solving for $l'(p)$,

$$\text{(A1)} \qquad l'(p) = 1 + \frac{E[V'(w+p-d)|d\leq l]}{V'(w+p-l)\ [1-F(l)]},$$

which is positive given the assumption on V'. Since $l'(p)>0$, it follows from the fact that E(V) is monotonically increasing in p, that E(V) is monotonically decreasing in l. For concavity, we must have $l''(p)<0$. This implies, by differentiating (A1) implicitly w.r.t p (again using Leibniz's Rule),

$$[1-F(l)]\Big[V'(w+p-l)\ f(l)\ l'(p) + E[V''(w+p-d)|d\leq l]\Big] +$$

$$E[V'(w+p-d)|d\leq l]\ \left[[l'(p)-1]\ \frac{V''(w+p-l)}{V'(w+p-l)}\ [1-F(l)] + f(l)\ l'(p)\right] < 0,$$

which is assumed to hold. Note that risk aversion is a necessary condition since $l'(p)>1$.

Next, we show that the customer's indifference curves, i.e. $l(p)$ holding $E(U)$ constant, is increasing in p, i.e. $l'(p)>0$. Holding $E(U)$ constant, we implicitly differentiate (1) w.r.t p. Using Leibniz's Rule we obtain analogously to the firm's problem,

$$\text{(A2)} \qquad l'(p) = 1 + \frac{U'(-p)F(l)}{E[U'(-p-d+l)|d\geq l]},$$

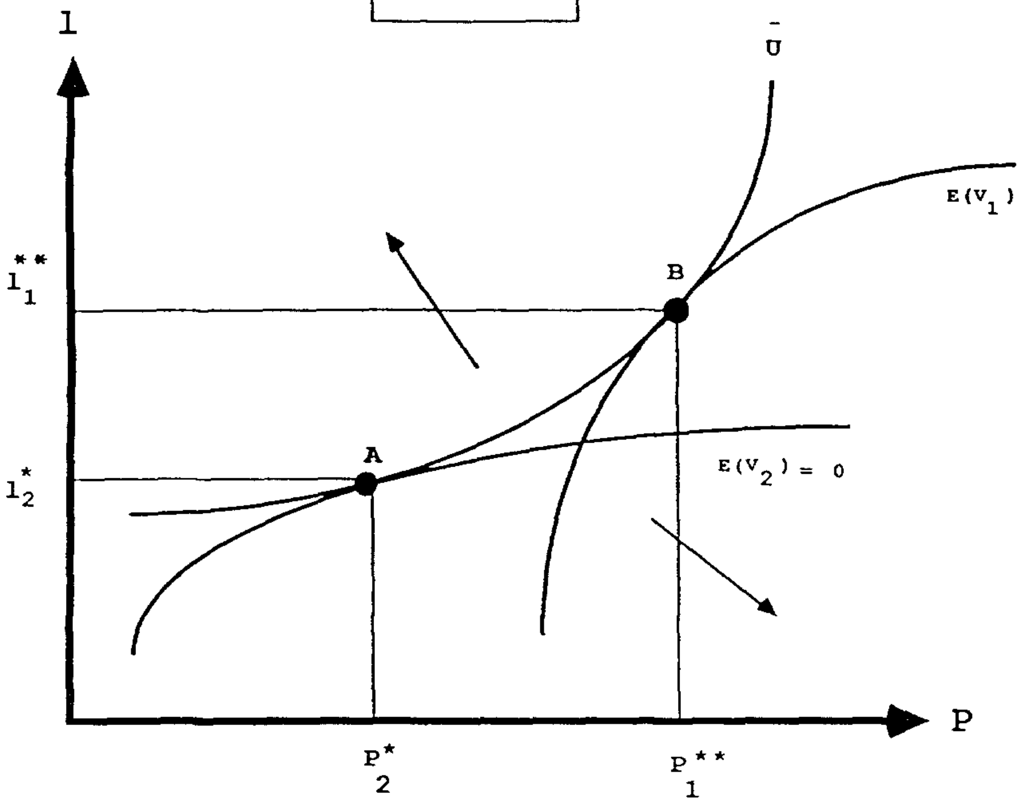
which is positive given the assumption on U'. Since $l'(p)>0$, it follows from the fact that $E(U)$ is monotonically decreasing in p, that $E(U)$ is monotonically increasing in l. For convexity, we must have $l''(p)>0$. This implies, by differentiating (A2) implicitly w.r.t p (again using Leibniz's Rule),

$$E[U'(-p-d+l)|d\geq l] \left[f(l)\ l'(p) - U''(-P)\ F(l)\right]$$

$$- F(l) \left[E[U''(-p-d+l)|d\geq l]\ [l'(p)-1] - U'(-p)\ f(l)\ l'(p)\right] > 0,$$

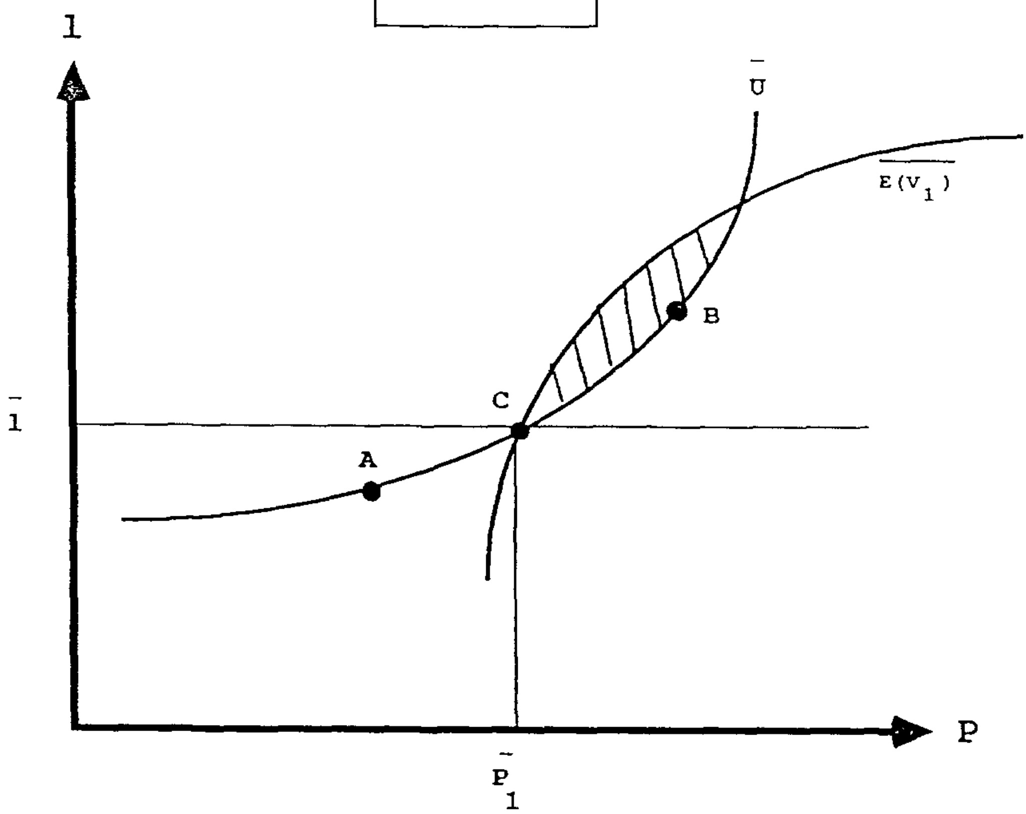
which is assumed to hold.

FIGURE 1



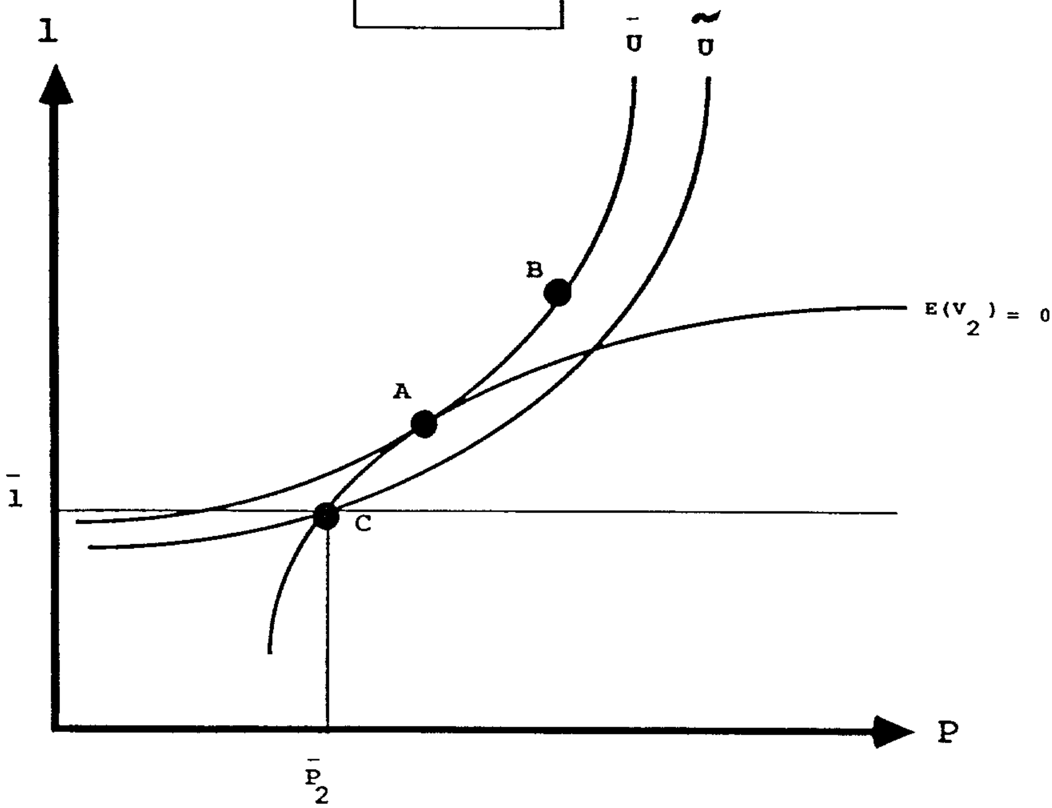
Note: The arrows indicate the direction of increased payoff to the firms and the customer

FIGURE 2



Note: Points A and B are defined as in Figure 1.
The shaded area is the region of mutual welfare gain

FIGURE 3



Note: Points A and B are defined as in Figure 1.

FIGURE 4

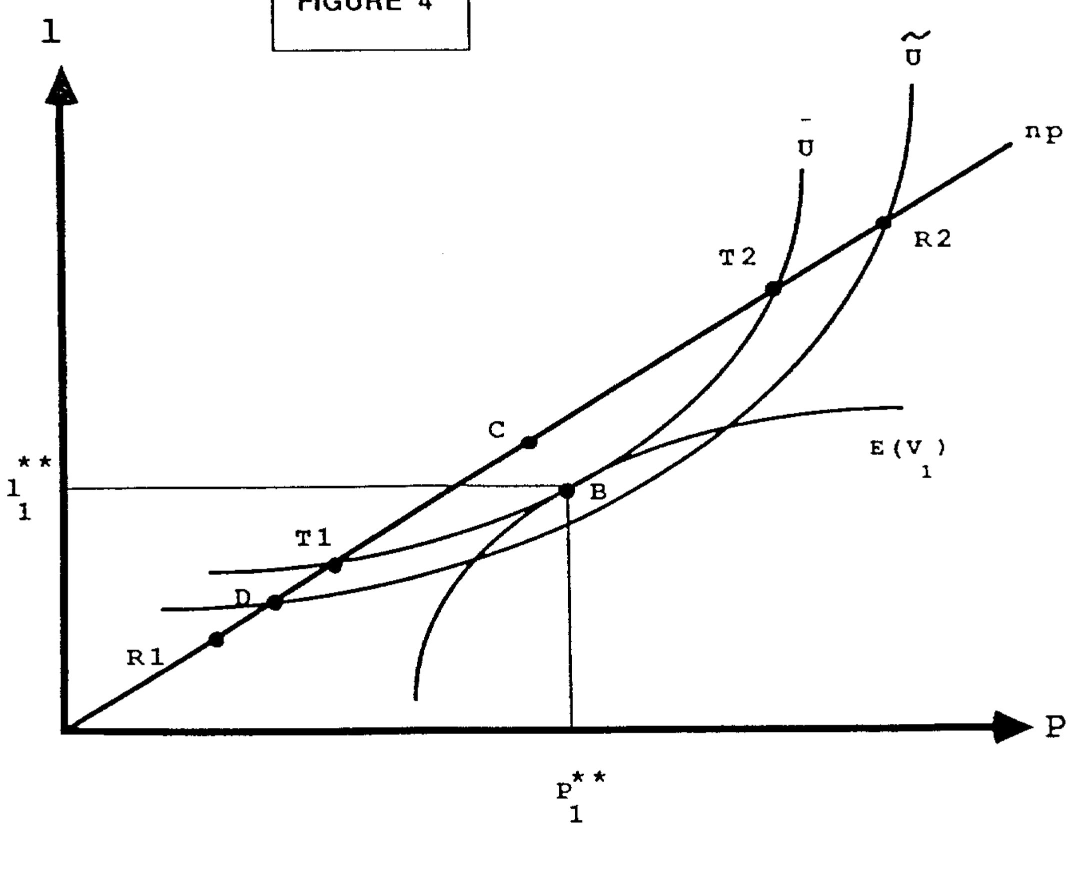


FIGURE 5.1

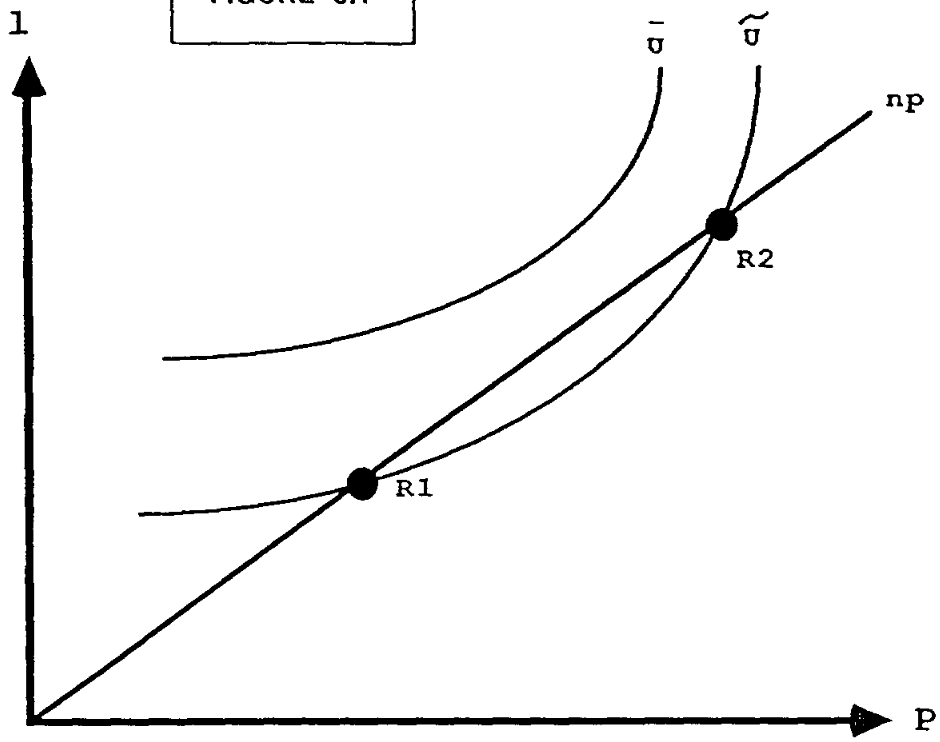
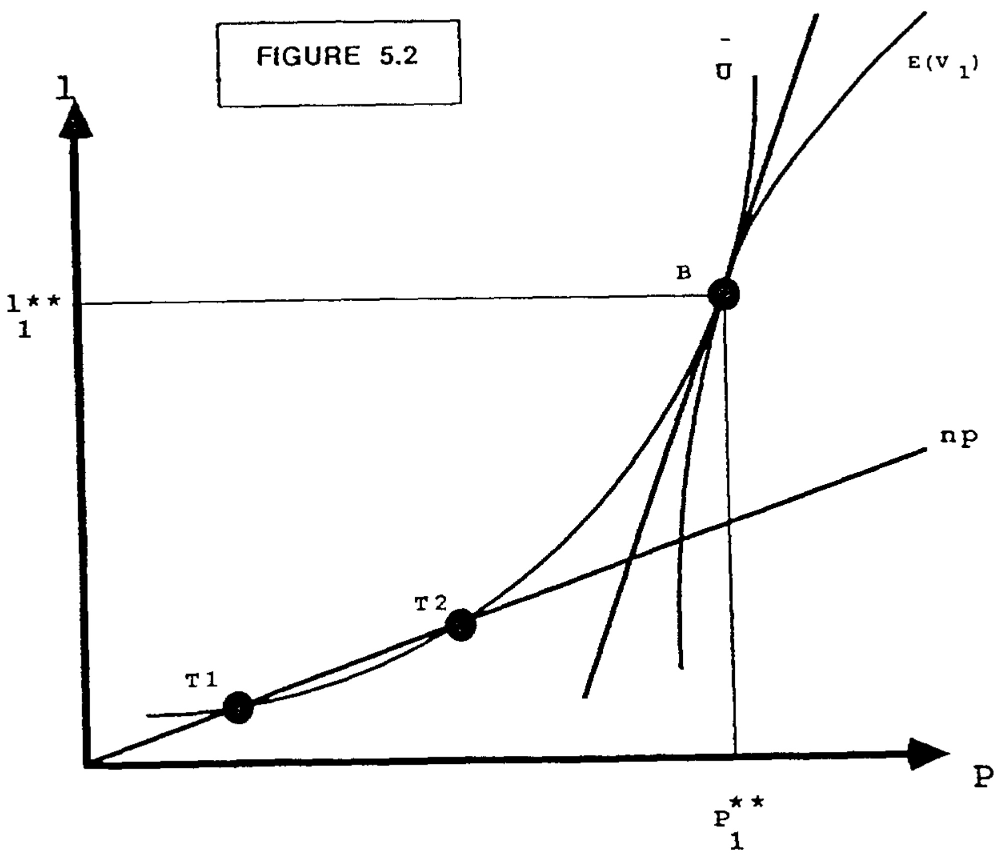


FIGURE 5.2



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