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To fight or not to fight? An analysis of submission, struggle, and the design of contests

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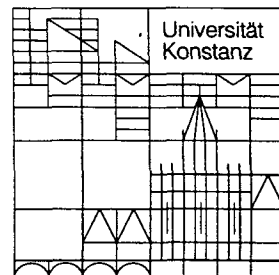
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**Sonderforschungsbereich 178
„Internationalisierung der Wirtschaft“**

Diskussionsbeiträge



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To Fight Or Not To Fight?

An Analysis of Submission, Struggle, and the Design of Contests*

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Abstract:

This paper considers the players' behaviour in an asymmetric two-player contest. When do they decide to "struggle" and when to "subjugate"? Analysing contest-success functions it is found that two crucial prerequisites for "struggle" or "war" have to be met. Thus, such an equilibrium is possible but restrictive. If a self-interested rule-setter chooses the contest-success function endogenously we show that one player will always subjugate. Applications to rent-seeking and environmental regulation are discussed.

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1. Introduction

Economic behaviour can often be described as a contest. Examples are: Wars, election campaigns, seeking politically contestable rents, and R & D races. Different aspects of such contests have been analysed in the literature. Much attention has been paid to the social costs of rent-seeking contests¹. Dixit (1987), for example, analyses how the possibility to pre-commit on the rent of one contestant influences the effort levels. Reasons for under- or overdissipation are given by Tullock (1980), Hillman/Katz (1989), Hillman/Riley (1989), and Ursprung (1990). Dasgupta/Stiglitz (1980), Dasgupta (1986), and Leininger (1991) concentrate on R & D- rivalry and patent competition.

Using the terminology of a military combat apart from "war" and "peace", "one-sided submission" - as Hirshleifer (1989) noted - is a possible outcome of a contest. But under which circumstances will a player in a contest fight and when will she subjugate? In this paper we derive the conditions for "war" and "one-sided submission" in a Cournot-contest by analysing the properties of contest-success-functions (CSF). It turns out that the conditions for "war" are restrictive. Thus, if this equilibrium is used, it needs some kind of justification. Illustrating our results with two popular CSF we can show that the Hirshleifer function (differences) can only produce corner solutions which correspond to a situation of "one-sided submission", whereas the Tullock function (ratios) leads to "war".

If the design of the CSF is under the authority of the master of the game trying to follow its own interests, will he choose "war" or "one-sided submission"? The CSF can be made endogenous if one thinks e.g. of a contest as a lobbying game and of the master of the game as a regulator or state². This means that the regulator can use the choice of the CSF as a strategic variable to achieve its own goals. We show that he has no incentive to choose sophisticated CSF's like those proposed by Tullock (1980) or Hirshleifer (1989). If we assume the regulator to be revenue-maximising he will always select "one-sided submission" which can be implemented by a simple take-it-or-leave-it offer.

The paper proceeds as follows. In the context of a Cournot-duopoly we first derive conditions for "one-sided submission" and "war" in lobbying contests by paying special attention to both firms' reaction functions in the lobbying contest. We conclude the analysis of lobbying

¹ For a detailed survey of the literature see Nitzan (1994).

² Throughout our analysis we use the terms "regulator" and "state" as synonyms.

functions with an application of our results to the renowned CSF's of Tullock (1980) and Hirshleifer (1989). In a second step we introduce the idea of a state using the choice of the CSF to maximise its revenues. In section 3 we conclude our analysis.

2. When to Fight in an Asymmetric Two-Player Contest?

2.1 Theoretical Considerations

We analyse the strategic interaction between two players in a two-stage decision problem. In order to give a straightforward economic interpretation we use the terminology of a Cournot duopoly³. Both competitors or firms can influence the regulation by making contributions L_1 and L_2 to the state⁴. Depending on these lobbying efforts the state can burden firm 2 with a tax $[t]$, while firm 1 will never be subject to such regulation. Afterwards both competitors choose their (homogenous) outputs x_1 and x_2 which are produced with constant-returns-to-scale technologies. Using the terminology of Salop/Scheffman (1983) one could think of firm 1 as engaging in "Raising Rivals' Costs" by influencing the state to implement regulation which disadvantages its competitor⁵. Thus, the tax $[t]$ could, for example, be interpreted as a pollution tax if one assumes that firm 2 uses a "dirtier" technology than firm 1⁶. We, therefore, arrive at both firms' costs given by

$$C_1 = b x_1, \tag{1}$$

$$C_2 = (b + t) x_2, \tag{2}$$

where $[b]$ indicates constant average and marginal production costs. The price $[P]$ is determined by the (linear) inverse demand function

$$P = a - X \quad \text{with} \quad X = x_1 + x_2. \tag{3}$$

Maximising profits $[\pi]$ for a given tax $[t]$ leads to:

$$\pi_1 = \frac{1}{9}(a - b + t)^2, \tag{4}$$

$$\pi_2 = \frac{1}{9}(a - b - 2t)^2. \tag{5}$$

³ Nevertheless, every fixed or variable rent contest may be characterised by the our results.

⁴ To give an example for lobbying contributions one can think of campaign contributions for political parties, perquisites for bureaucrats and politicians, etc.

⁵ Oster (1982) stresses the importance of regulation as a strategy to weaken competitors in the market place.

⁶ See Maloney/McCormick (1982).

Hence, we have introduced an asymmetry⁷ into the model by a redistribution of market shares from firm 2 to firm 1 through the implementation of a tax⁸. Furthermore, in our model of an endogenous rent the profits of firm 1 are higher and those of firm 2 lower than in the standard duopoly result.

At the first stage of the decision problem the state may either implement a high tax rate $[\bar{t}]$ or a low one $[\underline{t}]$, $\bar{t} > \underline{t}$. As the equations (4) and (5) indicate, firm 1 has an interest in implementing the high tax rate, while firm 2 will try to keep the tax rate as low as possible and acts as a rent-defender⁹. Nevertheless, it cannot be assured that both firms will always engage in lobbying. Therefore, we have to analyse the lobbying process.

We assume lobbying to influence the probability of implementing the high tax rate $[\bar{t}]$. This probability depends on the form of the contest-success function $[q]$ ¹⁰. Thinking of lobbying as technology we assume decreasing marginal returns from lobbying:

$$q: [L_1, L_2] \rightarrow [0,1] \text{ with } \frac{\partial q}{\partial L_1} \geq 0, \frac{\partial q}{\partial L_2} \leq 0, \frac{\partial^2 q}{\partial L_1^2} \leq 0, \frac{\partial^2 q}{\partial L_2^2} \geq 0, q(0, 0) = 0. \quad (6)$$

Both firms are assumed to be risk-neutral and, therefore, maximising their expected profits ($E[\pi_1]$, $E[\pi_2]$). "War" is the outcome of both firms' optimisation problems as long as the first-order (FOC_i) and second-order conditions (SOC_i) are satisfied. To ensure that it is profitable for the firms to engage in lobbying after all an additional constraint requires that a firm's profit is higher with lobbying than without lobbying (ICC_i)¹¹. Thus, we obtain for firm 1:

$$\max_{L_1} E[\pi_1] = q(L_1, L_2)\pi_1(\bar{t}) + (1 - q(L_1, L_2))\pi_1(\underline{t}) - L_1, \quad (7)$$

leading to

$$(FOC_1) \quad \frac{\partial E[\pi_1]}{\partial L_1} = 0, \quad (8)$$

⁷ The term "asymmetry" is somewhat ambiguous in the literature. Dixit (1987), for example, uses the term to describe a different treatment of both competitors by the CSF.

⁸ In a general lobbying model this is equivalent to a rent transfer from player 2 to player 1.

⁹ See Appelbaum/Katz (1986).

¹⁰ $(1-q)$ denotes respectively the probability of enacting the low tax rate.

¹¹ According to the literature on mechanism design we refer to these conditions as incentive-compatibility constraints (ICC_i).

$$(ICC_1) \quad E[\pi_1(L_1^*, L_2^*)] - E[\pi_1(0, 0)] \geq 0, \quad (9)$$

$$(SOC_1) \quad \frac{\partial^2 E[\pi_1(L_1^*, L_2^*)]}{\partial L_1^2} \leq 0. \quad (10)$$

Firm 2 maximises its expected profit respectively¹². For simplicity we assume that in the case of a low tax rate no tax at all is levied on firm 2's output [$\underline{t} = 0$]. The high tax [\bar{t}] is set equal to $\frac{1}{2}(a - b)$, which is the value where firm 2 drops out of the market¹³. Thus, the rent-seeking contest results in a game at stage 2 where either both competitors can earn symmetric Cournot duopoly profits or firm 1 can get a monopoly rent while firm 2 is forced to leave the market before subtracting lobbying outlays.

Using the implicit function rule we calculate the slope of the quasi-reaction functions¹⁴ ($RF_i, i = 1, 2$) from both firms' first-order conditions:

$$\left. \frac{\Delta L_1}{\Delta L_2} \right|_{RF_1} = \left\{ -\frac{q_{12}}{q_{11}} \text{ for } L_1 > 0; \max \left[0, -\frac{q_{12}}{q_{11}} \right] \text{ for } L_1 = 0 \right\}, \quad (11)$$

$$\left. \frac{\Delta L_1}{\Delta L_2} \right|_{RF_2} = \left\{ -\frac{q_{21}}{q_{22}} \text{ for } L_2 > 0; \max \left[0, -\frac{q_{21}}{q_{22}} \right] \text{ for } L_2 = 0 \right\}. \quad (12)$$

The slope of the quasi-reaction functions¹⁵ is the ratio of the cross-derivative and the direct second-derivative of the lobbying function. Both second derivatives indicate a change in the marginal effectiveness of lobbying. While q_{ii} represents the change due to a variation in a firm's own lobbying efforts, q_{ij} stands for the change in the probability [q] when the competitor shifts her efforts. Equation (6) demonstrates that $q_{11} < 0$ and $q_{22} > 0$. Thus, the cross-derivatives become decisive for the slope of the reaction functions. Young's theorem can be applied in this

¹² Note that firm 2's incentive compatibility constraint takes the following form:

$$E[\pi_2(L_1^*, L_2^*)] - E[\pi_2(L_1^*, 0)] \geq 0.$$

¹³ $\pi_2^0 = \frac{1}{9}(a - b - 2t)^2 = 0 \Leftrightarrow t = \frac{a - b}{2}$.

¹⁴ We call them quasi-reaction curves to stress that they only indicate a best answer as long as the relevant

$$ICC \text{ is not binding. Note that } q_{12} = \frac{\partial^2 q}{\partial L_1 \partial L_2}, q_{21} = \frac{\partial^2 q}{\partial L_2 \partial L_1}, q_{11} = \frac{\partial^2 q}{\partial L_1^2}, q_{22} = \frac{\partial^2 q}{\partial L_2^2}.$$

¹⁵ In standard game theory this expression is used to calculate the local stability condition (see Fudenberg/Tirole, 1993, p.24). It is also employed by Dixit (1987) and Baik/Shogren (1992) to analyse the structural stability of simultaneous move games.

context and states that both cross-derivatives are equal. We see, therefore, that if $q_{12} > 0$, RF_1 will have a positive slope while RF_2 will be falling and vice versa. Thus, we arrive at

Result 1:

a) If the cross-derivative is globally positive, "one-sided submission" will be the only equilibrium of the game, where only player 1 spends a positive amount on lobbying contributions, while her competitor invests no resources in lobbying. In other words if $q_{12} \geq 0 \forall (L_1, L_2)$, then $(L_1^(0), 0)$ is the only equilibrium.*

b) A negative cross-derivative for some L_i, L_j is necessary for "war".

The proof of result 1 is straightforward. (a) If the cross-derivatives are globally positive or zero, the slope of RF_2 will be zero. Thus, globally RF_2 lies on the L_1 -axes. Both RF 's intersect at $(L_1^*(0), 0)$. (b) If q_{12} is smaller than zero for some L_i, L_j , RF_2 is increasing according to (12) for this value or interval. Thus, there is some range in the L_1 - L_2 -space where firm 2's lobbying contributions are strictly positive. If RF_1 intersects here and no ICC is binding, there is an equilibrium with both firms engaging in lobbying.

Our result gives us strong conditions for "war" and "one-sided submission" in lobbying contests with a rather general CSF. "War" will only occur if the marginal effectiveness of player 1's lobbying is reduced by an increase in player 2's outlays. Figure 1 provides us with an example for "war".

Insert Figure 1

"One-sided submission" will be the outcome if an increase in player 2's contributions improves the effectiveness of player 1's own efforts to influence the regulator. One can think of situations where any kind of lobbying activity appreciates the public's sensitivity to the problem. At some airports, for example, competing airlines use different kinds of planes. Some firms own relatively silent planes while others stick to older and louder ones. It can be profitable for the firms with the modern and more silent planes to engage in lobbying for stricter noise reduction standards at the airports, because noise is a highly sensitive topic in many urban areas. If those airlines with louder planes start making "counter-lobbying" the

public's interest in this topic will be enhanced. Thus, lobbying would be "counter-productive" for those firms which are subject to potential regulation¹⁶.

Thus, two qualitative prerequisites of "war" in lobbying contests are derived.

- If firm 2 increases its lobbying outlays, the marginal effectiveness of firm 1's lobbying has to be reduced. This may be a reasonable assumption for many contests, but the example above shows that this need not be the case.
- Only complicated lobbying processes in the sense of taking into account changes in the marginal effectiveness of one player's lobbying induced by a change in its competitor's outlays can result in "war" as a possible outcome. A priori it seems hard to believe that firms can observe or a regulator is able to signal such sophisticated properties of the lobbying process, or - in our terminology - the form of the function [q]. Especially in the case of corruption it is likely that the regulator is restricted in signalling in detail how certain regulation can be bought.

Thus, strategic interaction in lobbying contests, for example by the use of the Tullock function (see section 2.1), needs a good empirical justification for these two crucial qualitative properties described above.

2.2 Illustration

Two lobbying functions are widely used in interest group models: the ratio model introduced by Tullock (1980) and the difference CSF by Hirshleifer (1989)¹⁷. We analyse, therefore, whether these functions lead us to "war" or "one-sided submission".

Tullock assumes the probability of success to be the ratio of both player's lobbying contributions,

$$q_1(L_1, L_2) = \frac{L_1}{L_1 + L_2} \Leftrightarrow q_1(L_1, L_2) = \left(1 + \frac{L_2}{L_1}\right)^{-1}. \quad (6')$$

¹⁶ Gialloretto (1989) describes such lobbying activities at the Frankfurt/Main airport.

¹⁷ As throughout the whole analysis, we restrict our attention to the case of N=2 players. Additionally we assume the exponents to be one.

Applying this function to our model and solving simultaneously both players' optimisation problems yields to the optimal lobbying outlays:

$$L_1^* = \frac{4 t(a - b - t)(2a - 2b + t)^2}{81 (2a - 2b - t)^2}, \quad (13)$$

$$L_2^* = \frac{16 t(2a - 2b + t)(a - b - t)^2}{81 (2a - 2b - t)^2}. \quad (14)$$

They are strictly positive as long as the size of the market is enough large compared to the effective per-unit production costs ($a - b - t > 0$).

While no incentive-compatibility constraint is binding¹⁸ and the second-order conditions are met, L_1^* and L_2^* denote the equilibrium lobbying contributions. The Tullock function, therefore, views "war" as an outcome of a lobbying game. Thus, we get:

Result 2: For the Tullock function, "war" exists as an interior Nash-equilibrium while no incentive-compatibility constraint is binding.

Figure 2 gives a graphic interpretation, assuming $a = 100$, $b = 5$, and the prohibitive tax rate of 47.5.

Insert Figure 2

Hirshleifer (1989) puts forward a logistic CSF which makes use of the difference of the players' lobbying outlays. For many problems, e.g. military combats, this function seems to be advantageous compared to Tullock's formulation. If one player refrains from making efforts the probability of success for its competitor does not automatically equal 1. Additionally it is, contrary to the Tullock CSF, defined at $(0, 0)$. It takes the following form:

$$q_1(L_1, L_2) = \frac{1}{1 + \exp\{k(L_2 - L_1)\}}. \quad (6'')$$

Analysing whether Hirshleifer's logistic function will lead us to "war" or "one-sided submission" one discovers that "war" is not a possible outcome under this CSF¹⁹. For such an interior solution, maximisation would require both second-order conditions to be negative or

¹⁸ $ICC_1(L_1^*, L_2^*) = \frac{1 t(2a - 2b + t)^3}{81 (2a - 2b - t)^2} > 0$, $ICC_2(L_1^*, L_2^*) = \frac{64 t(a - b - t)^3}{81 (2a - 2b - t)^2} > 0$

¹⁹ For a comment on Hirshleifer's CSF see Körber/Kolmar (1994).

zero. Because the second derivatives of the CSF [q] are identical, this requirement cannot be fulfilled simultaneously²⁰. Thus, evaluated at the same point it is impossible to meet these requirements at the same time. Hence, the quasi-reaction function is a best answer for only one player. Even the point $L_1 = L_2$ does not constitute a maximum but rather a point of inflection²¹. This leads us to

Result 3: The Hirshleifer CSF will never cause "war" as an outcome of the contest.

The logistic CSF, therefore, belongs to a different class of functions than those described above, because it does not fulfil the basic requirement of being simultaneously concave in L_1 and convex in L_2 and cannot, therefore, generate interior equilibria.

3. The Design of the Contest

In the last chapter we derived the properties of "war" and "one-sided submission" under the assumption that the regulator is just a passive broker of the pressure groups' different interests. Now we go one step further and analyse the conditions for both equilibria, taking into account that the regulator can use the choice of the CSF as a strategic variable to achieve its own goals. Which form of contest will be chosen if the state switches from its passive role into the driving seat of our political vehicle?

Throughout this analysis we employed a broad definition of lobbying outlays. One might consider them as those efforts necessary to supply special information to the regulator or as the firms' donations to parties to support their political goals. Even presents to individual politicians or bureaucrats for their personal use are within our definition. Although the last alternative would probably cross the borderline to corruption in most countries, it is in any case advantageous for the regulator to maximise the sum of such lobbying contributions.

By implementing the high tax rate $[\bar{t}]$ the regulator can award a monopoly rent to firm 1 while its competitor is forced to leave the market. Firm 1's willingness to pay for this additional profit

²⁰ Both second-order conditions are described by

$$\frac{\partial^2 q}{\partial L_1^2} = -\frac{k^2 \left(-\exp\{2k(L_2 - L_1)\} + \exp\{k(L_2 - L_1)\} \right)}{\left(1 + \exp\{k(L_2 - L_1)\} \right)^3} = \frac{\partial^2 q}{\partial L_2^2}.$$

²¹ $L_1 = L_2$ is a point of inflection and not a saddle point because here the first derivatives of the players' maximisation problems are positive, the second derivatives equal zero, and the third are unambiguously negative.

amounts to the expected value of the difference between the monopoly profit and the duopoly profit which it will earn anyway. Thus, firm 1 will invest at most $\pi^M - \pi^D - \varepsilon$, $\varepsilon \rightarrow 0$ in the lobbying contest if the probability of winning the contest is equal to one²². With $\varepsilon > 0$ the firm is strictly better off reaching the monopoly position. If the joint output of both competitors is bigger than in the monopoly case, total profits will be smaller²³ ²⁴. So any outcome with both firms remaining in the market creates total profits, and thus total maximum lobbying contributions, smaller than $\pi^M - \pi^D - \varepsilon$.

Result 4: *The maximum the regulator can appropriate from firm 1 in exchange for the granted rent is $\pi^M - \pi^D - \varepsilon$, $\varepsilon \rightarrow 0$.*

By the monotonicity of the joint profits the regulator will always have to implement the high tax to maximise its total profits. This leads us directly to

Result 5: *Every revenue-maximising political process will lead to "one-sided submission" with only firm 1 engaging in lobbying if there exists a CSF generating this as an equilibrium.*

In section 2 we showed that in the case of an exogenous CSF two conditions for "war" as a possible outcome of the game have to be met. Although "war" was possible, there were constraints on the existence of such an equilibrium. In the framework of a "revenue-maximising regulator" "one-sided submission" is the only equilibrium while a struggle with both firms engaging in lobbying is no longer possible.

Consequently, even if the state could overcome the informational constraints in signalling how to influence regulation, it would not be rational for it to use sophisticated CSF's. Such "complicated" functions would only be necessary to generate "war" as an equilibrium of the lobbying game, while the revenue-maximising outcome, however, can only be reached with

²² π^M denotes the monopoly profit while π^D stands for the duopoly profit without any tax.

²³ The expansion in total output can e.g. be calculated according to firm 1's output reaction function:

$$\frac{\partial x_1}{\partial x_2} = -\frac{1}{2} x_2.$$

²⁴ Formally this means $\left\{ \frac{\partial(\pi_1 + \pi_2)}{\partial x_1} = 0 \text{ for } x_1 + x_2 = x^M; \frac{\partial(\pi_1 + \pi_2)}{\partial x_1} < 0 \text{ for } x_1 + x_2 > x^M \right\}$.

"one-sided submission". This result can be achieved with a simple "take-it-or-leave-it" mechanism²⁵:

Lemma: A revenue-maximising lobbying mechanism is given by

$$q(L_1, L_2) = \begin{cases} 1, & L_1 = \pi^M - \pi^D - \varepsilon, L_2 \in [0, \infty) \\ 0, & L_1 \neq \pi^M - \pi^D - \varepsilon, L_2 \in [0, \infty) \end{cases} \text{ and } t = \frac{1}{2} (a-b).$$

If firm 1 accepts the regulator's offer, it will be able to increase its profits by an ε , while firm 2 will always suffer a loss²⁶. Hence, $(L_1, 0)$ is the only equilibrium.

Thus, in our setting there is no room for real strategic interaction between both firms because the state would not act revenue-maximising by implementing a CSF leading to "war" as an equilibrium.

3. Conclusions

In this paper we analysed the conditions for "war" and "one-sided submission" as an outcome of lobbying contests for the case of Cournot competition. As long as the CSF is exogenously given, both types of equilibria turn out to be possible.

Nevertheless, we showed that "war" as an equilibrium of the game has to meet two prerequisites. The marginal effectiveness of one player has to be decreased by an increase in its competitor's outlays. Thus, only sophisticated lobbying functions in the sense of having these cross effects are able to generate "war". Consequently, lobbying models with both players making outlays are restrictive and need an empirical justification for these properties. Applying our findings to the renowned Tullock and Hirshleifer functions we found that while the first can generate "war" as a possible equilibrium, the latter always leads to "one-sided submission" because of its functional properties.

If one allows for a CSF endogenously chosen by a state maximising lobbying outlays, "one-sided submission" is the only possible outcome. In such a framework "war" is only possible if either the firms do not act as a profit maximiser or the regulator does not behave rationally.

²⁵ It should be noted that, contrary to the assumption in (6), this mechanism is not twice continuously differentiable.

²⁶ This means: $\pi_1(L_1, L_2) = \pi^D + \varepsilon > \pi_1(\hat{L}_1, L_2) = \pi^D$, $\hat{L}_1 \neq L_1$ for firm 1, and $\pi_2(L_1, 0) = 0 > \pi_2(L_1, L_2)$ for firm 2.

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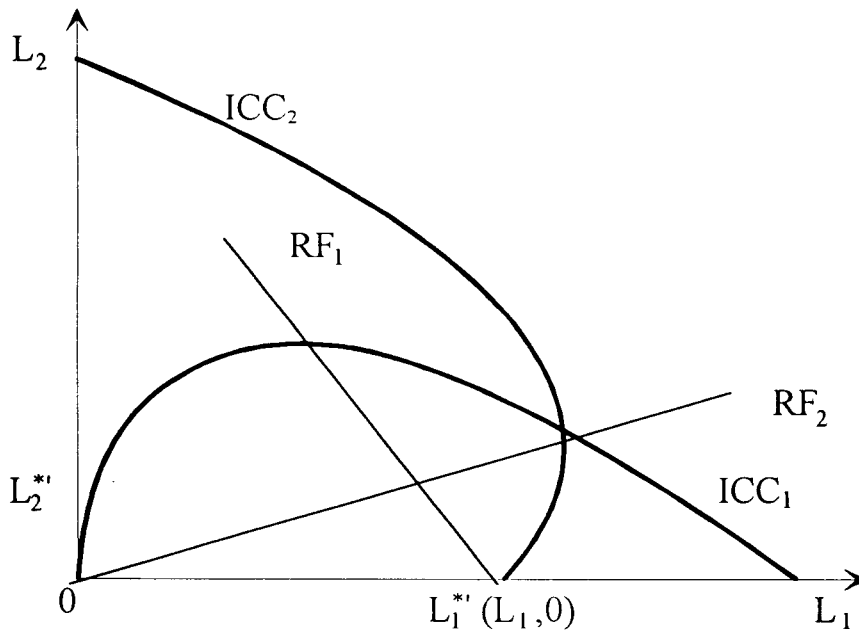


Figure 1

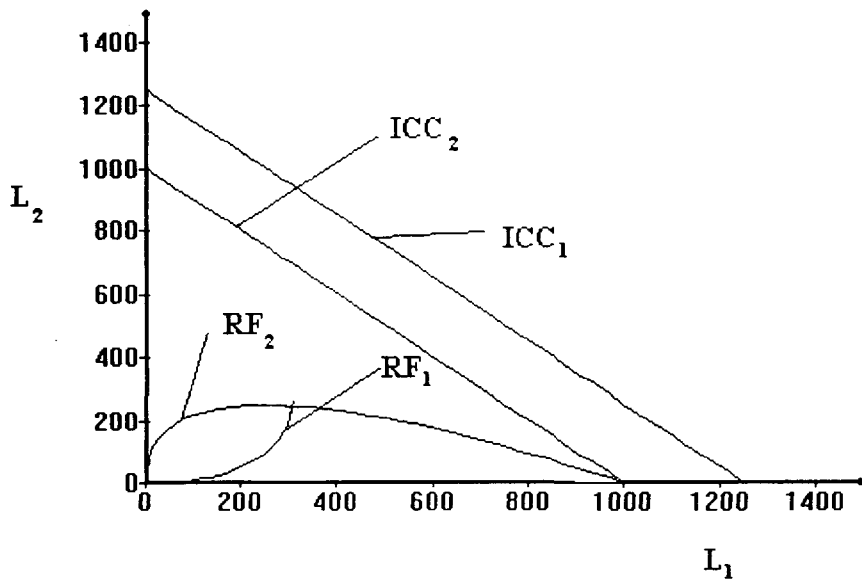


Figure 2