Journal of Theoretical Politics

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Journal of Theoretical Politics 1991 3: 81
DOI: 10.1177/0951692891003001006

The online version of this article can be found at:
http://jtp.sagepub.com/content/3/1/81

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Journal of Theoretical Politics 3(1): 81-101 (1991)

THE EFFECT OF FINES ON REGULATED INDUSTRIES

GAME THEORY vs. DECISION THEORY

George Tsebelis

ABSTRACT

A series of papers on regulation and fines utilizes formal analysis to conclude that a firm's compliance with regulation increases when the fines for violation are increased. The common denominator of these papers is the modelling of the firm as a decision-maker under risk: the firm's goal is to minimize expected losses *given some probability that it may get caught* violating certain regulations. A better approach is to *derive* these probabilities given that the regulatory agency endeavors to maximize its own gains. Therefore, the agency-firm interaction must be modelled explicitly as a game. If such an approach is adopted, the size of the fine or the level of standards has no impact upon the behavior of the firm under a wide range of conditions. On the contrary, an increase in the fine or a lowering of the standards reduces the frequency with which the agency enforces the law.

KEY WORDS • fines • formal theory • game theory • regulation

The problems of regulation, compliance and the implementation of related policies are the subject of numerous studies. Economic models of regulation have been introduced to study the behavior of polluters (Downing, 1981; Downing and Hanf, 1983; Downing and Kimball, 1982; Downing and Watson, 1974; Viscusi and Zeckhauser, 1979), the decision by states to comply with civil rights laws (Rodgers et al., 1972), the decision to comply with the Fair Labor Standards Act (Ehrenberg and Schumann, 1982), and questions of environmental and safety regulation (Langbein and Kerwin, 1985).[1]

These models are concerned exclusively with questions of compliance with regulation (from the point of view of regulated industries) and the optimal enforcement of laws (from the point of view of regulatory agencies or society). The models are not concerned with other related issues, including the relationship between agencies and law-makers (Weingast, 1984) or law-makers and interest groups (Lowi, 1969, Stigler, 1971). The integration of

* Support for this project was provided by the Academic Senate of UCLA. I would like to thank J. Aberbach, S. Ansolabehere, C. Gibson, W. Keech, J. Q. Wilson and J. Zaller for many useful discussions and bibliographical references.

1. For a survey of the logic of this voluminous literature which stems from Becker's seminal article on crime (1968), see Diver (1980).

these different models into a general theory would result in a major advance in our understanding of politics. Before attempting such an ambitious step, however, the robustness of the partial models must be tested.

The purpose of this paper is to demonstrate that several economic approaches to regulation are flawed in an important and interesting way: they consider firms and agencies separately. Each of the two actors maximizes their expected utility under the constraints imposed by the other. However, these constraints are not constant. On the contrary, they change continuously as a response to the opponent's strategy. The appropriate approach to the problem of regulation is not decision theory but game theory. In particular, the probabilities of enforcement of the law are not exogenous, but have to be derived as a consequence of the payoffs and rationality of the opponent.

This paper demonstrates that such a change in perspective (two rational players playing against each other, instead of one expected utility maximizer), is not innocuous. It entails important modifications in the conclusions of decision-theoretic models. In particular, it demonstrates that a modification of the payoffs of the regulated industries (for example, an increase in the fine or reduction in the standards) has, at equilibrium, *no impact* on the frequency of compliance. On the contrary, it changes the frequency of implementation of regulation.

In recent years a whole stream of game-theoretic articles on problems of regulation have been produced. Articles by Scholz (1984a, b) and Scholz and Feng (1986) deal essentially with prisoners' dilemma situations, and the logic is quite different from the mixed-strategy equilibrium model presented in this paper.

Articles by Baron and Myerson (1982), Loeb and Magat (1979), Sappington (1983) and Weitzman (1978) examine the problem of optimal regulation under one-sided uncertainty. In all these articles, regulatory policy is formulated *ex ante*. For example, in the Baron and Myerson model the agency designs a revelation game, which induces the firm to reveal its private information. However, these models do not include the possibility that the agency (at some cost) can observe the behavior of a firm and use this observation to improve regulatory policy.

Baron and Besanko (1984) developed a model which includes this possibility: the agency may be able to observe the performance of the firm and to use this observation (*ex post*) to improve its policy. However, the principal–agent framework they use in their analysis enables the agency to pre-commit to an audit policy irrespective of its optimality (for the agency or for society) once actual reports are received. In game-theoretic terms, the calculated equilibrium is not perfect. Baron and Besanko defend their approach by using reputational effects. While reputational arguments can be persuasive, one can also imagine the opposite case, where it makes no sense for the agency to pre-commit, or to keep its commitments, especially

if there is no higher-order player who will guarantee the enforcement of the commitment, or if the firms do not have any means of verifying whether commitments were kept.

This paper focuses exactly on this problem of monitoring. The agency is explicitly assumed not willing or able to make credible commitments, so the strategies of the firm and the agency are at perfect equilibrium; moreover, the probability of monitoring is dependent on the strategy adopted by firms.

Similar game-theoretic models concerning tax compliance have been proposed by Graetz et al. (1986), and Reinganum and Wilde (1986). Their models are applicable in cases like tax evasion where one player (the taxpayer, or the firm) has to submit a statement to the agency first, and the agency decides whether to audit or not upon receiving that information. Because they consider a sequential game with one-sided incomplete information, they come to conclusions different than mine. My basic model assumes a simultaneous-move game with complete information. So, either the firm submits no statement to the agency, or the content of this statement does not convey any relevant information to the agency. The archetypical case for application of this model is on-site inspections by the Occupational Health and Safety Administration (OHSA). The model is also applicable to such cases as the Antitrust Division of the Department of Justice and the Federal Trade Commission, if the information received does not enable these agencies to discriminate between violators and non-violators.[2]

In a summary way, the most similar models currently existing in the literature are the Baron and Besanko, which assumes the agency making the first move and pre-committing, and the tax compliance models who make the assumption that the taxpayers move first. My model is designed to cover the third possibility: simultaneity of moves.

The paper is organized into three parts. In the first, an example of the decision-theoretic approach to regulation is presented and its conclusions are examined. In the second, the same example is modified by the introduction of a second rational player: the regulatory agency. Game theory is then applied to find the mutually optimal behavior of firms and agencies, under complete and two-sided incomplete information; these new conclusions are then compared with the decision-theoretic approach. In the third part, the reasons for the discrepancies between the two approaches are explained, and important policy implications are examined.

2. Suzanne Weaver (1980: 136–7), describing how lawyers in the Antitrust Division find their cases, says that they think of their environment as one of 'information scarcity'. 'Most of the time the information they got did not have even the remotest possibility of becoming the subject of antitrust prosecution. "Ninety percent of these things are bummers", one staff attorney summed it up.' Similarly, Robert Katzman (1980: 165) reports the statement of a Federal Trade Commission official as follows: 'We simply do not have the resources to fully investigate every possible violation of the law which we learn about. Accordingly, we must constantly make hard choices among alternatives in order to maximize the effect of our enforcement activity.'

I. A Model of Compliance and Implementation in Regulation

The following discussion summarizes and highlights several conclusions of a model of regulatory implementation, negotiation and compliance as presented by Langbein and Kerwin (1985) (from here on referred to as L-K). The logic behind my choice of this model is threefold: first, the L-K model is well presented, lending itself to comparison; second, it is representative of the decision-theoretic approach to regulation, rendering meaningful comparisons; third, it is sufficiently complex that the alternative game-theoretic approach faces an interesting challenge and will be able to demonstrate its broader explanatory power.

According to the L-K model, whenever a regulatory standard is published, a firm can comply immediately or delay (which is equivalent to non-compliance). In the first case, the firm receives the benefits of compliance (e.g. immunity from liability suits), minus the costs of compliance (direct costs, loss of producer surplus). In the second case (non-compliance), there is a probability p that the firm will get caught. If the firm is not caught (with probability $1-p$), it forgoes both the costs and benefits of compliance. If, however, non-compliance is detected and action is initiated by the agency, the firm has the opportunity to exploit the available review process under the assumption that negotiation with the agency or litigation will result in lower compliance costs. Whether the proceeding is negotiation or litigation, the firm may win reduction of compliance costs (with probability w) or lose (with probability $1-w$).

Figure 1 of the L-K article is replicated here since it summarizes the above argument.[3] The expected values of each branch of the decision tree are reported. The algebraic symbols of the L-K article have the following meaning: Bc stands for the benefits of compliance, Cc for the costs of compliance, K for reduction of compliance costs in case of litigation or negotiation, N for the costs of the litigation or negotiation procedure, F for the fine to the firm, and finally, p and w are the probabilities of being discovered and winning reduction of costs in the negotiation or litigation process respectively.

The L-K model compares the expected utilities of each action: compliance and non-compliance in the first stage, negotiation and/or litigation in the second, claiming that in each case the firm will choose the expected utility-maximizing option. The authors point out that their decision rule assumes the risk neutrality of the firm even though it has been argued that firms are risk averse (see Joskow and Noll, 1981).[4]

3. The time discount factor of the original article is omitted because it is not essential to the subsequent argument.

4. The observations of the regulation literature parallel the observations of the economic literature of crime, that criminals are more sensitive to changes in the probabilities of arrest

The L-K model permits the investigation of the following cases: an increase in standards (increase *Cc*); an increase in legal protection from damage suits (increase *Bc*); an increase in fines (increase *F*); more reasonable compliance options (increase *K*); an increase in inspections (increase *p*); and cases in which firms win more litigated or negotiated arrangements (increase *w*). Each one of these modifications leads to different expected utilities of each option. The firm chooses the option that maximizes its expected utility. For example, if the probability of getting caught increases, then the expected utility of non-compliance decreases, and the firm is more likely to choose to comply. Similarly, if the costs of compliance increase, the choice of non-compliance becomes more likely.

By following the probabilities and payoffs of the decision tree in Figure 1 the reader can verify the following conclusions of the L-K model:[5]

Proposition 1. The decision of immediate compliance with the standards not only depends on the benefits and costs of compliance, but also depends on the remaining factors and probabilities, in particular, the expected outcome of the negotiation process. It is possible that firms will not comply even if the benefits of up-front compliance are positive ($Bc > Cc$).

Proposition 2. An increase in standards (*Cc*) increases the incentive of firms to avoid compliance.

Proposition 3. An increase in compliance benefits (*Bc*) reduces the probability of non-compliance.

Proposition 4. An increase in fines (*F*) reduces the probability of non-compliance.

Proposition 5. Improvement in compliance options in the negotiation process (a rise in *K*) reduces the probability of compliance.

Proposition 6. An increase in enforcement (*p*) reduces the probability of non-compliance.

Proposition 7. An increase in the probability of winning litigated or negotiated arrangements (*w*) increases the probability of non-compliance.

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than in penalties (see Becker, 1968; Stigler, 1970). However, none of these literatures which assume rational (expected utility maximizing) agents explains why or under what conditions such a discrepancy from expected utility calculations would occur. In the second part of this article, I provide an explanation of this phenomenon of 'risk aversion'.

5. My account of the L-K model is very brief and selective, since it concentrates on the issues I will discuss in the second part. The reader is advised to refer to the original article for the complete argument of these authors.

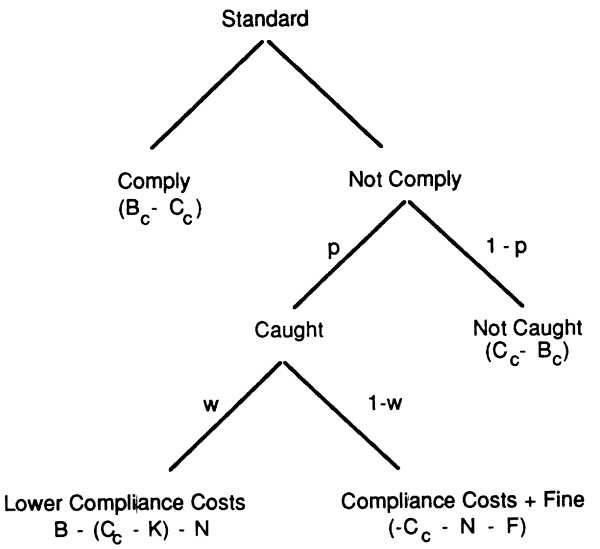

Figure 1. Decision-Theoretic Tree for One Firm (reprinted from Longbein and Kerwin, 1985)

In the following section, I explain the reasons why the probabilities p and w may increase or decrease; propositions 6 and 7 will not be taken as given, rather, the conditions of their validity will be investigated. In the process, it will be shown that the game-theoretic approach I propose comes to quite different conclusions than propositions 2, 3, 4 and 5, and that only proposition 1 resists game-theoretic scrutiny.

II. A Game-Theoretic Approach to Regulation

Where do the probabilities p and w originate?[6] The answer which comes immediately to mind is that 'these probabilities stem (at least partially) from the enforcement policy of the regulating agency'.[7] However, is this enforcement policy constant? Will the agency apply the same policy in an environment with many or with few violations? Will it behave the same way towards firms which have been complying in the past as it behaves towards constant violators?

On the other hand, will firms' behavior vary depending on the strictures

6. The following provides a partial answer to the question; the question will be discussed in greater detail in the next part.

7. I say partially, because even if an agency enforces the law, there is only a probability that it will be able to detect the violators. In this part of the article, I will examine only the strategic part of the interaction between an agency and a firm, and leave a more exhaustive analysis of non-strategic factors for the next part.

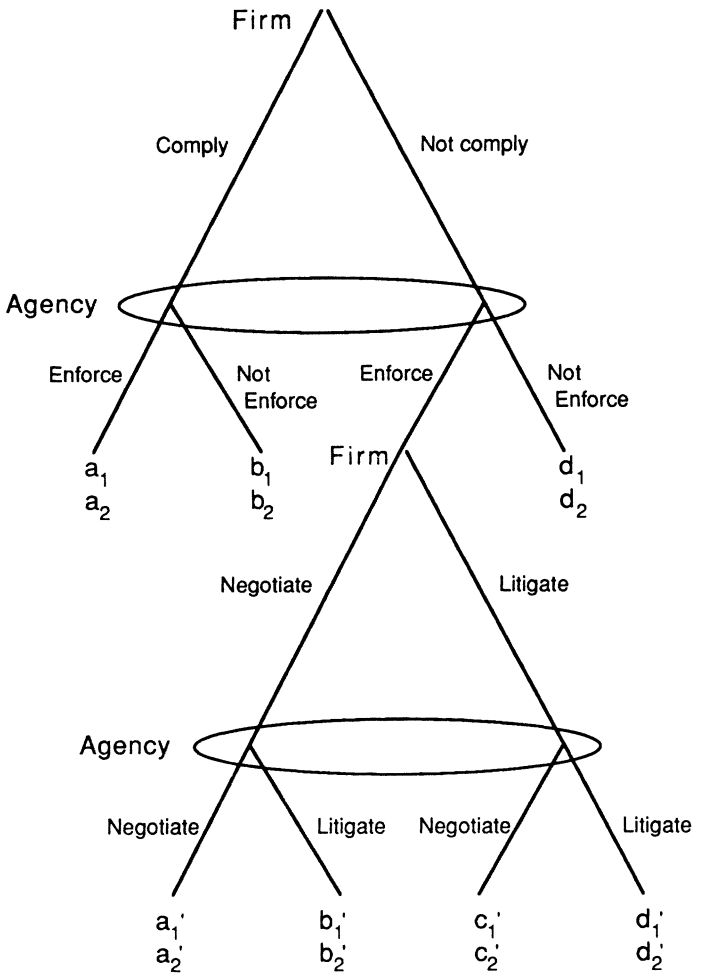

Figure 2. Compliance Game Between Agency and Firm (with litigation subgame)

of the agency being confronted? What happens if we consider this as a mutual adaptation process, in which each one of the two actors tries to respond to the other in an optimal way? Figure 2 replicates Figure 1 with one difference: it replaces the probabilities p and w by one of their sources – the agency and its policy.

The reader can verify that the firm confronts the same options: whether or not to comply with the standard; and, in case it is caught, whether or not to litigate. Similar options exist for the agency: whether or not to monitor (corresponding to the probability p in the previous model); and, in case a firm is caught in violation, whether or not to litigate (corresponding to the probability w of the decision-theoretic approach). In the final nodes of

the game tree, payoffs of the two players appear. The ellipses on the figure indicate information sets: cases in which one of the players (the agency) has to make a move without knowing what the other (the firm) is doing.

The common approach in finding the solution to this game is to make all the possible assumptions about the ordering of the payoffs of each player and then to find (Nash) equilibrium strategies, i.e. pairs of strategies with the property that they are optimal responses to each other. The underlying rationale behind the Nash equilibrium pairs is that only such strategy combinations are self-enforcing, i.e. they do not provide one of the two players with the incentive to deviate unilaterally from his or her strategy. However, the resulting task would be technically impossible since there are 7! (= 5040) possible orderings for each player and, therefore, $(7!)^2$ different games.

To simplify matters (without loss of explanatory power), I use the concept of subgame perfect equilibrium introduced by Selten (1975). Selten uses a backwards induction argument in order to eliminate 'unreasonable' equilibria – equilibria which are supported by non-credible threats (threats that a rational player, if called upon, would find it counterproductive to implement).

According to Selten, if the two players arrive at the node where they have to decide whether or not to litigate, they will follow their equilibrium strategies, receiving their equilibrium payoffs. Therefore, the entire subgame (which we will call the litigation subgame) can be substituted by these equilibrium payoffs, and the new game solved for equilibrium strategies.[8]

Let us call c_1, c_2 the payoffs of the firm and the agency respectively. Figure 3 represents the new reduced game with the property that any equilibrium strategy induces a subgame perfect-equilibrium strategy in the original game. This two-by-two game, which we call the compliance game, is simple enough to allow a detailed investigation. What is the ranking of the different payoffs for each actor? First of all, it is reasonable to assume that if the agency does not monitor, the firm will prefer not to comply with the standards. This assumption is more restrictive than the L-K model in which the benefits of compliance can exceed the costs, but it seems to me quite reasonable.[9] In algebraic terms,

$$\text{Assumption 1: } d_1 > b_1$$

It is also reasonable to assume that because of the enforcement costs of the agency, it would be preferable for them not to monitor if they know that

8. The implicit assumption here is that this game has a unique equilibrium in pure or mixed strategies. I represent the simplest possible game, but my argument holds regardless of the form of the game tree. There is an extensive game-theoretic literature concerning the litigation subgame (see Bebchuk (1984), Cooter Marks and Mnookin (1982), P'ng (1983) and Reinganum and Wilde (1986b)).

9. However, a similar analysis could be done for the opposite case, where benefits exceed costs, without modifying the argument presented in this paper.

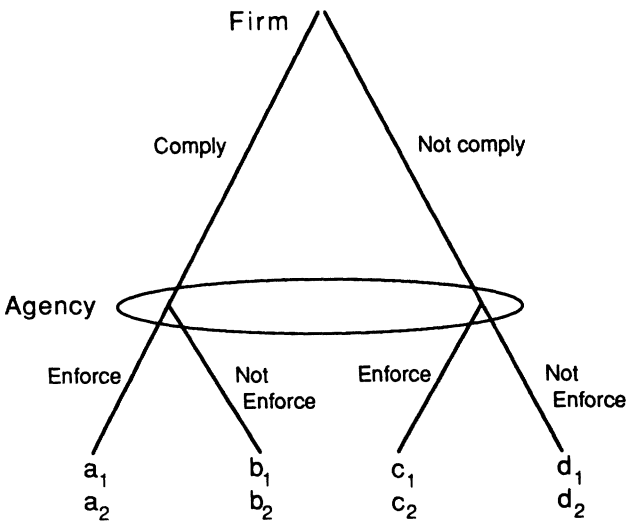

Figure 3. Compliance Game Between Agency and Firm

all firms complied with the standard. Several payoff functions of the agency share this assumption. Therefore, there is no need for further specificity.[10] In algebraic terms,

$$\text{Assumption 2: } b_2 > a_2$$

What remains is to compare the equilibrium payoffs of the litigation subgame with the rest of the payoffs of the compliance game. There are three possible cases:

1. *The firm has a dominant strategy of non-compliance.* In algebraic terms,

$$\text{Assumption 3: } c_1 > a_1$$

In this case, the firm will always violate the standards and the agency will decide whether or not to enforce the law according to whether or not $c_2 > d_2$.

2. *The agency has a dominant strategy of non-enforcement.* In algebraic terms,

$$\text{Assumption 4: } d_2 > c_2$$

In this case, the agency will not enforce the standards and the firm will not comply with them (Assumption 1). Assumption 4 has been debated

10. The main argument of the article holds for any discrete payoff function, of both the agency and the firm, provided the corresponding game has no pure strategy equilibria. So, the results of the two-by-two game I present here are generalizable (Tsebelis, 1990b).

extensively in the regulation literature. This assumption conforms to the spirit of 'capture' theories. Following Stigler's lead, such theories argue that 'regulation is acquired by the industry and is designed and operated primarily for its benefit'.[11] If Assumption 4 always holds, no further investigation is necessary: one would expect that the content of regulation would never go against the interests of the regulated or, if it did, that agencies would never monitor and firms would never conform. Other authors have indicated that opposed interests are involved in regulation, and that it is not likely that an agency will be permanently controlled by a single interest. J. Q. Wilson (1974: 159), for example, argues that 'if favoritism develops, it will represent an unstable equilibrium of forces, and the balance will shift from time to time'. According to this point of view, Assumption 4 may hold some of the time, but certainly not always. This leads to the third, most interesting and, as I show later, most frequent case. I return to further discussion of Assumption 4 in the conclusion to the present article.

3. *There is no dominant strategy for either player.* In algebraic terms,

$$\text{Assumption 3}': c_1 < a_1$$
$$\text{Assumption 4}': d_2 < c_2$$

All the payoffs in assumptions A1, A2, A3′, and A4′ represent *expected* utilities of the corresponding outcomes. For example, if the agency monitors and the firm does not comply, there is a probability that the firm will get caught; even if the firm is caught, it may be able to use the judicial system to escape; finally, even if it has to pay a fine, it may be able to delay payments. All these probabilities and discount factors are taken into account by the payoff c_1 of the firm in this model.

It is readily observed that under the assumptions A1, A2, A3′ and A4′, the game presented in Figure 3 has no pure strategy (Nash) equilibrium – the two players have no pure strategies which are optimal responses to each other. Therefore, the only equilibrium strategies that exist in this game are mixed strategies, i.e. probability distributions over the set of pure strategies (Ordeshook, 1986: Ch. 3). In other words, each player will use a combination of pure strategies so that when both apply a specific pair of strategies neither will have an incentive to deviate from his mixture. In this case, each player's strategy will be the optimal response to the other player, and therefore, both players will retain these (equilibrium) strategies.

The calculation of p^* and q^* gives (Luce and Raiffa, 1957):

$$p^* = (c_2 - d_2)/(b_2 - a_2 + c_2 - d_2) \quad (1)$$

$$q^* = (d_1 - b_1)/(a_1 - b_1 + d_1 - c_1) \quad (2)$$

The specified probabilities p^* and q^* are in the (0,1) open interval and thus

11. See Stigler (1971: 3).

acceptable as solutions because of assumptions 1, 2, 3′, and 4′. Moreover, since the game has no pure strategy equilibria, the mixed strategies specified by the probabilities p^* and q^* are the *unique* equilibrium strategies of the game.

Since this last proposition is very important for the subsequent development of the paper, it needs to be singled out and stated formally:

THEOREM 1. *Under assumptions 1, 2, 3′ and 4′ the only equilibrium in the compliance game is in mixed strategies as specified by equations (1) and (2).*

The specification of the problem reveals the impact of different policy measures on enforcement and compliance. For example, what happens if the legislator influenced by decision-theoretic arguments applies prescriptions similar to those presented in propositions 2, 3, 4 and 5 of the L-K model? All of these measures modify the payoffs of the firm.

Assume first that they have no impact on the payoffs of the agency. Such modifications may change the equilibrium of the litigation subgame and make non-compliance the dominant strategy for the firm (case 2 above). If, however, assumptions 1, 2, 3′ and 4′ continue to hold, modification of these payoffs has no impact upon the behavior of the agency at equilibrium. Examination of equations (1) and (2) indicates the following outcomes, which will be singled out for their importance and counter-intuitive significance.

THEOREM 2. *Under assumptions 1, 2, 3′ and 4′ modification of the payoffs of the firm leaves the frequency of violation of the standards at equilibrium* (p^*) *unchanged.* In particular, lowering standards, raising compliance benefits, increasing fines, or restricting compliance options have no impact on the frequency of violation of the standards by the firm at equilibrium.

THEOREM 3. *Under assumptions 1, 2, 3′ and 4′ modification of the payoffs of the firm modifies the frequency that the agency enforces the standards at equilibrium* (q^*). In particular, lowering standards, raising compliance benefits, increasing fines, or restricting compliance options will decrease the frequency of standard enforcement by the agency.

The proof of these two theorems is straightforward: inspection of equation (1) indicates that p^* does not depend on the payoffs of the firm, while equation (2) indicates a monotonic relationship between the payoffs of the firm and the mixed strategy of the agency q^*.[12] Still, an intuitive explanation of the discrepancy between conventional wisdom and the outcomes of formal reasoning is required. Why do policy analysts believe that a change in the payoffs of the firm will modify its behavior?

The reason for this discrepancy is that the analyses of compliance through

12. The monotonic relationship can be shown by testing the sign of the first derivatives.

decision theory have committed two related mistakes: relevant players (such as the agency) have been ignored, and only the short-run consequences of the policy have been examined. Indeed, it is plausible that when penalties increase, compliance will increase in the short run.

Consider first that compliance is a variable cost decision. This means that each firm will increase the level or the probability of compliance. Once the agency recognizes that this change in the behavior of firms is occurring, however, it will modify its own strategy and reduce the frequency of law enforcement. The firms will modify their behavior again, as will the agency, until the new equilibrium will be the one described by equations (1) and (2) in which modification of the payoffs of the firm has no impact upon its behavior.

The Occupational Safety and Health Administration (OSHA) often deals with issues where compliance is a variable-cost decision. Kelman (1980: 247) describes the problem as follows:

> Compliance is often no one-shot matter; it requires constant vigilance. Compliance with threshold-limit values cannot be a one-time proposition because equipment must be maintained at regular intervals. Closed chemical systems must be checked for leaks. Respirator filters must be replaced frequently so they do not become clogged . . .

Now consider the case where compliance requires investment in new technologies by the firm.[13] In this case, once the investment is made, stepping out of compliance is not feasible or even desirable. Higher fines may make more firms comply with one particular standard. Once the agency realizes that more firms comply with its instructions, it is likely to focus on some other problem; this decision will reduce the probability the violators will be caught, and make it more likely for the firms which did not comply in the beginning to continue following the same strategy.[14]

It can be argued that modifications like lowering standards, raising compliance benefits, increasing fines, or restricting compliance options have an impact on the payoffs of the agency. For example, it can be argued that raising standards will increase the effectiveness of the agency, and therefore would raise a_2 and b_2 as well. If this argument is accepted, then higher standards will lead – see equation (1) – to exactly the opposite result that the L-K model predicts: more frequent compliance by the firm.

Consider now the insistence of the OSHA on engineering controls rather than personal protective equipment that protect workers from health hazards. This decision has been labelled 'ideological' and 'irrational' because 'reducing exposure to health hazards (such as noise or chemicals) by

13. I thank one anonymous referee for the distinction between variable and fixed cost compliance.

14. Both these arguments are verbal presentations of an evolutionary approach. While they are the easiest to present verbally, they are only part of the arguments that support the equilibrium described by equations (1) and (2).

engineering controls is often horrendously expensive, especially when the new controls must be fitted onto existing machines at existing plants with fixed layouts. By contrast, personal protective equipment - ear-plugs, earmuffs, and respirators - costs a tiny fraction of what engineering controls cost' (Kelman 1980: 251).

If modification of one player's payoffs affects his or her own behavior, as decision-theoretic models claim, there is no reason for OSHA to insist on engineering controls. Since personal protective equipment is cheaper, reducing the costs of compliance would induce more firms to comply. Indeed, in a decision-theoretic framework OSHA's decision seems counterproductive and the charge of ideological and irrational behavior may be well merited.

However, in my model's framework this decision is perfectly intelligible. Engineering devices reduce the monitoring costs of the agency, and consequently increase the frequency of compliance by firms (equation 1).

These results indicate that the decision-theoretic approach to regulation is partial and short-run in nature. If the conclusions of decision theory and game theory are so divergent, what are the logical and/or empirical foundations of the validity of the game-theoretical approach? In particular, even though under assumptions 1, 2, 3′ and 4′ there is a unique equilibrium, how do we know that players will choose the corresponding strategies?

There are five different arguments that demonstrate why the equilibrium calculated by equations (1) and (2) is reasonable. The five approaches start with completely different assumptions: some assume perfect rationality and complete or incomplete information, others assume sequential or simultaneous moves, continuous or discrete choices, and one assumes that the players have myopic adjustive behavior. However, all five stories end with the same conclusion: the equilibrium of the game is given by equations (1) and (2). The conclusion is that the equilibrium strategies calculated by (1) and (2) have not only normative merit (they are the mutually best responses), but a positive merit as well (they are likely to be chosen).

1. Perfect Rationality and Complete Information. The equilibrium calculated by equations (1) and (2) presents all the desirable properties of stability required in game theory. In particular, the equilibrium is regular (Harsanyi, 1973), perfect (Selten, 1975), essential (Wu Wen-tsun and Jiang Jia-he, 1962), and proper (Myerson, 1978).[15] Moreover, the equilibrium is stable in the sense of Kohlberg and Mertens (1986: 1004); it satisfies both the backwards induction rationality of the extensive form and the iterated dominance rationality of the normal form, while simultaneously being independent of irrelevant details in the description of the game.

2. Perfect Rationality and Incomplete Information. The game-theoretic literature I reviewed in the introduction of this article was assuming

15. For the proofs of all these propositions, see van Damme (1984).

one-sided incomplete information. It is true that the most important sources of incomplete information are the firms and that in a first approximation the regulating agency's payoffs can be assumed as known. It is, however, both more interesting and more realistic to examine the case of two-sided incomplete information. Assume now that all players know their own payoffs, but not the payoffs of their opponent; more precisely, the opponent's payoffs have a systematic component (following assumptions 1, 2, 3′ and 4′) known to both players, and some random element known only to the opponent. I have shown elsewhere (Tsebelis 1990b: Appendix) that as the random element tends to zero, the two players will select the strategies described by equations (1) and (2).

3. Perfect Rationality and Continuous Choices. For reasons of mathematical simplicity the model was presented as a two-by-two game, where each player had only two choices, and the results were interpreted as frequencies of each pure strategy. However, one can assume that there is a continuum of choices, that the payoffs are linear functions of the choices of both players, and have exactly the same results interpreted now as levels (of compliance or of monitoring).[16]

4. One Agency and Multiple Firms. Suppose now that the agency has to decide its strategy first, knowing that the firms will subsequently choose their best course of action. Under assumptions 1, 2, 3′ and 4′, if the agency chooses any level of law enforcement which is higher than q^*, the firms will comply and the agency will want to reduce this frequency. On the other hand, if the agency chooses any level which is lower than q^*, then all firms will violate the law, which will induce the agency to increase the frequency of law enforcement. So, no frequency of law enforcement greater or smaller than q^* is stable. Therefore, the agency will choose q^* as the level of law enforcement.[17]

5. Adaptive Behavior of the Players. Under a much weaker assumption of simple adaptive behavior, the two players will converge in this equilibrium behavior if they change their pure strategy whenever such a change would make them better off.[18] A firm, for example, looks at the results of its policy and questions whether compliance 'pays', or an agency enforces the standards whenever such a behavior makes it better off.

In conclusion, completely different assumptions lead to the same equilibrium outcome. This result should be interpreted as an indication of the robustness of the equilibrium strategies calculated by equations (1) and (2).

16. Theorems 2 and 3 hold also if the payoffs of each player are linear functions of his own strategies (and any function of the opponent's strategies).

17. The technical basis of this argument is the Stackelberg equilibrium concept, where one player moves first, knowing that no matter what he does, the other will choose the strategy that maximizes his own payoffs: see Moulin (1981).

18. For a further discussion of this point see Tsebelis (1990a).

In summary, Part II introduced a game-theoretic model and compared it with the decision-theoretic model of Part I. The decision-theoretic model replaces one of the two players in the compliance game with a (fixed) probability distribution. Elsewhere I have called this substitution of a player with a probability distribution the Robinson Crusoe fallacy and demonstrated that it leads to the mistaken impression that a modification of the payoffs of one player (the firm) will modify that player's behavior, while in fact it will influence the behavior of the other player (the agency).[19]

However, the discussion was based on assumptions 1, 2, 3′ and 4′. How reasonable are they? More importantly, how frequently are they fulfilled?

III. Conclusions and Discussion

In order to answer these questions we have to provide a more accurate account of where the probabilities p and w of the L-K model originated. In Part II, the answer was that they came (at least partially) from the mixed strategies of the agency. Here I explain the qualifier 'partially'.

In fact, the mixed strategies of the agency are only one of the possible sources of probabilities. Consider for example the litigation subgame and two different cases: in the first, the firm has no case because it has repeatedly violated a serious regulation, while in the second the legal position of the agency is weak. It is plausible that these two cases will be solved in different ways. In the first, the firm is likely to opt for negotiation, while in the second it will opt for litigation. Therefore, the outcomes of the litigation subgame are likely to be different. If an independent observer knew all the relevant information, these differences in outcome would have been anticipated. If, however, the relevant information was missing, each one of the two outcomes would have been probable. In the case of missing information, one may be led to describe the situation through a probability distribution. I have called such probabilities, which are generated by a mixture of causes, situations or games, partition frequencies (Tsebelis, 1989).

There is a substantial difference between probabilities which describe partition frequencies and probabilities which describe mixed strategies in a game. Information about partition frequencies is offered a priori or has to be calculated from outside sources. At the limit, common knowledge of all the relevant information would eliminate such probabilities, since every player would know with certainty within which case he finds himself. In contrast, information about mixed strategies must be derived from the game itself, and from the assumption of the rationality of the players. Each player has the incentive to mislead an opponent about his mixed strategy, as

19. See Tsebelis (1989).

knowing the strategy of one's opponent is a decisive advantage in the game.

Returning to the game tree of Figure 2, it is possible that a decrease in fine modifies the outcome of the litigation game in such a way that its equilibrium value (c_1, c_2) follows either Assumption 3 or Assumption 4 of Part II. In this case, one of the two players has a dominant strategy: either the firm prefers not to comply because the penalty is small, or the agency prefers not to enforce the law because it is 'captured' by firms, or because the effort is not worth the result. In such a case, the modification of the fine modifies the equilibrium value of the entire game. It is precisely what Proposition 1 of the L-K model asserts, and it is what partition frequencies describe. If all the relevant information was available, both players could predict exactly the equilibrium value.

It is possible, however, that a modification of the payoffs is such that assumptions 1, 2, 3′ and 4′ continue to hold. In this case, the equilibrium strategy for each player in the compliance game is a mixed strategy. Probabilities are not and cannot be given a priori, but they have to be calculated as a consequence of each player trying to adopt an optimal response to the other's strategy. In this case, a modification of the payoffs of one player will have no impact upon his own behavior; however, it will have an impact on the behavior of the opponent, as Part II demonstrated.

To clarify matters, suppose the fine is such that the compliance game has a pure strategy equilibrium in which the firm always violates the law. In this case, an increase in the fine will have no impact on the behavior of either player until the equilibrium of the litigation subgame is such that assumptions 3′ and 4′ are true. In this case, both players will suddenly (in a discontinuous way) begin using mixed strategies. From this point on, any further increase in the fine will not modify the probability of compliance of the firm as the decision-theoretic model asserts, but it will modify the behavior of the agency.

Let us now consider a more complicated and realistic case, one where the firm and the agency do not know each other's payoffs. More precisely, the agency does not know whether the firm's payoffs follow Assumption 3 or 3′, but it knows that any firm follows Assumption 3 with probability f; and the firm does not know whether the agency's payoffs follow Assumption 4 or 4′, but it knows that an agency follows Assumption 4 with probability g. Or, alternatively, assume that the agency faces several firms some of which have payoffs following Assumption 3 (frequency f) while others follow Assumption 3′ (frequency $(1-f)$); and the firms know that the agency is internally divided and some of its personnel follow Assumption 4 (with probability g) while the rest follow Assumption 4′. According to the vocabulary introduced in this article, f and g are partition frequencies.

It can be shown (Bianco et al., 1990) that if the probabilities (or frequencies) f and g of different 'types' of firms and agencies are known to both players, under a wide variety of values of f and g the equilibrium of this

game with incomplete information is *exactly the same* as the equilibrium described by equations (1) and (2).

The intuitive explanation of this result is as follows: Call firms with dominant strategies (that follow Assumption 3) 'naive' and firms that follow Assumption 3′ 'sophisticated'. Similarly, call agencies with dominant strategies (that follow Assumption 4) 'naive' and agencies that follow Assumption 4′ 'sophisticated'. The naive players are always going to choose their dominant strategy. However, the sophisticated players are going to modify their strategy and take into account the existence of naive players in the following way: sophisticated firms will know that there is a proportion f of firms which do not comply, and will reduce their own frequency of non-compliance, so that the overall frequency of compliance is given by equation (1). Similarly, the sophisticated part of the personnel of the agency will take into account the existence of the naive part, and increase its frequency of monitoring, so that the final frequency of monitoring is given by equation (2).[20]

This more general argument indicates that a wide variety of agencies' and firms' payoffs can be captured by the model of Part 2, even if all firms or all agents in an agency do not follow assumptions 3′ and 4′. Consequently, even if p and w are theoretically a mixture of partition frequencies and mixed strategies, the final outcome is the same as if they were purely mixed strategies.

The conclusion from this game-theoretic analysis is that the thesis that modifications of the payoffs of a firm will lead to the modification of its strategy is questionable. This belief is based on the counterfactual assumption that agencies are not rational actors trying to maximize their own payoffs. On the contrary, my analysis indicates that modifying the firm's payoffs leads the agency to modify its strategy. In particular, the measures that are thought to increase the frequency of compliance actually cause the agency to reduce the frequency of implementing a specific standard. Therefore, such measures can be used not to increase the frequency of compliance but to reduce the costs of monitoring.

An important generalization of the compliance game follows from this last remark, and is shown in Figure 4. Consider a third actor who can decide the value of different payoffs for the compliance game. There are two such possible actors: the first is the legislature who can decide the incentive structure of the monitoring agency *and* the payoffs for some particular group of firms. The second possible actor is the agency itself who may have discretion in setting the standards, fines, and in general the payoffs of the firms in its own jurisdiction. The difference between these two stylized actors is that the legislature can decide the payoffs of both players in the

20. However, if the proportion of sophisticated players is very low, it is possible that the modification of their behavior will not be sufficient to bring the equilibrium back to equations (1) and (2).

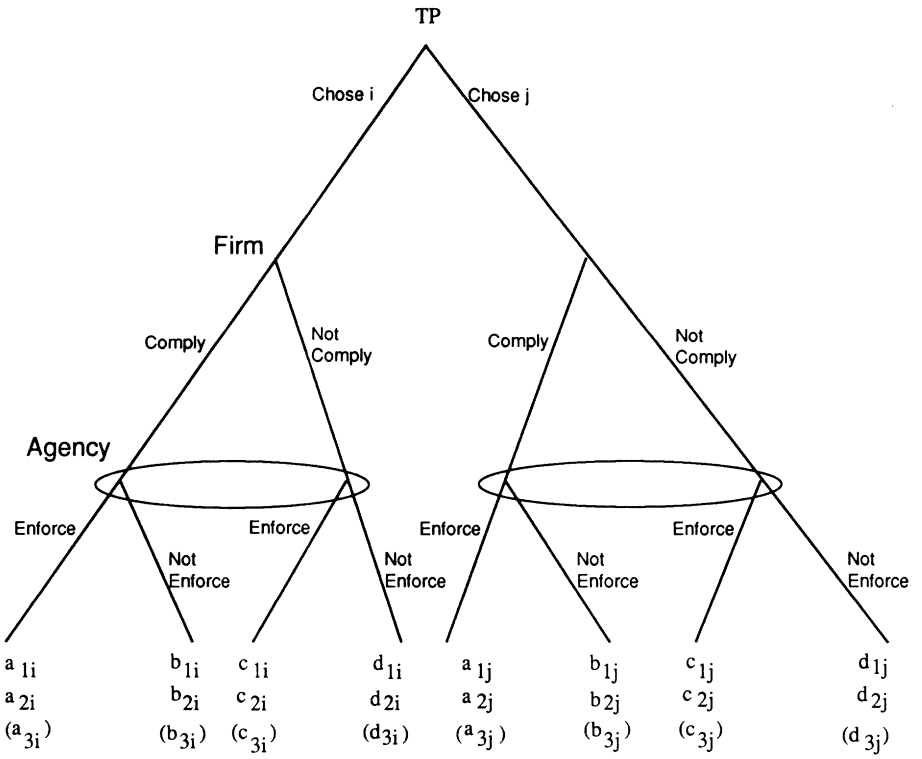

Figure 4. Three-person Game: Legislature, Agency and Firm

compliance game, while the agency can decide the payoffs only of the firm.

One can conceptualize the role of this third player as selecting one particular compliance game to be played by the agency and the firms. Figure 4 presents two of these subgames, indicated by the subscripts i and j in the players' payoffs. TP moves first and sets the payoffs of the compliance game. Then, the agency and the firms move simultaneously. For notational simplicity Figure 4 presents TP's payoffs third, despite the fact that TP moves first in the game.

How would such a third player (TP) decide which particular compliance subgame to select? TP would use Selten's (1975) subgame perfectness concept to select among the different subgames. TP knows that, no matter which subgame he selects, the two players will choose their equilibrium (mixed) strategies. TP can therefore calculate his own payoffs resulting from the selection of each particular subgame. So, the choice among subgames is replaced by the choice among their equilibria, and TP selects the equilibrium l which gives him the highest payoff. In algebraic terms TP selects:

$$\underset{l \in \{ij\}}{\arg\max} \; \begin{array}{l} (p_l^*)(q_l^*)a_{kl} + (p_l^*)(1-q_l^*)b_{kl} + \\ (p_l^*)(1-q_l^*)c_{kl} + (1-p_l^*)(1-q_l^*)d_{kl} \end{array} \tag{3}$$

where $k=3$ if TP is the legislature and $k=2$ if TP is the agency.

From (3) it becomes clear that regardless of whether TP is the legislature or the agency, it can select the particular subgame which maximizes its own payoffs, regardless of what form the utility function takes or which tradeoffs it makes.

For example, assuming that the firm's and the agency's payoffs are independent of each other, the legislature can choose to increase fines, not because higher fines will induce firms to comply more often, but because they will reduce monitoring costs. Similarly, if the legislature wants to increase compliance by firms, it can raise the agency's budget knowing perfectly well that doing so will have no impact on the equilibrium behavior of the agency.

On the other hand, the agency can use its rule-making power not to modify the behavior of the firm, but to modify its own strategy. For example, setting high fines will lead to a game with the same frequency of compliance by the firm, but with reduced strain of implementation by the agency. An agency striving to minimize its own efforts would therefore opt for lower standards, high compliance benefits, high fines, or restriction of compliance options. However, an agency which opts to maximize its budget would propose and/or select legislation with higher standards, low compliance benefits, low fines and an array of compliance options. Since the implications of all these choices are known to TP, TP can choose the game with the optimal combination of outcomes.

References

Baron, D.P. and Besanko, D. (1984) 'Regulation, Asymmetric Information, and Auditing', *Rand Journal of Economics* 15: 447–70.

Baron, D.P. and Myerson, R.B. (1982) 'Regulating a Monopolist with Unknown Costs', *Econometrica* 50: 911–30.

Bebchuk, L. (1984) 'Litigation, Settlement under Imperfect Information', *Rand Journal of Economics* 15: 404–15.

Becker, G. (1968) 'Crime and Punishment: An Economic Approach', *Journal of Political Economy* 76: 211–33.

Bianco, W., Ordeshook, P. and Tsebelis, G. (1990) 'Crime and Punishment: Are One-Shot, Two-Person Games Enough?', *American Political Science Review* 84: 569–86.

Cooter, R., Marks, S. and Mnookin, R. (1982) 'Bargaining in the Shadow of the Law: A Testable Model of Strategic Behavior', *Journal of Legal Studies* 11: 225–51.

Damme, E.E.C. van (1984) *Refinements of the Nash Equilibrium Concept*. New York: Springer.

Diver, C.S. (1980) 'A Theory of Regulatory Enforcement', *Public Policy* 28: 257–300.

Downing, P.B. (1981) 'A Political Economy Model of Implementing Pollution Laws', *Journal of Environmental Economics and Management* 8: 255–71.

Downing, P.B. and Hanf, K., eds (1983) *International Comparisons of Pollution Enforcement*. Boston: Kluwer-Nijhoff.

Downing, P.B. and Kimball, N. (1982) 'Enforcing Pollution Control Laws in the US', *Policy Studies Journal* 11: 55–65.

Downing, P.B. and Watson, W.D., Jr (1974) 'The Economics of Enforcing Air Pollution Controls', *Journal of Environmental Economics and Management* 1: 219–36.

Ehrenberg, R.G. and Schumann, P. L. (1982) 'Compliance with the Overtime Pay Provisions of the Fair Labor Standards Act', *Journal of Law and Economics* 25: 159–81.

Friedman, J.W. and Rosenthal, R.W. (1986) 'A Positive Approach to Non-Cooperative Games', *Journal of Economic Behavior and Organization* 7: 235–51.

Graetz, M.J., Reinganum, J.F. and Wilde, L.J. (1986) 'The Tax Compliance Game: Toward an Interactive Theory of Law Enforcement', *Journal of Law, Economics, and Organization* 2: 1–32.

Harsanyi, J.C. (1973) 'Games With Randomly Distributed Payoffs: A New Rationale For Mixed Strategy Equilibrium Points', *International Journal of Game Theory* 2: 1–23.

Hirsch, M.W. and Smale, S. (1974) *Differential Equations, Dynamic Systems and Linear Algebra*. New York: Academic Press.

Joskow, P.L. and Noll, R.G. (1981) 'Regulation in Theory and in Practice: An Overview', in G. Fromm (ed.) *Studies in Public Regulation*. Boston: MIT Press.

Katzmann, R.A. (1980) 'Federal Trade Commission', in J.Q. Wilson (ed.) *The Politics of Regulation*. New York: Basic Books.

Kelman, S. (1980) 'Occupational Safety and Health Administration', in J.Q. Wilson (ed.) *The Politics of Regulation*. New York: Basic Books.

Kohlberg, E. and Mertens, J.-F. (1986) 'On the Strategic Stability of Equilibria', *Econometrica* 54: 1003–37.

Langbein, L. and Kerwin, C.M. (1985) 'Implementation, Negotiation and Compliance in Environmental and Safety Regulation', *Journal of Politics* 47: 854–80.

Loeb, M. and Magat, W.A. (1979) 'A Decentralized Method of Utility Regulation', *Journal of Law and Economics* 22: 399–404.

Lowi, T.J. (1969) *The End of Liberalism*. New York: Norton.

Luce, R.D. and Raiffa, H. (1957) *Games and Decisions*. Wiley.

May, R.M. (1963) *Stability and Complexity in Model Ecosystems*. Princeton, NJ: Princeton University Press.

Moulin, H. (1981) *Game Theory for the Social Sciences*. New York: New York University Press.

Myerson, R.B. (1978) 'Refinements of the Nash Equilibrium Concept', *International Journal of Game Theory* 7: 73–80.

Nash, J.F., Jr (1951) 'Noncooperative Games', *Annals of Mathematics* 54: 289–95.

Ordeshook, P.C. (1986) *Game Theory and Political Theory*. Cambridge: Cambridge University Press.

Pearce, D.G. (1984) 'Rationalizable Strategic Behavior and the Problem of Perfection', *Econometrica* 52: 1029–50.

P'ng, I.P.L. (1983) 'Strategic Behavior in Suit, Settlement and Trial', *Bell Journal of Economics* 14: 539–50.

Reinganum, J.F. and Wilde, L.L. (1986a) 'Equilibrium Verification and Reporting Policies in a Model of Tax Compliance', *International Economic Review* 27: 739–60.

Reinganum, J.F. and Wilde, L.L. (1986b) 'Settlement, Litigation, and the Allocation of Litigation Costs', *Rand Journal of Economics* 17: 557–66.

Rodgers, J., Harrell, R. and Bullock, C.S., III (1972) *Law and Social Change: Civil Rights Laws and their Consequences*. New York: McGraw Hill.

Sappington, D. (1983) 'Optimal Regulation of a Multiproduct Monopoly with Unknown Technological Capabilities', *Bell Journal of Economics* 14: 453–63.

Scholz, John T. (1984a) 'Cooperation, Deterrence, and the Ecology of Regulatory Enforcement', *Law and Society Review* 18: 179–224.

Scholz, John T. (1984b) 'Voluntary Compliance and Regulatory Enforcement', *Law and Policy* 6: 385–404.

Scholz, John T. and Feng Heng Wei (1986) 'Regulatory Enforcement in a Federalist System', *American Political Science Review* 80: 1249–70.

Selten, R. (1975) 'Reexamination of the Perfectness Concept for Equilibrium Points in Extensive Games', *International Journal of Game Theory* 4: 25–55.

Stigler, G. J. (1971) 'The Theory of Economic Regulation', *Bell Journal of Economics and Management Science* 2: 3–21.

Tsebelis, G. (1989) 'The Abuse of Probability in Political Analysis: The Robinson Crusoe Fallacy', *American Political Science Review* 83: 77–92.

Tsebelis, G. (1990a) 'Are Sanctions Effective? A Game Theoretic Analysis', *Journal of Conflict Resolution* 34: 3–28.

Tsebelis, G. (1990b) 'Penalty Has no Impact on Crime: A Game Theoretic Analysis', *Rationality and Society* 2: 255–86.

Viscusi, W. K. and Zeckhauser, R. (1979) 'Optimal Standards with Incomplete Enforcement', *Public Policy* 5: 437–56.

Weaver, S. (1980) 'Antitrust Division of the Department of Justice', in J. Q. Wilson (ed.) *The Politics of Regulation*. New York: Basic Books.

Weingast, B. R. (1984) 'The Congressional Bureaucratic System: A Principal Agent Perspective (with Applications to the SEC)', *Public Choice* 44: 437–56.

Weitzman, M. L. (1978) 'Optimal Rewards for Economic Regulation', *American Economic Review* 68: 683–91.

Wilson, J. Q. (1974) 'The Politics of Regulation', in James W. McKie (ed.) *Social Responsibility and the Business Predicament*. Washington DC: Brookings Institution.

Wu Wen-tsun and Jiang Jia-He (1962) 'Essential Equilibrium Points of N-person Non-Cooperative Games', *Scientia Sinica*: 1307–32.

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Paper submitted 20 October 1989; accepted for publication 8 May 1990.