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BUREAUCRATIC COMPLIANCE AS A GAME ON THE UNIT SQUARE

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BUREAUCRATIC COMPLIANCE AS A GAME ON THE UNIT SQUARE*

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The most rigorous extensive theory of bureaucratic behavior yet developed is contained in William Niskanen's Bureaucracy and Representative Government. Niskanen's theory has numerous and important derivations explaining significant aspects of bureaucratic behavior, but even more importantly, it demonstrates the basic advantages of deductive methodology. By clearly and precisely stating its assumptions, Niskanen's theory invites falsification and correction in a way that can hopefully lead to a cumulative body of knowledge about bureaucratic organizations.

Already a fairly large body of literature has developed using Niskanen's theory as a starting point, showing how changes in Niskanen's assumptions can lead to a more realistic, yet still rigorous theory of bureaucratic behavior.[1] This paper will review some of the more important elaborations of Niskanen's theory to date and suggest a still more fundamental alteration of the assumption set. Basically,

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this paper will argue that the bureau head's supply decision cannot be regarded as an isolated decision, constrained by a fixed budget-output schedule. Rather, the bureau head's supply decision and the sponsor's budget appropriation decision must be analyzed in strategic interaction. This perspective suggests a game-theoretic model and permits the analyst to ask questions about the uniqueness and efficiency of joint solutions that are difficult or impossible to investigate with simpler models.

I. NISKANEN'S BASIC MODEL

Niskanen's basic model consists of the head of a governmental bureau acting under a budget constraint given by

$$B = aQ - bQ^2, \tag{1}$$

where B is the budget which the bureau's sponsor is willing to grant the bureau for a given expected level of output Q by the bureau (Niskanen, p. 25). The budget constraint is the integral of the demand function for that bureau's output by the bureau's sponsor. Niskanen also assumes an increasing marginal cost function of the form

$$TC = cQ + dQ^2. \tag{2}$$

Niskanen's bureau head is presumed to value such things as salary, the perquisites of the office, public reputation, power, patronage, the output of the bureau, and the ease of managing the bureau. Almost all these things are assumed to be positively

associated with the size of the bureau's budget. Niskanen's bureau head is then presumed to maximize the budget of the bureau in order to maximize his utility. Since the budget is at a maximum when Q is equal to a/2b, this is the bureau head's choice of output as long as total costs (TC) are less than the budget at this budget-maximizing output.

However, if TC is greater than the budget when Q is at a/2b, then the budget-maximizing bureau head will decide on a level of output which assures equality of budget and total costs. By setting B equal to TC, we discover that the bureau head will then decide on an output equal to

$$Q = \frac{(a - c)}{(b + d)} . \qquad (3)$$

This result, Niskanen suggests, indicates that the primary problem with bureaucracy is oversupply since it is larger than the output which would maximize net value to the legislative sponsor.

II. THE MANAGERIAL DISCRETION CRITIQUE OF NISKANEN'S MODEL

Jean-Luc Migué and Gérard Bélanger have criticized, or rather generalized, the basic behavioral assumption of Niskanen's model. While Niskanen assumed that the things valued by the bureau head are intrinsic to the budget and that the bureau head must therefore maximize his budget, Migué and Bélanger argue that one should differentiate between the bureau's output and all other budget-related perquisites of the office. Some bureau heads may value the bureau's output <u>independently</u> of the rewards of office, and their behavior will

be different from those bureau heads who derive no intrinsic satisfaction from the bureau's output. An output-maximizing bureau head will devote his budget to the actual costs of producing the output (call this concept TCQ), while other bureau heads may spend less than the entire budget on TCQ in order to have a fund for other purposes (called the managerial discretionary profit, or MDP).

Since the managerial discretionary profit is equal to the difference between the size of the budget and the amount of the budget actually spent on producing the bureau's output, then from equations 1 and 2 we can write

$$MDP = aQ - bQ^2 - cQ - dQ^2 . \qquad (4)$$

By differentiation, the level of output that maximizes managerial discretionary profit will be

$$Q = \frac{(a - c)}{2(b + d)} . \qquad (5)$$

This is the level of output that will be achieved by a bureau head who values only those things which can be achieved through managerial profit. This result may be compared with Niskanen's predicted output in figure 1. The managerial discretionary profit is the distance between the budget lines and the total cost lines; as the illustration shows, the distance between these lines is maximized at that level of output specified in equation 5. The problem with this level of output is not overproduction, but inefficiency, since the sponsor's most-preferred level of output is achieved, but at a budget cost to the sponsor larger than actual production costs.

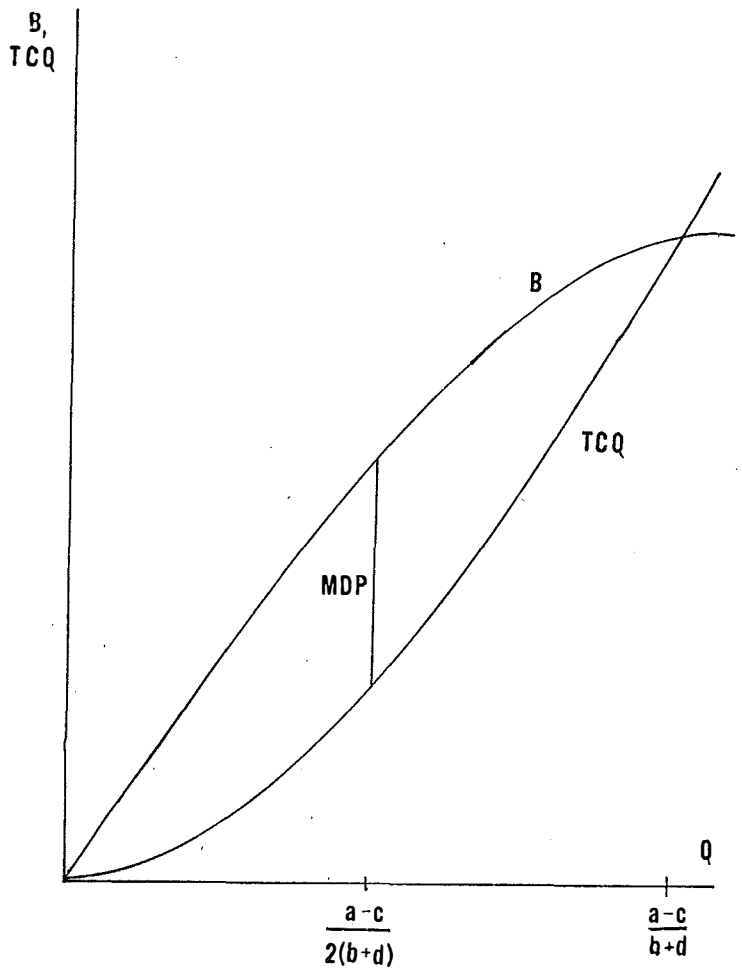

Figure 1

Budget-Maximizing and Profit-Maximizing Levels of Outputs

This analysis leaves us with two possible ideal-type bureaucrats: the one who maximizes the budget of the agency and the one who maximizes only managerial discretionary profit. But as Migué and Bélanger point out, it is possible to have a bureau head who values both, to varying degrees. That is, the agency head's utility may be described as a function of both B and MDP. But since the budget is assumed to be strictly a function of output, then it is also possible to say that the agency head's utility is a function of output and MDP:

$$U_h = f(Q,MDP). \qquad (6)$$

A particular agency head's choice of output level will be anywhere between the limits defined by the ideal-type budget-maximizing and profit-maximizing models.

III. WHAT ABOUT THE LEGISLATURE?

Migué and Bélanger make what I feel is an important contribution to Niskanen's theory by making it allow for perfectly realistic alternative motivational bases for agency heads. However, as in Niskanen's model, Migué and Bélanger leave no room for legislative impact on the final output of the agency other than setting the budget constraint which informs the agency head's decision. While the agency head can choose any level of output that maximizes his utility, the legislature has no way of influencing that decision in the context of a given demand function. The bureau head, according to both Niskanen and Migué and Bélanger, can put any proportion of the total budget into

actual production costs or perquisites of the office, while the legislature is given no opportunity to react to either "oversupply" or profit-maximizing" behavior on the part of the agency head. This, I believe, is the most fundamental weakness of Niskanen's theory. It allows for none of the bargaining between legislative sponsor and agency head which observers find so prominent a characteristic of the budget process.

Albert Breton and Ronald Wintrobe address the problem of the legislature in yet another note on Niskanen's theory. As they argue, the "basic flaw" in the argument is "that sponsors are completely passive. Politicians interested in their reelection will obviously attempt to exploit their position as monopsony buyers of the bureau's output."[2] Breton and Wintrobe suggest that we imagine agency heads as being subject to hierarchical controls from the governing political party.[3] The governing political party is assumed to be capable of getting information about the true total cost curve facing the agency head, at some cost.

If this is the case, what would be the most preferred outcome for the party in power? If the budget line is interpreted as the total evaluation function of the output of the agency, then the party in power would prefer the level of output preferred by the profit-maximizing bureau head, but at a budget cost equal to the true cost at that level. That is, they would like to assume the MDP for themselves, where MDP is of course interpreted broadly now as "net benefit."

The possibility that the legislature will be able to regain some of the net benefit or consumer surplus generated by the production of Q requires some additional terminology. In figure 2 what was formerly called the budget line is now called the sponsor's total evaluation curve (TE). The difference between the total evaluation and total costs at any point is called the surplus (S). The actual budget will fall between the total cost curve and the total evaluation curve, splitting the surplus into two parts. The part retained by the agency head is again managerial discretionary profit. The part regained by the legislature is regained net benefit.

Breton and Wintrobe assume that it is possible to get back their part of the surplus by spending resources on control devices. Figure 3 illustrates such a situation. In figure 3, the total cost of control devices (called TCD) is shown as a sharply rising curve, while the regained net benefit (NB) is shown as increasing at a decreasing rate with respect to the quantity of control devices (D). The party in power will produce control devices until the slopes of the two lines are equal.

IV. A CRITIQUE OF ONE-SIDED EQUILIBRIUM SOLUTIONS

Breton and Wintrobe also use their assumptions to arrive at an "equilibrium size of the bureau's budget, given the availability and use of antidistortion devices."[4] In doing so, I feel they make the mirror image of the mistake they accuse Niskanen of making. While they claim that Niskanen is incorrect to assume a passive

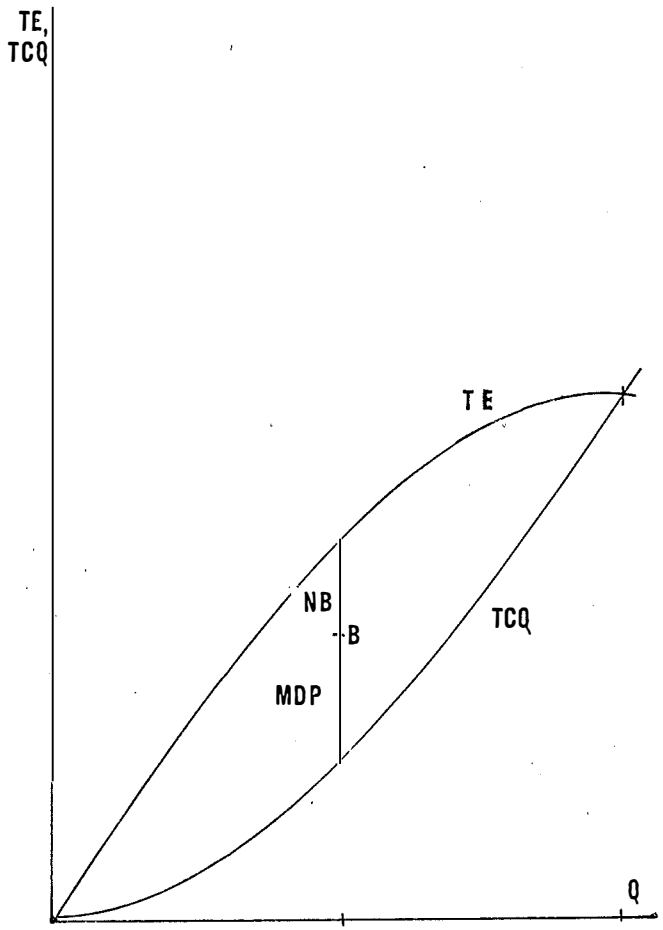

Figure 2

Net Benefit and Managerial Discretionary Profit

Determined by Legislative Budget Decision

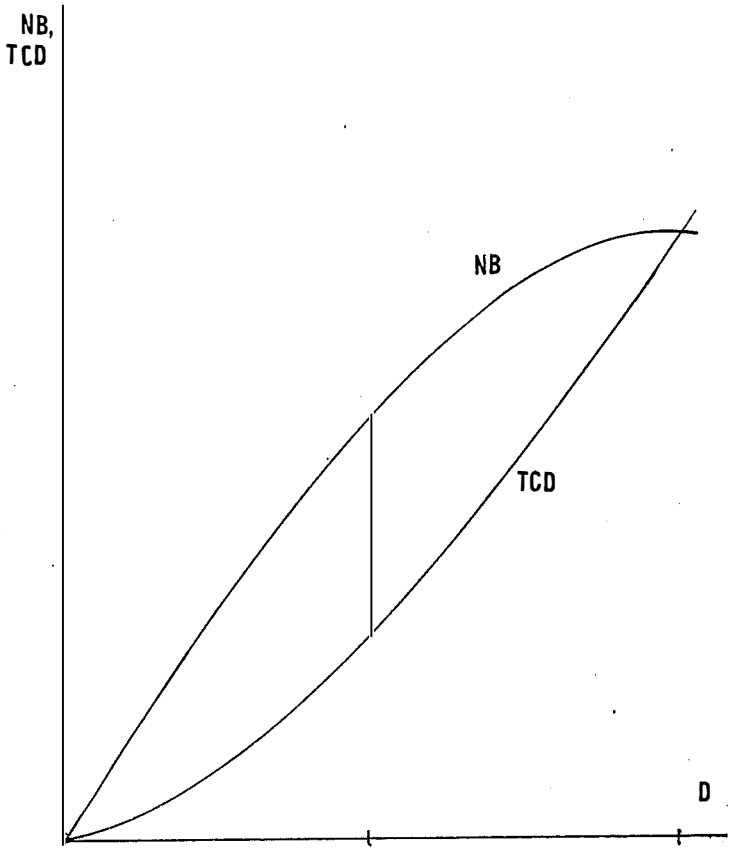

Figure 3

Cost of Control Devices and Regained Net Benefit

as a Function of Quantity of Control Devices

legislature, Breton and Wintrobe seem to assume a passive agency head. While Niskanen's equilibrium level of output is determined by a decision of the agency head alone, Breton and Wintrobe's equilibrium is determined by the legislature alone. Both Niskanen and Breton and Wintrobe fail to consider the more complex possibility that the final result is determined by both the governing political party and the agency head in a bargaining context. One cannot determine the budget outcome just by looking at the preferences of one player or another; the players are engaged in a game.

Niskanen and Breton and Wintrobe propose a unique equilibrium solution where one very well may not exist. Does this mean that the budget process is, in the final outcome, unanalyzable in any rigorous sense? Obviously not; it simply means that we must not impose certain kinds of solutions where more complex ones may be necessary. We must use those analytical techniques that have been developed for bargaining situations and which leave open the question of equilibria, unique or otherwise. The purpose of the remainder of this paper is to demonstrate the use and applicability of a kind of game-theoretic analysis to the problem addressed by Niskanen, Migué and Bélanger, and Breton and Wintrobe. It is hoped that this type of analysis will much more closely approximate the budget process than the single-actor decisions modeled heretofore, and that this analysis will permit more complex and interesting questions to be asked of the model -- questions dealing with the uniqueness and Pareto optimality of equilibrium results.

V. GAMES ON THE UNIT SQUARE AND THEIR POLITICAL APPLICATIONS

I propose that our starting point be the assumption that both the agency head and the party in power determine the output of the agency. The party in power does this by deciding how much money to appropriate to the agency; the agency head decides how much of its budget is actually spent on producing Q.

Each player therefore has an infinite number of choices along his strategy dimension. Games with an infinite but countable number of pure strategies are difficult to handle. For instance, the game which rewards the individual who can choose the highest integer does not have a solution since there are an infinite, unbounded, but countable number of strategy choices for each player. However, games with infinite and uncountable strategies, such as games whose strategy sets can be represented by all the points on a bounded line segment, do have solutions. If the assumption is made that each player's pure strategies form a continuum represented by the interval (for example) from zero to one, the game is called a game on the unit square (for two-person games).

The political applications of infinite games up to the present time have involved zero-sum infinite games. For instance, the use of infinite games has allowed Aranson, Hinich, and Ordeshook to develop a more parsimonious set of assumptions with which to exorcise the voters' paradox devil from democratic elections.[5] On the other hand, there seem to be no applications of nonzero-sum infinite games to politics. The problem of obtaining bureaucratic compliance would seem to be an ideal setting for such an application.

What are the potential advantages of such an application? Infinite game analysis allows for the possibility of a unique equilibrium solution as sought by Niskanen, Migué and Bélanger, and Breton and Wintrobe. However, it does not impose one. Instead, it also allows for multiple equilibria, unstable equilibria, divergent games, mixed strategy solutions, and even prisoners' dilemmas, all of which may well occur in the actual world of bureaucratic-legislative relations. Further, certain mathematical theorems allow us to predict what kinds of solutions will occur in given conditions. Hypothetical, but plausible conditions, are explored in the next section.

VI. BUREAUCRATIC COMPLIANCE AS A GAME

Let us view the relationship between the party in power and the head of a bureaucratic agency as a game. The agency head has a strategy dimension, let us call it H, which goes from 0 to 1. Any particular strategy, h, denotes the proportion of his total budget, B, which he actually dedicates to the production of the agency output, Q. The party in power naturally wants the agency head to choose h = 1, using all the budget for the production of the formally authorized output, Q. The problem then is one of compliance, unless the agency head is an ideal-type output-maximixing bureaucrat.

The governing party has a strategy dimension as well, which may be denoted by G and which also goes from 0 to 1. Any particular strategy, g, is interpretable as that proportion of R (where R is the total resources available for the service provided by the agency in question) which the governing party actually decides to appropriate

for that agency. Thus, the product, gR, is equal to the agency budget, B. Neglecting the kind of explicit control devices suggested by Breton and Wintrobe, the use of R can itself be viewed as a reward-punishment dimension for influencing agency behavior. The larger proportion of R that is spent on the budget, the greater the reward, while the larger proportion of R that is kept in reserve, the greater the punishment effect.

We may note that the parameter R, the strategy choices g and h, and the cost-output function completely determine the system. For instance, let us imagine that R = \$10,000 if the governing party chooses g of one-half, then the budget will equal \$5,000. If the agency head selects h = .72, then \$3,600 will be spent on the production of Q, and \$1,400 will be left as managerial discretionary profit. If the cost-output function is $\$50(Q) + \$.25(Q^2) + \$2500$, then Q will be equal to $2\sqrt{TCQ} - 100$, or (for this example), 20 units.

VII. PAYOFF FUNCTIONS AND CHOICE OF STRATEGY

How then do the governing party and the agency head make their choice of strategies? In order to make a choice they must have an understanding of the payoffs associated with their choices.

For instance, let us look at the payoff function for the governing party, which will be denoted by M_g. The party is presumably seeking to maximize its net benefit, which is found by subtracting budget expenditures from its total evaluation of the agency's output. Retaining Niskanen's evaluation function, we obtain

$$M_g = aQ - bQ^2 - B \quad (7)$$

More complex payoff functions may certainly be assumed without changing the general nature of the following discussion.

The agency head may get some pleasure from both agency output and from managerial profit, as pointed out by Migué and Bélanger. We may write, in its most general form,

$$M_h = M_h(Q,MDP). \quad (8)$$

We should note that all the arguments in both payoff functions are expressible in terms of the parameters and the strategy choices:

$$B = gR; \quad (9)$$

$$MDP = (1 - h)B = (1 - h)gR; \quad (10)$$

$$Q = f(TCQ) = f(ghR). \quad (11)$$

VIII. THE QUESTION OF EQUILIBRIA

When may we say a pure equilibrium strategy exists? An important game-theoretic result shows that if M_g is concave in G and if M_h is concave in H, then at least one pair of strategies exists that results in equilibrium.[6] Given what we know about bureaucratic behavior, is this likely?

With a cost function of the sort proposed by Niskanen and a net benefit-maximizing governing party as in equation 8, the concavity assumptions are indeed met. This is because of the assumption of

increasing marginal cost and the assumption that the payoff is the difference between the evaluation of the produced good by the party and the costs incurred by the sponsor.

Similarly, if the agency head has decreasing marginal evaluation of the good and of managerial profit, the concavity assumption for M_h in H will also be met.

Having argued that at least one set of equilibrium strategies is likely, can it also be shown that there is a unique equilibrium? Nikaido and Isoda have also demonstrated that additional conditions establish the uniqueness of equilibrium. For the present problem, M_g must be convex in H and M_h must be convex in G.

I would argue that this condition will probably not be met. For instance, let us look again at M_g. If the governing party behaves as if it were maximizing net benefit, as we suppose, and as long as the party in power has decreasing marginal evaluation of Q, M_g will be concave rather than convex in H. This means that it is impossible to establish the uniqueness of equilibrium in the bureaucratic compliance game despite Niskanen's attempt to find just such an equilibrium.

IX. THE QUESTION OF PARETO OPTIMALITY

An example serves to show that equilibria, even when a unique equilibrium exists, may not be Pareto optimal for the players in this game of bureaucratic compliance.

For instance, let us maintain the net benefit-maximizing payoff function postulated for the legislative sponsor:

$$M_g = aQ - bQ^2 - B. \quad (12)$$

A somewhat similar payoff function for the agency head is

$$M_h = a'Q - b'Q^2 + MDP. \tag{13}$$

Total resources available to the party for the service in question are still equal to R, and constant marginal costs are assumed:

$$TCQ = cQ. \tag{14}$$

Substituting for Q, B, and TCQ in M_g, we obtain

$$M_g = a(ghR/c) - b(ghR)^2/c^2 - gR. \tag{15}$$

Similar substitutions for M_h yield

$$M_h = \frac{a'ghR}{c} - \frac{b'(ghR)^2}{c^2} + g(1 - h)R. \tag{16}$$

By differentiating with respect to g, we obtain the slope of the payoff function for the governing party with respect to its own strategy dimension. Setting the result equal to zero and solving for g yields a reaction curve for the governing party in terms of the agency head's strategy dimension:

$$g = \frac{cah - c^2}{2bRh^2}. \tag{17}$$

A similar manipulation yields a reaction curve for the agency head

in terms of the governing party's strategy dimension:

$$h = \frac{ca' - c^2}{2b'Rg}. \tag{18}$$

Solving for these two reaction curves yields any equilibria position. In the case of the payoff functions hypothesized in the example, the equilibrium strategies are

$$g = \frac{(a' - c)(ab' - a'b + bc)}{2R(b')^2}; \tag{19}$$

and

$$h = \frac{b'c}{ab' - a'b + bc}. \tag{20}$$

As a numerical example, let us take the sponsor's evaluation function to be $200(Q) - (1/2)(Q^2)$ as in an example by Niskanen (p.49). The sponsor's ultimate payoff function is simply

$$M_g = 200(Q) - (1/2)(Q^2) - B. \tag{21}$$

Let us assume that the bureau head has an evaluation of Q equal to $50(Q) - (1/8)Q^2$, and his payoff function is

$$M_h = 50(Q) - (1/8)(Q^2) + MDP. \tag{22}$$

The resources available to the sponsor for Q are equal to $4800, and

one unit of Q is produced for every $48 actually spent on the production of Q by the agency head.

With these parameters, equilibrium occurs when the sponsoring party spends about 32 percent of its resources, or $1536 on the agency's budget, and the agency spends about one-quarter of the budget on the production of Q. This means that $384 are spent on the production of Q, and so eight units of Q are produced. This level of output is valued by the sponsor at $1568, yet it had to pay $1536 for the budget; it therefore received a net payoff of only $32. At equilibrium the agency head evaluates this level of production intrinsically at $392 and, in addition, had a managerial profit of $1152.

On the other hand, notice what would have been the payoff if they could have agreed on the nonequilibrium solution at which 100 percent of the resources go into the agency budget, and 100 percent of the agency budget goes into production of Q.[7] In this situation, one hundred units of Q would be produced, for a net payoff to the sponsor of $10,200, as opposed to $392. The agency head's payoff, even with no managerial profit, would be equal to $3750. Thus, both players would have been better off at a nonequilibrium strategy pair. They are in a prisoners' dilemma.

X. PARETO OPTIMALITY: A COMMON CHARACTERISTIC OF COMPLIANCE SITUATIONS?

This last example suggests the possibility that prisoners' dilemmas may occur in other bureaucratic relationships. Surely, for instance, the agency head has subordinates who have their own goals

which might be different from those of either the agency head or the legislative sponsor. These subordinates may be playing similar compliance-type games with the agency head. Is it possible that these games might be Pareto suboptimal for these players as well?

There are certain characteristics of a generalized supervisor-subordinate relationship that suggest the possibility of built-in suboptimality. These characteristics are the following:

1. The superior tends to have a set of incentives available to him with which to reward subordinate behavior (e.g. special funds, time off, etc.). These rewards tend to be increasingly costly to the supervisor after a certain level of expenditure, but they are not so costly to him as is noncompliance on the part of the subordinate.
2. The subordinate has some compliance dimension available to him (output measure, probability of compliance with a set of rules). Increasing compliance is costly to him, but not so costly as failure to be rewarded by the superior.

In other words, both the superior and the subordinate are in a situation in which a change in either person's strategy dimension affects each player in opposite ways (increased compliance is costly to the subordinate but very welcome to the supervisor). Further, each person is <u>more</u> affected by changes in his opponent's strategy dimension than he is by changes in his own strategy dimension. Thus, the superior can be hurt more by noncompliance on the part of the subordinate than he can be helped by economizing on the flow of rewards. Similarly, the subordinate can be hurt more by failure to get rewards from the superior

than he can be helped by cutting back on his degree of compliance.

Let us see what these conditions mean in terms of a simple compliance game. Just two points on each strategy dimension are illustrated in figure 4: moderate and high compliance on the part of the subordinate, and moderate and high rewards on the part of the supervisor. The superior would most prefer to be in box B, because he could obtain a high degree of compliance for only a moderate expenditure in reward resources. However, if he had to choose between boxes A and C, he would prefer A because (as was mentioned above) a reduction in compliance is more costly than increased reward. His last choice is box D.

The subordinate would prefer box D with a high reward and only moderate compliance on his part. If he had to choose between A and C, however, he would prefer box A because a reduction in rewards hurts him more than an increase in compliance. His last choice is Box B.

The equilibrium result is of course the moderate level of reward and compliance, even though both individuals would be better off with a high degree of reward and a high degree of compliance. The Pareto optimal result is not achieved because both superior and subordinate have an incentive to break away from it. The supervisors quite naturally have an incentive to give less than the maximum reward for subordinates, and the subordinates quite naturally have an incentive to float through their work situation with less than 100 percent effort.

The important result is that in compliance situations as I have described them, there is a necessary and natural tendency towards

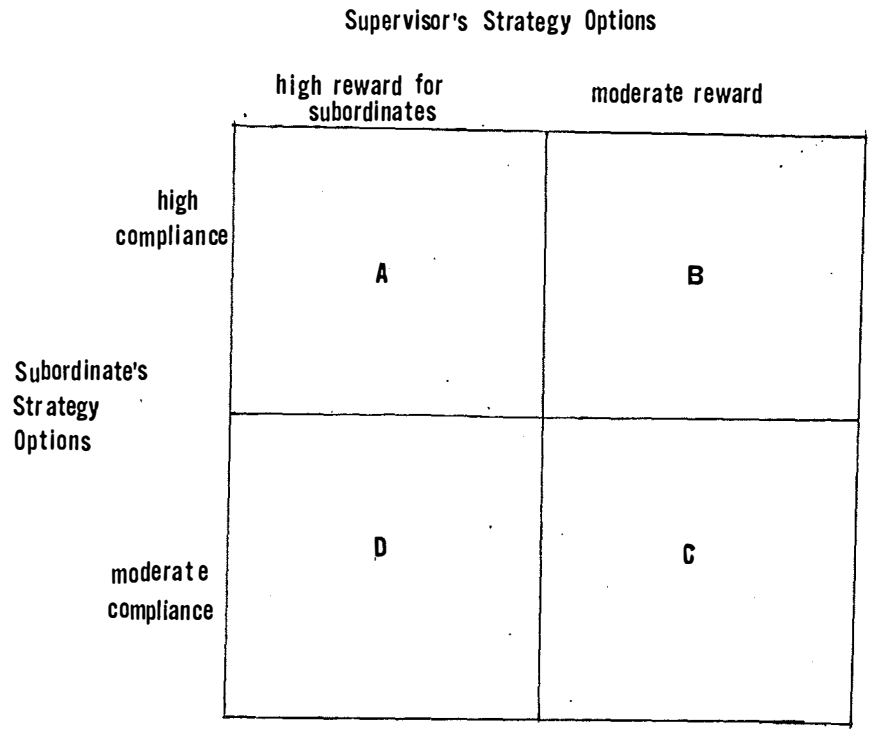

Figure 4

Strategy Options and Outcomes for Generalized Compliance Game

suboptimality. Of course, not all supervisor-subordinate situations are as I have described them. The major exception, I would imagine, would be those work situations in which the task assignment is itself rewarding, as for artists and professionals. Of course, these are also the situations in which hierarchical organizational arrangements are less common precisely because there is no problem of compliance perceived.

XI. SUMMARY: HIERARCHY AND COMPLIANCE

Prior to World War II, the paradigm in public administration was a Wilsonian-Weberian model of organization which emphasized the concept of hierarchical control. Authority descended from the top in an organization, and it was assumed that subordinates must carry out orders in an automatic, virtually mechanistic way. Since World War II, psychologists, sociologists, and political scientists have demonstrated myriad ways in which subordinates act as decisionmakers in their own right by forming informal organizations, by reacting perversely to certain styles of supervision, and by political bargaining with superiors and associates. In the reaction to the mechanistic model of organization, the concept of hierarchy has become rather an embarrassment since no one has quite shown how to incorporate both hierarchy and subordinate autonomy into a new paradigm for public administration.

Niskanen's model of budget formation was clearly based on the recognition that the agency head (the subordinate of Congress in the Wilsonian paradigm) had autonomy. Yet his highly sophisticated theory suffers because, as Breton and Wintrobe point out, Niskanen completely

ignores the existence of hierarchical controls from the agency sponsor. The game on the unit square, I would suggest, is capable of incorporating both the idea of subordinate autonomy and hierarchical controls in a single analytical framework. The subordinate is an autonomous player in the game; yet he is subject to a reward-punishment strategy dimension that his superior manipulates by virtue of his position in a hierarchy. It is interesting to note that even a simple bureaucratic structure like this is subject to inefficiencies.

In this paper the game on the unit square has been used to analyze a single hierarchical relationship, that of governing party and agency head. However, the same mode of analysis could be used to analyze other hierarchical relationships throughout the chain of command. It could even be used to develop a generalized model of bureaucratic compliance in which a subordinate has a strategy dimension denoting his degree of compliance (with a set of rules or a production schedule, for instance) and the superior has a reward-punishment strategy dimension much like the governing party's strategy dimension in this analysis. It would be interesting to see if such a mode of analysis could serve as an integrative framework for theories about hierarchical behavior at all levels in an organization.

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FOOTNOTES

1. See Breton and Wintrobe, Hettich, and Migué and Bélanger.

2. Breton and Wintrobe, p. 198.

3. The shift from legislature to party in power as the analytical sponsor or buyer of the agency's services has an advantage that Breton and Wintrobe do not mention. The legislature is noted for its conflict, rather than consensus, and is the prime example of an arena subject to cyclical or intransitive collective preferences. Niskanen's assumption that the agency sponsor has a unitary evaluation function is therefore very problematic when the sponsor is viewed as a legislative body. The governing party can perhaps be viewed as being more likely to have a transitive collective preference structure.

4. Breton and Wintrobe, p. 200.

5. See Aranson and Ordeshook, Hinich and Ordeshook, and Riker and Ordeshook, pp. 307-337.

6. See Nikaido and Isoda.

7. This outcome is not in equilibrium because the agency head, for instance, would have a strong incentive to reduce his allocation of the agency budget to production of Q. This can be seen by noting that the slope of the agency head's payoff, with respect to his own strategy dimension, is strongly negative at the outcome suggested.