PUBLIC SECTOR EFFICIENCY –

A GAME–THEORETIC ANALYSIS

by

Fredrik Carlsen

Dissertation submitted for the degree of dr. oecon.

Norwegian School of Economics and Business Administration,

Helleveien 30, 5035 Bergen – Sandviken, Norway

9140002265

PREFACE

This work is an attempt to apply game theory to a standard model of bureaucracy. The emphasis is on the implications of the model for the cost efficiency of public institutions.

I would like to thank the members of my dissertation committee, Aanund Hylland, Terje Lensberg and in particular my main advisor, Frøystein Gjesdal, for providing many valuable comments, my parents for improving the English language and Marit and Dagrun for their patience and support.

June, 1991

Fredrik Carlsen

CONTENTS

CHAPTER 1

INTRODUCTION

A substantial amount of public services is produced by bureaus which receive their revenues as the result of political decisions rather than their customers' choices. In Western Europe, the total supply of services in the health, education, and cultural sectors is basically decided by the authorities. In Norway, the municipalities are responsible for producing the bulk of these services.

Public institutions like hospitals, nursing homes, schools and theatres act as agents for elected politicians. The democratic ideal is that the institutions loyally execute political decisions which in turn reflect the preferences of the electorate. However, since the public sector is huge and complex, we would expect a number of agency problems to exist, for instance in the relationships between the constituency and the politicians, between political bodies and administrators and between the political decision system as a whole and the institutions.

Our work deals with the last of these agency relationships. We will draw on formal models of bureaucracy to characterize the interaction between the political decision system and the institutions. In particular, we explore how different assumptions about the interaction process affect the cost efficiency of the institutions. In the introduction, we will outline the basic problems we will study and discuss how various lines of research can throw light on the issues.

The authorities face an agency problem when the authorities and the institutions have different objectives and the institutions have superior information which enable them to pursue their goals at the expense of the objectives of the authorities. A basic assumption of our work is that the authorities and the institutions disagree on a number of issues, like whether an institution has excessive slack and which priority to assign to the institution's different tasks. The institutions are better informed than the authorities about their true costs, their production technology and the customers' true demand for the institutions' services. Since monitoring is costly, the institutions can exploit their information monopoly to choose a different resource allocation than preferred by the authorities.

Agency problems in the relationships between investors and corporate managers and between regulators and for–profit firms have been meticulously analyzed in accounting, finance and economic literature. However, there exists very little research on the relationship between public authorities and institutions. The distinct feature of this agency problem is that the principal's preferences and strategies are the results of a complex interaction process involving many parts with divergent objectives. The special nature of a political decision process affects the stability of the principal's preferences, its ability to undertake commitments and the policy variables which are at its disposal.

For instance, consider the interaction between a county and a hospital in Norway. The county's policy is affected by at least seven types of agents, the Federal Department of Municipal Affairs, the Executive Officer of the county including his/her economic staff, the administrative officers, the leaders of the main political parties, the Executive Council, sector committees and the County Council. The hospital is a bit more homogeneous but its policy is set through bargaining between the hospital board, where county politicians constitute the majority, and several layers of administrators and physicians.

Various reform proposals for the public sector, like piece–rate systems, global budgets and increased discretion for institutions in matters of finance, personnel administration and capital investments, affect the framework of the interaction process between the political decision system and the institutions. In order to assess the effects of proposed reforms, it would be helpful to have a formal model which captures important elements of this interaction process. Such a model should roughly predict how the outcome of the process depends on the basic rules of the process.

The last decades, mathematical tools have been developed to deal with situations involving strategic interdependencies between the agents. Basically, game theory describes the outcome of an interaction process as a function of the agents' information sets, preferences, policy instruments and the sequence of moves of the game. The equilibrium outcome of the game is a set of strategies which assign actions to the agents at each decision node contingent on the state of nature observed by the agents. The equilibrium strategies maximize each agent's expected utility when all agents believe that the other agents pursue their optimal strategies.

The basic idea of our work is that the interaction process between the political decision system and the institutions fruitfully can be modeled formally as a game between the process's key agents. If this assumption is correct, we can get valuable information about the outcome of the interaction process in real life by computing the equlibrium strategies of the corresponding game. Within the model, public sector reform proposals must be understood as changes in the basic rules of the formal game. For instance, reforms may restrict or enhance the strategy spaces of the agents or change the agents' preferences or information sets. By comparing the equilibrium outcomes of various games, we are able to evaluate the effects of the reform proposals, contingent on our assumptions about how the interaction process works.

We now turn to the issue of formulating a formal model of the interaction process between the political decision system and the institutions. Very little research has been carried out to describe formal games between public sector agents. The vast majority of applications of game theory is found in the literature on industrial organization where the agents' basic objective is to maximize profit. For the agents whose behaviour we want to study, profit is obviously not a relevant objective. The prime goal of the authorities is to provide the general public with services. However, when setting targets for the volume and quality of different services, the authorities must take into account that revenues are limited or that it is costly to raise revenues. The institutions' main objectives are probably also to serve the general public, although we would expect the authorities and the institutions to disagree on several aspects concerning the management of the institutions.

The public choice literature on "bureau and sponsor" makes assumptions about the agents' preferences which are broadly in accordance with what we would expect for the real life agents we want to study. Hence, we will base the analysis of the following chapters on a standard model of bureau and sponsor. We will extend the model by applying some recent developments in game and agency theory which hopefully makes the model richer as a description of the game between public sector agents.

Niskanen's work on bureaucracy and representative government from 1971 is regarded as the starting point of the bureau and sponsor literature. Niskanen, as well as most of his successors, consider the bureau as an administrative agency which executes the decisions of a political body, the sponsor. Hence, the bureaucracy literature discusses agency problems within the political decision system rather than between the political decision system and the institutions. This difference in emphasis is probably due to the fact that most writers are American. The models are often related to interaction processes within the U.S. federal administration. Therefore, in our work, we must modify the interpretation of the formal model compared to the bulk of bureaucracy studies.

According to Niskanen (71), the power of the bureau is derived from its superior information about the true values of output and minimum costs and the bureau's status as a monopoly supplier of output. Niskanen did not model the agents' information sets formally. Instead, he argued that the bureau's informational advantage enables it to present the sponsor with a take–it–or–leave–it offer. Hence, the bureau can pick its preferred point on the sponsor's reservation utility locus. Niskanen assumed that the bureau is a revenue–maximizer. Therefore, the outcome of the game yields too high output but not necessarily cost inefficient production.

Niskanen's successors, as well as Niskanen himself in his paper from 1975, introduced slack in the bureau's utility function. The inclusion of slack in the utility function of the formally subordinate agent has become a widespread way of modeling the conflicting interests of the parties in a bilateral relationship. Williamson (64) suggested that a corporate manager's preferences for slack constitutes part of the shareholders' agency problem. Building on Williamson, Migue & Belanger (74) proposed that the bureau's utility function should have both output and slack as arguments. These assumptions about the bureau's preferences have by now been widely accepted. The sponsor's utility function has remained basically unchanged since Niskanen's first contribution. The sponsor derives positive utility from output and dislikes granting money. Therefore, the main disputes between the two agents concern the size of the bureau's budget and how to allocate the budget to productive activities and slack.

The major contribution of the recent papers in the Niskanen–tradition, Miller (77), Moene (86) and Chan & Mestelman (88), has been to apply the Nash–equilibrium concept to various one–period games under certainty. The authors explore how different orders of moves and different policy instruments for the two agents affect the equilibrium outcome. As a tool for analyses of the interaction process in the public sector, the present generation of bureaucracy models have two shortcomings.

First, except for one paper (Bendor, Taylor & van Gaalen (87)), the information structure of the agents has not been explicitly modeled by the authors. Instead, the authors refer to asymmetric information between the agents to justify their choices of the agents' policy variables. However, the agents of the models do not compute their strategies by maximizing their expected utility under uncertainty. It is unsatisfactory to apply an equilibrium concept which explicitly requires the agents to have complete information and, simultaneouly, justify the models' setting by referring to the presence of private information. If the researcher wants to capture the effects on the interaction process of a particular information structure, he/she should explicitly model the agents' information sets and let the agents optimize under uncertainty. Modern development in game theory clearly shows that how we formally model the information structure has a profound influence on the equilibrium outcome of the game.

Second, there has been no systematic attempt in the bureaucracy literature to build formal models which mimic the agents' moves in real life. In papers on bureaucracy written by economists, we seldom find references to empirical studies of the public sector. An obvious shortcoming is that the models solely deal with one–period games. A basic feature of the budget process in the public sector is that decisions concerning the size of a bureau's budget are repeated regularly. However, no formal study has explored the consequences of extending a basic one–period game between the bureau and the sponsor to several periods (an exception is Spencer (82), but she does not adress the issues we focus on in our work).

Detailed discussions of how the interaction process in the public sector takes place can be found in a branch of the bureaucracy literature pursued by political scientists (see the surveys by Jackson (83) and Bendor (87)). These papers (examples are Bendor, Taylor & van Gaalen (85) and Chubb (85)) elaborate on the distribution of information between the agents and how the authorities apply various policy instruments to counter their information disadvantage. The papers also consider how the outcome of the interaction process is affected by the presence of many sponsors.

A weakness of most of these works is that the formal models do not comply with game theory's demands concerning rational behaviour. Hence, the equilibrium outcomes of the games are often not sensible. The informal discussion of the papers centers on the relationship between political committees and public agencies in the U.S. federal administration. Therefore, the description of the interaction process is not necessarily entirely relevant for our purposes.

During the rest of this introduction, we will discuss other strands of literature which are related to the bureaucracy tradition. We start with regulation theory, which is a normative approach to the authorities' agency problem. Traditional welfare theory has not emphasized the informational constraints of the policy makers. By contrast, regulation theory deals with how the authorities counter the informational advantage of public institutions. Typically, the policy maker formulates a scheme which induces the enterprises to maximize a social welfare function given the appropriate incentive constraints. The social welfare function is in general a weighted sum of consumer and producer surplus (surveys of the regulation literature are given by Vickers & Yarrow (88) and Baron (89)).

The main strength of the regulation literature is its comprehensive treatment of asymmetric information. Originating in agency theory (Ross (73), Holstrøm (79)), the regulation literature explicitly models the information structure and requires each agent to act rationally according to its information set. This approach has brought a number of valuable results which illustrate the trade–offs faced by the authorities when promoting the public interests. For example, there is a trade–off between allocative efficiency and a desirable income distribution when costs are not observable (Baron & Myerson (82)), and there is a trade–off between allocative and cost efficiency when actual costs can be observed but effort can not (Laffont & Tirole (86)).

For our purposes, there are two problems with the regulation approach. First, contrary to the bureaucracy literature, regulation theory normally assumes that the public institutions' utility functions contain profit and slack. The institutions receive their revenues partly through a regulated price and partly by transfers from the authorities. Therefore, regulation theory is more relevant for electricity and telecommunication enterprises than for hospitals and schools.

Second, regulation theory makes very strong assumptions about how the policy maker's preferences and decisions are formed. For each period of the game, the authorities formulate a scheme ex ante which is automatically executed after the institutions have made their moves. Hence, regulation theory states how the policy makers should act, if they are able to commit themselves to a policy for some duration of time, and if their preferences are stable and in accordance with the social welfare function. Regulation theory also assumes that the policy makers can make the scheme dependent on every ex post observable variable.

The regulation literature's model of the policy maker is very different from what we find in organization theories of the public sector, like the "garbage can" theory (Cohen, March & Olsen (76)) or the "incremental theory" (Wildavsky (75,88), Danziger (78)). The garbage can theory states that the authorities spend most of their time and energy to solve problems as they arise. Therefore, the authorities have limited ability to undertake long–term planning. Reforms and schemes are not primarily instruments to affect the resource allocation of the public sector but to legitimize the political system. The incremental tradition claims that the enormous complexity of the public sector makes the incremental approach rational as a mode of decision–making. The policy makers can only evaluate a small part of the public institutions' activities at a time. The bulk of the institutions' activities does not receive attention from the policy makers.

These organizational theories indicate that the models of regulation theory make far too optimistic assumptions about the policy makers' ability to express preferences and formulate and stick to incentive schemes. A fruitful approach to the interaction between sponsors and bureaus should therefore experiment with alternative and more realistic assumptions concerning the behaviour of the participants of the political decision system compared to what we find in regulation theory.

The lack of realism in modelling the policy maker, makes regulation theory vulnerable to the same type of criticism that James Buchanan has put forward against traditional welfare theory (for instance in Brennan & Buchanan (80,85)). Buchanan's main point is that reform proposals which are sensible under the assumption that the policy maker is benevolent, might be totally wrong if the policy maker's preferences are significantly different from those of society. The policy recommendations of welfare theory are therefore sensitive to the theory's assumptions concerning the behaviour of the policy maker. Buchanan argues that proposals for reforms should be based on the assumption that the rules of the political decision process could be exploited by the process participants to pursue their personal goals.

In similar manner, one could argue that the policy recommendations of regulation theory are based on an unrealistic view of how the regulator behaves. For example, since the policy maker by assumption is able to commit itself to a scheme for each period of the game and seeks to maximize society's welfare function, there is no point in ex ante limiting the policy maker's discretion to decide on the form of the scheme. However, if we instead assume that the policy maker is able to change the policy during the period, the conclusion of our analysis may change radically. Then, it may be wise to implement reforms which restrict the discretion of the policy maker. As seen by society, the important point is whether the reform pushes the equilibrium outcome of the game between the policy maker and the institutions in a desirable direction.

The impact of the institutional framework on the equilibrium strategies of the authorities and the private sector agents has received much attention in recent macroeconomic literature. The main theme of the literature following the seminal articles by Barro & Gordon (83a,b), is how the authorities can undertake commitments which induce private agents to behave in compliance with the authorities' macroeconomic goals.

We will include a brief discussion of another important public choice approach to the question of how public sector agents act, the theory of rent–seeking and interest groups (some of these works are surveyed by Noll (89)). The basic assumption of these theories is that public policy decisions are affected by organized interest groups. These groups partly compete for public revenues (as stressed by Olsen (65,82), Tullock (67)) and partly interact to eliminate inefficiencies due to market failures (as stressed by Becker (83,85)). The success of an interest group to influence the policy maker depends on a variety of characteristics of the group, including its ability to create organizations with homogeneous goals.

The perspective offered by these theories are valuable for the study of the issue we have raised. In real life, the authorities' policy depends on the preferences of the participants of the political decision process and how the agents interact. The theories of rent–seeking and interest groups suggest how we could model the process leading to the formulation of the policy maker's strategy. However, the works in this tradition do not model the agents' interactions formally, but are based on ad hoc assumptions about the relationship between the agents' behaviour and the outcome of the interaction.

To conclude: We have argued that formal models of bureau and sponsor provide a useful starting point for analyses of the relationship between public authorities and non–profit institutions producing services for the general public. However, the present generation of bureaucracy models should be extended. First, the information structure of the interaction between the public sector agents should be formally modeled. For this task, we can draw on the rapidly expanding literature on regulation of for–profit firms. Second, the assignment of policy variables to the agents and the sequencing of the agents' moves should be based on organization theories of the formulation of public policies in addition to empirical studies of the public sector. There exist some Scandinavian studies which are relevant for the issues we intend to study (Brunsson & Rombach (82), Jønsson (82) and Brunsson (86) for Sweden, the Bergen–project (Høgheim et al (89a,b)) for Norway).

In chapter 2, we survey the literature on bureau and sponsor and explain how we will develop the basic bureaucracy model

REFERENCES

Baron, D. 1989: Design of Regulatory Mechanisms and Institutions, in Schmalensee, R. & Willig, R. (ed): Handbook of Industrial Organization, Volume II, Elsevier Science Publishers.

Baron, D. & Myerson, R. 1982: Regulating a Monopolist with Unknown Costs, Econometrica 50, 911–930.

Barro, R. & Gordon, D. 1983a: A Positive Theory of Monetary Policy in a Natural Rate Model, Journal of Political Economy 91, 589–610.

Barro, R. & Gordon, D. 1983b: Rules, Discretion and Reputation in a Model of Monetary Policy, Journal of Monetary Economics 12, 101–122.

Becker, G. 1983: A Theory of Competition among Pressure Groups for Political Influence, Quarterly Journal of Economics 93, 371–400.

Becker, G. 1985: Public Policies, Pressure Groups and Dead Weight Costs, Journal of Public Economics 28, 329–347.

Bendor, J. 1987: Review Article, Formal Models of Bureaucracy, British Journal of Political Science 18, 353–395.

Bendor, J. Taylor, S. & van Gaalen, R. 1985: Bureaucratic Expertise versus Legislative Authority, American Political Science Review 79, 1041–1060.

Bendor, J. Taylor, S. & van Gaalen, R. 1987: Politicians, Bureaucrats and Asymmetric Information, American Journal of Political Science 31, 796–828.

Brennan, G. & Buchanan, J. 1980: The Power to Tax. Analytical Foundations of a Fiscal Constitution, Cambridge University Press.

Brennan, G. & Buchanan, J. 1985: The Reason of Rules, Cambridge University Press.

Brunsson, N. 1986: Organizing for Inconsistencies: on Organizational Conflict, Depression and Hypocracy as Substitutes for Action, Scandinavian Journal of Management Studies, 165–185.

Brunsson, N. & Rombach, B. 1982: Går det att spara?, Doxa.

Chan, K. & Mestelman, S. 1988: Institutions, Efficiency and the Strategic Behaviour of Sponsors and Bureaus, Journal of Public Economics 37, 91–102.

Chubb, J. 1985: The Political Economy of Federalism, American Political Science Review 79, 994–1015.

Cohen, M., March, J. & Olsen, J. 1976: People, Problems, Solutions and the Ambiguity of Relevance, in March, J. & Olsen, J. (ed): Ambiguity and Choice in Organizations, Universitetsforlaget.

Danziger, J. 1978: Making Budgets, Sage.

Holmstrøm, B. 1979: Moral Hazard and Observability, Bell Journal of Economics 10, 74–91.

Høgheim, S., Monsen, N., Olsen, R. & Olson, O. 1989a: Action Research in Accounting – Experiences in the Process of Redesigning an Annual Report, mimeograph, Norges Handelshøyskole, Bergen.

Høgheim, S., Monsen, N., Olsen, R. & Olson, O. 1989b: The Two Worlds of Management Control, mimeograph, Norges Handelshøyskole, Bergen.

Jackson, P. 1983: The Political Economy of Bureaucracy, Philip Allen.

Jønsson, S. 1982: Budgetary Behaviour in Local Government, Accounting, Organizations and Society 7, 287–304.

Laffont, J. & Tirole, J. 1986: Using Cost Observation to Regulate Firms, Journal of Political Economy 94, 614–641.

Migue, J. & Belanger, G. 1974: Towards a General Theory of Managerial Discretion, Public Choice 17, 27–43.

Miller, G. 1977: Bureaucratic Compliance as a Game on the Unit Square, Public Choice 19, 37–53.

Moene, K. 1986: Types of Bureaucratic Interaction, Journal of Public Economics 29, 333–345.

Niskanen, W. 1971: Bureaucracy and Representative Government, Aldine Atherton.

Niskanen, W. 1975: Bureaucrats and Politicians, Journal of Law and Economics 18, 617–643.

Noll, R. 1989: Economic Perspectives on the Politics of Regulation, in Schmalensee, R. & Willig, R. (ed): Handbook of Industrial Organization, Volume II, Elsevier Science Publishers.

Olson, M. 1965: The Logic of Collective Action, Harvard University Press.

Olson, M. 1982: The Rise and Decline of Nations: Economic Growth, Stagflation, and Social Rigidities, Yale University Press.

Ross, S. 1973: The Economic Theory of Agency: The Principal's problem, American Economic Review 63, 134–139.

Spencer, B. 1982: Asymmetric Information and Excessive Budgets in Government Bureaucracies, Journal of Economic Behaviour and Organization 3, 197–224.

Tullock, G. 1967: The Welfare Costs of Tariffs, Monopolies and Theft, Western Economic Journal 5, 224–232.

Vickers, J. & Yarrow, G. 1988: Privatization – An Economic Analyzis, MIT Press.

Wildavsky, A. 1975: Budgeting, a Comparative Theory of Budgeting Processes, Little, Brown & Co.

Wildavsky, A. 1988: The New Politics of the Budgetary Process, Scott, Foresman & Co.

CHAPTER 2

MODELS OF BUREAU AND SPONSOR

2.1 INTRODUCTION

The first sections of this chapter, 2.1 and 2.2, survey works by economists on the relationship between a sponsor, which grants the bureau a budget, and a bureau, which produces output.[1] We criticize some of the models and claim that the assumptions underlying the agents' behavioural strategies sometimes are unsatisfactory.

Formal modelling of the relationship between public bureaus and their sponsors dates back to the contribution of Niskanen (71). Since then, only a few formal studies on bureaucracy have been carried out by economists despite the fact that bureaus produce a significant part of the society's goods and services, as Moene (86) has pointed out.

Many aspects of the relationship between sponsor and bureau have been dealt with in the papers. Here we shall concentrate on one aspect, the efficiency with which the bureau produces its services. Other aspects of their interaction, for instance whether the amount of output is optimal from society's point of view, will receive less attention.

In section 2.3, we outline and justify the choice of our basic one–period model. We offer a discussion of alternative interpretations of the model and relate it to other models in the literature. We also describe how the basic model is developed in the following chapters. Section 2.4 is a brief note on the terminology we will use.

Niskanen (71) assumes that the bureau can be regarded as a budget–maximizing decision maker and that the sponsor reacts passively to the bureau's proposals. As a result, the outcome of their interaction is that the output of services is too high, inefficiently produced or both. Niskanen's model was heavily criticized for overlooking important aspects of the bureau's utility function and for neglecting the legislature's opportunities to take action to reduce the bureau's power. Since Niskanen's study, a number of studies have explored whether his conclusions are sensitive to the model's assumption.

We will now try to categorize the works that followed Niskanen. This will give us an impression of where the research in the area stands and where it needs to be extended. We will concentrate on the models' implications for public sector efficiency. Therefore, this survey does not include important works in the Niskanen–tradition which are mainly concerned with other aspects of his model.[2] The models which we shall survey, are taken from the following nine works; Niskanen (71), Migue & Belanger (74), Niskanen (75), Miller (77), Orzechowski (77), Spencer (80), Miller & Moe (83), Moene (86) and Chan & Mestelman (88).

It is convenient to classify the models according to three dimensions; the utility functions of the agents, the agents' choice (instrument) variables and the setting. The last term includes the models' assumptions about the agents' behavioural strategies, that is, whether the agents' strategies are derived from explicit utility–maximization or simply based on some heuristic rule of thumb. We will deal with the three dimensions successively.

The utility functions

Only four variables have an important role in the models. Other variables are included, but all of them can either be easily redefined in terms of the four variables, or are less important to the main subject of interest. The core of all models can therefore be expressed with four or less variables, defined as follows:

c – the budget of the bureau granted by the sponsor

Q – the output of the bureau

l – the bureau's use of labour input

MDP – managerial discretionary profit, the part of the bureau's budget that is not strictly used for production of output.

Some authors refer to managerial discretionary profit as the difference between the budget and minimum cost of production.

$MDP = c - \kappa$

κ – the minimum costs of production of Q

In some of the models, one of the agents is not allowed to do more than accepting or rejecting the proposal of the adversary. The yes/no decision could therefore possibly be said to be the fifth variable of the model.

There seems to be no disagreement about the form of the sponsor's utility function. In all of the nine papers, it is of the form:

$$U = U\underset{+\ -}{(Q,c)} \qquad (2.1)$$

The sponsor derives positive utility from the output of the bureau and dislikes granting money.

There is less agreement concerning the form of the bureau's utility function. The most common (which we find in all papers except in those by Niskanen (71), Miller & Moe (83) and Orzechowski (77)) is:

$$V = V\underset{+\quad +}{(Q,MDP)} \qquad (2.2)$$

The bureau gets positive utility from both output and managerial discretionary profit. In general, less managerial discretionary profit means higher output. Hence, the bureau faces a trade–off between Q and MDP.

Most of the authors also explore the consequences of making the bureau's utility function dependent only on Q or MDP.

The second approach is that of Niskanen (71) and Miller & Moe (83) which assumes that the bureau's utility is solely derived from the budget:

$$V = V\underset{+}{(c)} \qquad (2.3)$$

The third alternative is the paper by Orzechowski (77) which models V to be a function of output and labour input:

$$V = V\underset{+\ +}{(Q,l)} \qquad (2.4)$$

<u>The instrument variables</u>

A survey of the nine papers shows that there are seven different alternatives concerning the agents' instrument variables. We will label them from A to G:

A:

– Sponsor says yes/no

– Bureau sets c and Q

This alternative is found in Niskanen (71,75), Migue & Belanger (74), Orzechowski (77), Spencer (80), Moene (86) and Chan & Mestelman (88)

B:

– Sponsor sets c and Q

– Bureau says yes/no

This formulation can be found in Moene (86) and Chan & Mestelman (88).

C:

– Sponsor sets c

– Bureau sets Q

(Moene (86) and Chan & Mestelman (88))

D:

– Sponsor sets c

– Bureau sets average cost (c/Q)

(Spencer (80), Miller & Moe (83), Moene (86) and Chan & Mestelman (88))

E:

– Sponsor sets demand curve (Maximum c given Q)

– Bureau sets c and Q

(Niskanen (75) and Chan & Mestelman (88))

F:

– Sponsor first sets demand curve, then c and Q after the bureau's move

– Bureau sets supply curve (Q as a function of c)

(Miller & Moe (83))

G:
– Sponsor sets c
– Bureau sets MDP as a proportion of c

(Miller (77))

The settings

The early papers, Niskanen (71,75), Migue & Belanger (74), Orzechowski (77), and also Spencer (80), do not cast their models in a game–theoretic framework. The authors discuss how the interaction between the agents take place in the real life, but do not try to mimic the agents' real life behaviour when assigning choice variables to the bureau and the sponsor. Niskanen (71) argues that the bureau has superior information about its true costs and preferences while the sponsor's preferences are common knowledge. Accordingly, Niskanen argued, the bureau has the upper hand in the negotiations with the sponsor. From his discussion, Niskanen concludes that the interaction works as though the bureau is able to present the sponsor with an all–or–nothing offer, holding the sponsor down to its reservation utility. His model is therefore equivalent to a leader–follower game under complete information where the sponsor's choice variable is to accept or reject the bureau's offer. The other papers apply the same arguments to justify their models.

The second generation of papers, those of Miller (77), Moene (86) and Chan & Mestelman (88), apply a game–theoretic methodology. The order of moves of the agents is made explicit. Miller (77) and Chan & Mestelman (88) let the agents move simultaneously and the equilibrium outcomes are strategy pairs conforming with the Nash–equilibrium concept. The agents' utility functions, choice variables and the production function are common knowledge. The agent's moves are explicitly derived from utility–maximization. The models of Moene (86) are of two sorts. Some of his models are leader–follower games without uncertainty. However, in two of his models, 3.2 and 3.3, the follower has incomplete information. In these two models, the outcome of the game is not the result of expected utility–maximization by both agents. In model 3.4, the leader has incomplete information and maximizes its expected utility.

The contribution by Miller & Moe (83) represents a peculiar halfway house. They explicitly specify the agents' choice variables as well as the game's order of moves. However, sometimes an agent's move is based on utility–maximization, sometimes it is derived from heuristic rules of thumb. Like Niskanen, they justify their choices of behavioural strategies by referring to the complexity of the tasks faced by the agents and their lack of information.

For all papers, the interaction takes place only once. None of the models describe multi–period games. Neither do any of the papers formalize the information structure of the game, with the exception of Moene's model 3.4.

We will now go through the different models and note whether output is efficiently produced and why waste of resources takes place. Efficient production means that managerial discretionary profit is zero. We label the models; A.1, A.2.., B.1.. and so on. The analysis is summarized in table 2.1. The table will perhaps simplify reading.

2.2 THE MODELS

A.1 (Niskanen (71), pp. 45)

Niskanen assumed that the bureau's utility function is (2.3), that the bureau is a Stackelberg leader that sets both budget and output and that the sponsor can only say yes or no. If no deal is struck, no production takes place. Figure 2.1 shows the sponsor's total evaluation function c(Q). c(Q) gives, for each Q, the sponsor's maximum willingness to pay. $\kappa(Q)$ is the bureau's cost function. The resulting equilibrium can be of two types, depending on the cost and evaluation functions. We have drawn two cost functions, κ_1 for high costs and κ_2 for low costs. At A, κ_1 applies and the solution is cost–constrained. The production is efficient. The bureau cannot increase output without beeing squeezed by too low budgets and too high costs. At B, κ_2 applies and the solution is demand–constrained. Increased output will not lead to higher budgets but must be financed by cutting waste (since waste is not part of the bureau's utility function, B is only one of many possible solutions, the rest lie to the right of B).

The sponsor's preferred position is somewhere on the minimum cost–line, depending on the form of its utility function. Since A gives the sponsor no net utility, the sponsor will want output to be lower than at A. Therefore, neither A nor B is optimal from the sponsor's point of view. The solution of the Niskanen (71) model has either too high output or too high costs as seen by the sponsor.

A weakness of the Niskanen model is his choice of instrument variable for the sponsor. In real life, the sponsor is not restricted to accepting or rejecting the bureau's proposal. The sponsor sets the bureau's budget, while basing its decision on information provided by the bureau. A better approach is to model the sponsor's probability beliefs about the bureau's true costs explicitly and let the sponsor set grants to maximize its expected utility.

Niskanen's model was evaluated in a number of papers in the years after the publication of his "Bureaucracy and representative government". One line of criticism concerns his choice of utility function for the bureau. This argument was subsequently incorporated in the later works with which we will deal. A second point of view was raised by Breton & Wintrobe (75) who argued that the government would be able to control whether costs were at minimum costs and whether output was higher than the social optimum. However, they argued that this control could only be imposed at a cost such that at optimum there would be some inefficiency. Breton & Wintrobe argued that it is easier for the sponsor to stop excessive output than to stop waste and that this causes the equilibrium output to shrink below A in figure 1. A similar point was made by Thompson (73) who maintained that the A–solution is not credible since it assumes that the sponsor has no information at all about the cost structure of the bureau. Thompson's point was developed by Spencer (80).

A.2 (Spencer (80), pp. 232)

Spencer (80) retained the utility function (2.2) and the setting of the Niskanen model, but assumed that the sponsor was able to observe the average cost of the bureau. In figure 2.2 at D, average cost is equal to the slope of the line OD. The sponsor can instruct the bureau to propose a level of output where the slope of the evaluation curve is greater or equal to average cost. If average cost exceeds marginal benefit of output, the sponsor knows for sure that output is not optimal. Since the sponsor is the one that formally decides on the budget, point B can no longer be an equilibrium if the cost conditions are as on figure 2.2.

Spencer concludes that the bureau will pick point C as the new solution, because C maximizes the budget under the condition that the slope of c(Q) must be greater or equal to average cost. Compared to the cost–constrained solution of the Niskanen model, we see that inefficiency is introduced. The sponsor contains output and its control measure, average cost, is too crude to avoid the introduction of waste.

Niskanen's model was heavily criticized for making the utility function of the bureau unrealistic. Migue & Belanger (74) pointed out that budget maximization would mean output maximization at least for the cost–constrained solution, and that this implies that resources will not be allocated to any other purpose than output production. The authors argued that this implication of Niskanen's model was both unrealistic and contrary to the spirit of the parallel literature on management's behaviour in profit–seeking firms (see

Willamson (64) for a standard model on managerial capitalism where discretionary profit enters the manager's utility function in addition to profit for the owners). Migue & Belanger proposed that the bureau should be modelled as having the utility function (2.2). The bureau wants both high output and budgets in excess of minimum costs. The excess budget is named managerial discretionary profit (MDP) and is given an interpretation similar to that in the literature on managerial capitalism. Lack of perfect control of the bureau's management would lead them to incur expenses that are not strictly needed for the production of public services. Such expenses are for example incompetitively high salaries, excess staff or luxurious offices.

A.3 (Migue & Belanger (74), Niskanen (75), Moene (86), pp. 337)

Niskanen switched to the Migue & Belanger utility function in his paper from 1975 but retained the assumption that the sponsor is the Stackelberg leader. The optimal choice of budget/output for the bureau is shown in figure 2.3 at E. The iso–utility curve V^0 is that of the bureau and reflects its preferences for output/MDP, where MDP is the distance between c(Q) and the cost curve. Once again, inefficient production is introduced. Since the bureau extracts positive utility from MDP, the new solution will give less output and less efficient production.

Model 3.2 of Moene (86) applies the same utility function as Niskanen (75). Moene does not state explicitly how the interaction between the agents takes place. First, the bureau gives the sponsor information about its costs. Then the sponsor makes its move, but it is not clear what the sponsor's choice variable is. The bureau starts out by exaggerating its fixed costs and understating its marginal costs in order to induce the sponsor to appropriate a high grant level. Moene argues that the bureau's informational advantage enables it to achieve its preferred outcome, point E. However, if the sponsor is free to decide on both the bureau's budget and output, it is unlikely that it chooses a combination of grants and output located on the cost curve reported by the bureau. Telling the truth is not incentive–compatible for the bureau, and the sponsor should therefore not accept the bureau's verbal information as the truth.

Another interpretation of Moene's model is that although the sponsor formally sets the size of output and/or the budget, it is – for some institutional reason – constrained to choose a point on the bureau's reported supply function. If this interpretation of Moene's model is correct, the model equals that of Niskanen (75).

The setting in Migue & Belanger (74) is not clearly expressed by the authors, but I interpret their model to be the same as that of Niskanen (75).

A.4 (Spencer (80), pp. 230)

Spencer (80) introduces a new variant of the type A models at page 230 of her paper. She assumes that the bureau's utility depends on MDP alone:

$$V = \underset{+}{V(MDP)} \qquad (2.5)$$

The bureau will propose to the sponsor that production takes place at the point on c(Q) where discretionary profit is maximized. Thus, the solution is F in figure 2.3. At point F, the waste of the production is at a maximum. If the sponsor has the utility function (2.1), we would expect the sponsor to prefer the solution to be somewhere around G. Therefore, in this category, output is approximately optimal as seen from the sponsor, but the whole gain from reduction of output is expropriated by the bureau in the form of MDP. There is still no net benefit left for the sponsor.

A.5 (Chan & Mestelman (88) pp. 99)

Chan & Mestelman's model five on page 99 is a version of Niskanen's model where the utility functions of sponsor and bureau have the forms (2.1) and (2.2) and the players move simultaneously. They apply the Nash–equilibrium concept. However, since the sponsor's only decision variable is to say yes or no, the equilibrium solution is the same as for category A.3.

A.6 (Orzechowski (77))

Orzechowski introduces the utility function (2.4). He assumes that the bureau prefers one particular kind of MDP, that of excessive staff. The bureau moves first and sets budget/output under the restriction that the package must be accepted by the sponsor. The result is inefficiency due to too much use of labour input.

We now turn to setting B, the sponsor sets both budget and output. The bureau can do nothing but accept or reject the proposal. The models to be surveyed are two by Moene

(86) and Chan & Mestelman (88). Both assume that the sponsor has full information on the cost curve, otherwise it is not meaningful to say that the sponsor has the real power to set budget/output.

B.1 (Moene (86), pp. 337)

In Moene's model 3.1, page 337, the sponsor moves first. The utility functions are those of (2.1) and (2.2). Since the sponsor has full information on the cost structure of the bureau, it will choose to set discretionary profit equal to zero. The solution will be at point H in figure 2.4, where U^0 is the iso–utility curve of the sponsor. Production is efficient.

B.2 (Chan & Mestelman (88) pp. 100)

Chan & Mestelman's model number six is similar to that of Moene, except that the agents move simultaneously. This does not affect the equilibrium outcome which is still at H.

We now turn to category C, where the sponsor sets the budget and the bureau sets output. The three models in this category do all assume that both agents have complete information about the other agent's preferences and the cost structure of the production. The utility functions of the models are all of the types (2.1) and (2.2).

C.1 (Moene (86), pp. 343)

In Moene's model 4.1, the sponsor first sets the budget. Then output is decided upon by the bureau. Moene introduces the function Q(c) which denotes the bureau's optimal reaction to a budget decision of B. The outcome is illustrated in figure 2.4 as I, where U^1 is a iso–utility curve of the sponsor. There is some inefficiency but less than at F and probably also less than at E in figure 2.3. The output is quite low. This is because the sponsor uses a low budget as a strategic tool to force down the managerial discretionary profit.

C.2 (Moene (86), pp. 344)

In Moene's model 4.2, the bureau chooses output first. Since there is complete information about the cost structure, the sponsor will not grant more than the minimal production costs. Therefore, the bureau knows that MDP will equal zero. The bureau can do nothing better than setting output as high as possible. The outcome is therefore at point A in figure 2.1. Output is high and there is efficient production.

C.3 (Chan & Mestelman (88) pp. 97)

Model one by Chan & Mestelman is a game between sponsor and bureau where they choose budget and output simultaneously. The astonishing result of this is that zero output and zero grants is the only equilibrium! This curious result occurs because of the special form of the production function. Chan & Mestelman define managerial discretionary profit as a private good which is consumed by the bureau and set:

$$c = Q + MDP \qquad (2.6)$$

It is easy to see that no output is the only possible Nash–equilibrium when the sponsor sets budget and the bureau sets output simultaneously, provided the bureau's marginal benefit of MDP is sufficiently high. For a given output, the sponsor will always set budget equal to output, thus making MDP equal to zero. For a given budget, the bureau will set output below the budget when the marginal benefit of MDP for MDP equal to zero exceeds the marginal benefit output. Therefore, there does not exist any positive budget and output level from which neither of the two agents will want to deviate. Hence, zero output and budget is the only Nash–equilibrium.

We now turn to the next category of models. In category D, the sponsor sets the budget and the bureau sets the supply function (for a given output, the bureau demands a budget, in some of the models the bureau sets a supply price, a price per unit output). In all of the following models, the authors assume that the sponsor does not know the real cost function of the bureau. Therefore it does not know whether the announced supply function is the true cost function or not.

Since the sponsor does not know the true cost function, the bureau has incentives to "cheat", to set the supply price higher than real average costs. In settings where the bureau moves first, the sponsor should anticipate the bureau's lack of incentives to give correct information. Therefore, the sponsor should try to make the bureau produce at lower costs than suggested by the bureau's supply price. The sponsor does not do that in the models we shall survey. On the contrary, the sponsor sets the budget under the assumption that the resulting output will equal the budget divided to the quoted supply price. Therefore, we must interpret the models as based on a particular institutional framework, where the sponsor can not affect the costs per unit output.

In category D, we discuss models by Orzechowski (77), Spencer (80), Miller & Moe (83), Moene (86) and Chan & Mestelman (88).

D.1 (Chan & Mestelman (88), pp. 98)

The utility functions of the agents are given by (2.1) and (2.2), and the agents move simultaneously. The bureau sets the supply price above its true costs in order to extract some MDP. The sponsor's choice of budget depends on the supply price. We can be sure that the sponsor's preferred output level decreases as a function of the supply price. However, the sponsor's choice of budget may both increase and decrease with the supply price depending on the form of its utility function. Therefore, the resulting Nash–equilibrium gives some ineffiency and underprovision of output. All Pareto improving allocations require an increase in output.

D.2 (Moene (86), pp. 340)

The utility functions are as in D.1. The bureau moves first. Fixed costs are common knowledge, but the sponsor does not know the real marginal costs. The intuition of the equilibrium outcome is the same as for D.1. The bureau chooses a point on the sponsor's reaction curve. Since the slope of the sponsor's reaction curve is ambiguous, the equilibrium supply price of D.2 can be higher or lower compared to D.1. The bureau will still set the supply price higher than real marginal costs in order to extract MDP.

D.3 (Spencer (80), pp. 232)

The utility functions are given by (2.1) and (2.5). The setting is the same as for D.2. The bureau first sets the supply price. The sponsor reacts by setting the budget. Since only MDP is contained in the bureau's utility function, the supply price will be set considerably above real marginal costs and the production will therefore be inefficient. The equilibrium outcome is generally inferior to the outcome of D.2 as seen by the sponsor.

D.4 (Miller & Moe (83), pp. 304)

The authors refer to this model as the "demand–concealing" one. The sponsor demands that the bureau shall reveal its supply function, that is, the maximum amount of output it will produce as a function of the price per unit of output. The utility function of the bureau is (2.3). In order to extract a high budget, the bureau promises to produce as much as it is able to for a given price. In other words, it will reveal its true cost function. Hence, the production will be efficient. The sponsor chooses its preferred output level, denoted H in figure 2.4.

We see that this outcome is different from the equilibrium outcomes of settings D.1 – D.3. This is mainly due to the specifications of the bureau's utility function. When the bureau solely cares about the budget, it will want to set the supply price to induce the sponsor to grant a high budget. Since the budget is the product of price and output, the bureau will want to produce as much as it can for a given price. Hence, it gives the sponsor a more favourable offer than if it cares much about managerial discretionary profit.

D.5 (Moene (86), pp. 341)

The last model in this category is Moene's model 3.4. The setting is as for D.2 with the exception that the bureau is ignorant of the preferences of the sponsor. The bureau does not know whether the sponsor prefers production to take place for a given supply function. Since the bureau is risk averse, this uncertainty will induce it to set the supply price lower than for D.2. Therefore, on average, the production is more efficient with uncertainty concerning the sponsor's preferences.

Category E contains two models where the sponsor sets a demand price, c/Q, and the bureau sets the budget.

E.1 (Niskanen (75), pp. 622)

Niskanen (75) applies utility functions of the form (2.1)–(2.2). Niskanen's innovation, compared to model A.3, is that the sponsor has some alternative source of supply. Hence, the sponsor does not accept a price per unit of output which is higher than it has to pay elsewhere. The bureau has by assumption the power to choose among the outcomes which the sponsor accepts. The bureau sets budget and output to maximize its utility with the restriction that budget divided by output equals the sponsor's unit costs of procuring output from the alternative source.

We can interpret the Niskanen model as a game consisting of two moves. First, the sponsor sets the demand price, making it equal to the price of its alternative source. Then the bureau sets the budget. The resulting outcome is very sensitive to the sponsor's demand price. Unless the sponsor's demand price is less than or equal to the bureau's average costs for every feasible output level, the bureau will be able to extract some slack.

E.2 (Chan & Mestelman (88), pp. 98)

The utility functions and the instrument variables are as for E.1. The agents move simultaneously. The Nash–equilibrium outcome is the combination of demand price and budget from which the agents do not want to deviate. The production function is given by (2.6). The sponsor has full information about the bureau's marginal costs. Therefore, for a given budget, it sets the demand price to eliminate managerial discretionary profit.

Given that MDP equals zero, the bureau will want to make the budget as large as possible since it derives positive utility from output. Chan & Mestelman assume that the sponsor has an initial endowment of funds and that grants can not exceed this level. Hence, the bureau will set the budget equal to its maximum level. Whether equilibrium output is too high or too low depends on the sponsor's endowment. Chan & Mestelman claim that there can be under–provision of output in the sense that a Pareto improvement can take place by increasing output. However, this conclusion rests on the assumption that the sponsor's initial endowment is less than the output level corresponding to the Pareto–optimal allocation for MDP equal to zero. This seems to be an unrealistic assumption. For instance, if the sponsor supplies funds to many bureaus, it is obviously optimal not to give its total budget to one bureau. Hence, we would expect output to be too high in this game. Both agents can gain from simultaneously decreasing output and increasing managerial discretionary profit.

The conclusion of Chan & Mestelman is close to the results of the first Niskanen model (A.1). The bureau exploits its discretion to expand output while the sponsor's power to set the demand price has the same effect on the outcome as if the bureau did not care about slack.

Categories F and G contain only one model each.

F (Miller & Moe (83), pp. 302)

Miller & Moe refer to this model as "demand–revealing". The moves are carried out in three steps. First, the sponsor sets the demand curve, which coincides with its evaluation curve. Second, the bureau sets the supply curve strategically to maximize its utility. The bureau's utility function is of the form (2.3). Third, the sponsor picks output/budget.

Whether there is inefficient production or not, depends on the specific form of the cost and evaluation functions.

G. (Miller (77))

The setting of Miller's model is quite parallel to that of Chan & Mestelman in category C (C.3). They apply the same utility functions and the one–shot Nash–equilibrium concept. However, there is one crucial difference. The model of C.3 assumes that the bureau sets output, while Miller assumes that the bureau sets the proportion of the budget that shall be allocated to production of output. We remember that for C.3, there was no other equilibrium but $c = Q = 0$. Miller's alternative formulation allows an equilibrium which seems more realistic where both budget and output are positive, but where there is some inefficiency since the bureau will set output a bit lower than when MDP $= 0$.

This survey is summarized in table 2.1. The table gives the resulting efficiency for every category and is in three dimensions; order of moves, instrument variable and utility function of the bureau. Pluss, zero and minus denote efficient, partly inefficient and very inefficient production, respectively.

Table 2.1 clearly shows that the theory of bureau and sponsor is in a premature phase. Only some of the possible settings have been explored. The resulting efficiency is very sensitive to changes in setting. However, some conclusions can be drawn:

– Efficiency will generally be high when the bureau cares primarily about the magnitude of the budget. The sponsor's problem is then mainly to avoid overproduction of services.

– When the sponsor's only instrument is the power to reject the bureau's proposal, the resulting efficiency will generally be low.

– When the sponsor sets both budget and output, efficiency will be high provided the sponsor has full information concerning the bureau's costs.

– When the bureau only cares about managerial discretionary profit, the efficiency will be low, at least for the two categories A/D.

– Whether the sponsor gains from moving first, depends on the agents' instrument variables.

– When the bureau sets a supply function, the outcome is inefficient unless the bureau's utility function only depends on the magnitude of the budget.

2.3 OUR MODEL

The objective of the dissertation is to extend the bureaucracy literature by incorporating new elements from game and agency theory, making the model of the interaction between the agents more realistic. In this section, we justify and discuss our choice of basic one–period model and how it will be extended in the forthcoming chapters.

The present models have two obvious shortcomings. First, none of them explicitly takes into account that the relationship between sponsor and bureau is repeated. A fundamental characteristics of budgeting processes in the public sector is that they are repetitive. Second, the present models do not incorporate uncertainty in a satisfactory manner. Some papers state that one of the agents has incomplete information, but do not apply equilibrium concepts where all agents maximize their expected utility. The information of the two agents is obviously important for the outcome of the interaction. Examples of incomplete information in the public sector which have importance in practice are uncertainty about the true costs of the bureau, the preferences of the agents and the general public's benefit from the services. In the dissertation, we start with a simple one–period model under certainty and extend the model to take into account multi–period interactions as well as different types of uncertainty.

The production function

The production function of Chan & Mestelman (88) is given by (2.6):

$$Q = c - MDP \qquad (2.6)$$

We will use a similar production function:

$$Q = c + e \qquad (2.7)$$

e – effort

Effort can be interpreted as minus managerial discretionary profit. (2.7) says that output can be increased by spending more money or by spending money more efficiently.

Since MDP must be zero or positive, it is perhaps natural to introduce the restriction:

$e_{min} \leq e \leq e_{max}$

e – effort

If we follow the model of Chan & Mestelman, we should set $e_{max} = 0$ and define the production as taking place at minimum cost if output is equal to budget. However, we will not include this restriction. The justification for not restricting effort is that the concept of minimum costs is artificial and has little to do with real life, particularly for public services. In real life, it has little meaning to operate with a concept; "least costs per unit output", especially in a dynamic environment. What we under some circumstances could be able to define, is the costs of the present best practice found amoung the bureaus. But the sponsor has no guarantee that the present practice cannot be improved. We will therefore not label the production as efficient or not, but rather more or less efficient, depending on the effort level.

The interpretation of equation (2.7) depends on the bureau's activity. (2.7) can be interpreted as representing a very simple technology where the bureau's task is solely to pass on grants to the general public. Lack of effort reflects the fact that the bureau allocates some of the budget to non–productive activites. Hence, the bureau splits the budget into production and slack.

On the other hand, if the bureau's production is very complex, effort represents a large variety of characteristics related to the general question of whether the organization is well managed. Effort must be interpreted as an indicator of the bureau's efficiency rather than a traditional production factor.

In regulation theory, (Laffont & Tirole (86,87)), effort affects the firm's production costs. Higher effort leads to lower costs per unit and higher production for a given level of revenues. Hence, equation (2.7) can be interpreted as a simplification of the standard production function of regulation theory.

In my view, the first interpretation of (2.7) is not satisfactory. Production of public services is generally far more complicated than just steering a flow of funds to the customers. For the bulk of public services, like education or health services, the quality and volume of the production crucially depend on how the bureau is organized. We interpret effort as a production factor, representing a multiple of activities related to the management of complex organizations. Hence, effort can only be adjusted gradually.

In the basic one–period model, we assume that the true production function is common knowledge. In chapter 3 we compute the basic one–period equilbrium outcomes when the production function has the form given by (2.7). In later chapters, we will introduce different types of uncertainty concerning the production function. In chapter 5, we modify (2.7) to introduce output uncertainty. Effort can be observed but not the benefit of output to the general public. We compute and interpret Bayesian equilibria for alternative order of moves. We also distinguish between games where both have incomplete information and games where only the sponsor is ignorant about the true value of output. When the bureau moves first and has private information, the game is a signalling game. We compute a perfect Bayesian equilibrium outcome of this game.

In chapter 8, we introduce uncertainty concerning the true costs of the bureau. The sponsor can observe output but not effort. We allow the sponsor to construct ex ante schemes which make the bureau's budget dependent on output. The model can be interpreted as a moral hazard or an adverse selection model depending on whether the bureau has private information when the scheme is formulated. We also consider multi–period games with cost uncertainty. When the sponsor can not commit itself to a scheme for more than one period, there will be a ratchet–effect. We compute numerically perfect Bayesian equilibria for two multi–period games without commitment.

Instrument variables

The next task is to assign instrument variables to the two agents. For the basic one–period model, we assume that the sponsor sets the budget and that the bureau sets effort. This combination is not used by Chan & Mestelman. Miller (77) applies almost the same instrument variables, but he lets the bureau set effort as a proportion of the budget. This is an important difference since Miller's instrument variable can be thought of as a price whereas our instrument variable is a quantity. The equilibrium outcome of various games can therefore be different for the two models. However, when we apply the one–shot Nash–equilibrium concept with simultaneous moves, the outcomes will have the same characteristics.

Our choice of instrument variable for the bureau is consistent with agency theory. However, our choice of instrument variable for the sponsor is not in accordance with agency theory. In agency theory, the principal is allowed to construct enforcable contracts where the agent's reward is dependent on observable output. We have assumed that there is complete information about all variables in our basic model. We further assume that output and effort are observable but not verifiable. This assumption allows us to exclude forcing contracts from the analysis. The nature of effort makes our assumption that effort can not be verified reasonable. We justify our assumption concerning the non–verifiability of output by referring to the special nature of public services. The output of most public services is complex and multi–dimensional, making quantitative assesments difficult. We will deviate from this assumption in chapters 7 and 8. In chapter 7, we let the sponsor set the demand price instead of the budget. We compare the Nash–equilibria of alternative one–period games for the two instrument variables. In chapter 8, we allow the sponsor to formulate output–contingent ex ante contracts.

Utility functions

We apply the utility functions (2.1) and (2.2). We rewrite them to introduce our new notation:

$$U = U(\underset{+}{Q},\underset{-}{c}) \qquad (2.8)$$

$$V = V(\underset{+}{Q},\underset{-}{e}) \qquad (2.9)$$

To simplify further, we assume that the utility functions are additive in their arguments:

$$U = \underset{+}{U^1(Q)} - \underset{-}{U^2(c)} \qquad (2.10)$$

$$V = \underset{+}{V^1(Q)} - \underset{-}{V^2(e)} \qquad (2.11)$$

Separability implies that the bureau's disutility of effort and the sponsor's disutility of granting funds are independent of the level of output.

The sponsor's utility function is the same as applied in most bureaucracy models. The sponsor prefers the production to be as high as possible for a given level of grants.

The bureau's utility function is in line with most recent works in the Niskanen–tradition. The convention of including slack or effort in the utility function of the (formally) subordinate agent in a non–competitive relationship is widespread in modern microeconomics and can be traced in the theory of managerial capitalism as well as in agency theory (Jensen & Meckling (76), Baiman (82)).

The main difference between the preferences of our bureau and the agent in standard agency theory is that our bureau derives positive utility from output while the agent is striving for profit. Niskanen (71), pp. 15, defines a bureau as an organization where "the owners and employees .. do not appropriate any part of the difference between revenues and costs as personal income". The difference between a public bureau and a for–profit organization partly stems from restrictions imposed on public bureaus and partly from the nature of public services. First, most public sector wages are centrally regulated. In general, the agents in our analysis do not have discretion to set the employees' financial compensation. Therefore, the wage level can be excluded from the utility function in our analysis. Second, residual funds accrue to the sponsor as most public bureaus are owned by the state or the municipal sector. Third, employees in public organization develop strong preferences for expansion of public services. Through their work, they continuously unveil unsaturated demands for their services, partly because public organizations provide services which satisfy the population's basic needs and partly because public services generally are free of charge. In addition, high output leads to less criticism from the general public and the authorities. Therefore, we argue that there is a strong case for including output in the bureau's utility function.

The notion that agents derive negative utility from effort has been criticized by Perrow (86), pp. 224–236. Perrow claims that agency theory underestimates the importance of cooperation and team spirit within an organization. It is obviously correct that all efforts are not perceived as negative by the bureau. Therefore, we should be careful how to interpret effort. Perrow's criticism can be countered in two ways. First, we can assume that agents do not dislike effort up to a certain level. Hence, the assumptions we make about the bureau's preferences are only valid for some effort levels. Second, we can define effort as those actions for which the sponsor and the bureau disagree on the costs and benefits of their effects. Typical examples of the latter conflict are the level of salaries and fringe benefits, the direction and priorities of research, the need for new equipment and furniture, the mechanisms utilized for motivation and pressure within the organization and the number of employees needed for different tasks. It contains only those parts of the overall attempt to improve services which are perceived as negative by the bureau. Effort in this sense can be thought of as reorganization of present patterns in order to increase efficiency which is felt to be uncomfortable by the bureau's staff.

The inefficiency of the public sector is not in general the result of deliberate action, but rather the result of inaction. Wildavsky (64), pp. 109, claims that budgeting becomes harder for the US Congress because old programs are difficult to stop. Even though the cost of a program exceeds its benefits, agencies will fight for it to protect its overall budgetary base. The demand for public services will change and the public will feel that output is reduced if public institutions do not change their priorities.

Next, we discuss whether the bureau should be guaranteed a minimum utility level. In agency theory, the agent can choose whether to accept the sponsor's contract. In the public sector, the bureau does generally not have this option. It must accept the sponsor's decision and make the best out of the situation. Therefore, we shall in general not assume that the bureau's utility must exceed a reservation utility level. The sponsor is free to choose the budget level. But contrary to agency theory, the sponsor does not necessarily want to set the budget as low as possible because the sponsor cares about output instead of profit.

A related question concerns the interpretation of the Pareto–optimal production of services. Let W be:

$$W = U(Q,c) + \lambda\, V(Q,e) \qquad (2.12)$$

Maximization of W gives the Pareto–optimal combinations of budget and effort where λ determines the point on the Pareto–optimal set. W is a weighted sum of the agents' utility functions. For the special case where $\lambda = 0$, W is identical to the sponsor's utility function.

W can be given at least three interpretations. First, if the sponsor maximizes its utility with the restriction that the bureau's utility should exceed its reservation utility, W is the Langrange expression it maximizes. In that case, λ depends on the reservation utility. A related interpretation is that it is costly for the authorities to decrease the bureau's utility level, for instance because of the political costs of cutting budgets of public institutions. Then λ reflects the authorities' distaste for trouble with the bureaucracy.

Second, W can be interpreted as a Bergson welfare function with λ reflecting the weights of the agents. If society's preferences are identical to the sponsor's preferences, λ equals zero. A possible interpretation of W is that U(Q,c) represents the interests of the general public while V(Q,e) represents the producers' interests. Society's preferences are a weighted average of consumer and producer preferences.

Third, the Pareto–optimal outcome can be the result of bargaining between the sponsor and the bureau where they bargain jointly over budget and effort. For this interpretation, λ reflects the bargaining strength of the agents. The higher is λ, the stronger is the bureau.

In chapter 3, we outline and compare the cooperative bargaining solution with the Nash–equilibrium outcomes of our basic one–period game for alternative orders of moves. In chapter 6, we consider reputation building in multi–period games where the bureau does not know the sponsor's true preferences. The sponsor may want to maintain or build a reputation as hard–nosed to convince the bureau that it should increase its effort level. We also compute perfect Bayesian equilibria of multi–period games where there is uncertainty concerning both agents' preferences.

We now collect together the three basic equations of our model:

$$Q = c + e \qquad (2.7)$$

$$U = U^1(Q) - U^2(c) \qquad (2.10)$$

$$V = V^1(Q) - V^2(e) \qquad (2.11)$$

(2.7), (2.10) and (2.11) constitute the basic model. The interpretation of the model applied to local authorities is that schools and hospitals have goals that are partly commensurate with and partly differ from those of the authorities. Both parts agree that it is preferable to have short health queues and satisfied patients to long waiting lists and bad service. Both prefer polite and bright scholars to uninterested and noisy kids. Both authority and institution agree that high quality and sufficient production is a good thing.

Where the authorities and the institutions disagree is how to achieve better quality and higher production. The authorities prefer the institutions to make the production more efficient, while keeping expenditures within existing limits. The institutions prefer improvements to take place through higher grants, thus through increased public budgets.

Other extentions

In chapter 4, we discuss alternative multi–period extentions of the basic model and in particular the implications of the folk–theorem for the equilibrium outcome of infinite repeated games. We compute numerically subgame perfect equilibria of long but finite games where the agents move alternately. These equilibria can be perceived as finite games counterparts to infinite games where the agents apply Markov strategies. In chapter 7, we find Markov perfect equilibria of infinite games for a special utility function when the sponsor sets the demand price.

In chapter 9, we consider a one–period game when many bureaus move first and the sponsor reacts to their move. The equilibrium outcome gives a very low effort level, which illustrates that the gains from having many bureaus crucially depend on the sponsor's ability to commit itself to a scheme ex ante.

In chapter 10, we briefly discuss the role of investment in the interaction between the sponsor and the bureau. Chapter 11 concludes. In every chapter, we include a discussion which relates the results to empirical findings of the public sector or to problems facing the public sector.

We will briefly mention two important topics which we do not consider. First, the expenditures of public institutions are not solely dependent on the present grants from the authorities. The institutions can also run deficits which are financed by loans. The financial situation of the institutions will affect the behaviour of the authorities. Hence, in a realistic multi–period analysis, a multi–period budget restriction should be applied. We only consider one–period budget restrictions.

Second, when there are many public institutions producing roughly the same output, the authorities are able to infer information about their true costs and the true benefits of their services by comparing the performances of the institutions. The impact of various forms of competition is a key subject in regulation theory and of considerably interest for the study of public institutions in general. However, we do not explore this topic.

2.4 ON THE TERMINOLOGY

We will repeatedly refer to the equilibrium outcomes of three one–period games. To facilitate the reading, we introduce specific names for these games and the corresponding solutions.

– The basic Nash–Cournot game is a one–shot game where the players move simultaneously. For our basic one–period game, the players simultaneously set budget and effort, respectively. This does not necessarily imply that the players move at the same point in time, but that they do not know the opponent's move when moving. The Nash–equilibrium outcome of the Nash–Cournot game is named the Nash–Cournot solution.

– When the sponsor moves first and does not change its instrument variable during the period, the bureau sets effort while taking the sponsor's move as given. This is named a Stackelberg game with sponsor as leader. The Nash–equilibrium outcome of this game is the Stackelberg solution with sponsor as leader.

– When the bureau moves first and the sponsor reacts to its move, we have a Stackelberg game with bureau as leader. The Nash–equilibrium outcome is the Stackelberg solution with bureau as leader.

ENDNOTES

[1]Jackson (83) and Sørensen (86) discuss some of the works which are surveyed here.

[2]These papers include the works of McGuire et al (79) on competition among bureaus, Toma & Toma (80) on the introduction of tax limits and Oates & Strassmann (78) on pollution fees.

REFERENCES

Baiman, S. 1982: Agency Research in Managerial Accounting: A Survey, Journal of Accounting Literature 1, 154–213.

Breton, A. & Wintrobe, R. 1975: The Equilibrium Size of a Budget–maximizing Bureau: A Note on Niskanen's Theory of Bureaucracy, Journal of Political Economy 83, 195–208.

Chan, K. & Mestelman, S. 1988: Institutions, Efficiency and the Strategic Behaviour of Sponsors and Bureaus, Journal of Public Economics 37, 91–102.

Jackson, P. 1983: The Political Economy of Bureaucracy, Philip Allen, London.

Jensen, M. & Meckling, W. 1976: Theory of the Firm: Managerial Behaviour, Agency Costs and Ownership Structure, Journal of Financial Economics 3, 305–360.

Laffont, J. & Tirole, J. 1986: Using Cost Observation to Regulate Firms, Journal of Political Economy 94, 614–641.

Laffont, J. & Tirole, J. 1987: Comparative Statics of the Optimal Dynamic Incentive Contract, European Economic Review 31, 901–926.

McGuire, T., Coiner, M. & Spancake, L. 1979: Budget–maximizing Agencies and Efficiency in Government, Public Choice 34, 333–358.

Migue, J. & Belanger, G. 1974: Towards a General Theory of Managerial Discretion, Public Choice 17, 27–43.

Miller, G. 1977: Bureaucratic Compliance as a Game on the Unit Square, Public Choice 29, 37–53.

Miller, G. & Moe, T. 1983: Bureaucrats, Legislators and the Size of Government, American Political Science Review 77, 297–322.

Moene, K. 1986: Types of Bureaucratic Interaction, Journal of Public Economics 29, 333–346.

Niskanen, W. 1971: Bureaucracy and Representative Government, Aldine–Atherton, Chicago.

Niskanen, W. 1975: Bureaucrats and Politicians, Journal of Law and Economics 18, 617–643.

NOU 84:23 Produktivitetsfremmende reformer i statens budsjettsystem

Oates, W. & Strassman, D. 1978: The Use of Effluent Fees to Regulate Public Sector Sources of Pollution, Journal of Environmental Economics and Management 5, 283–291.

Orzechowski, W. 1977: Economic models of Bureaucracy: Survey, Extensions and Evidence, in Borcherding, T. (ed): Budgets and Bureaucrats, Duke University Press, Durham.

Perrow, C. 1986: Complex Organizations, a Critical Essay, Newberry Award Records Inc.

Spencer, B. 1980: Outside Information and the Degree of Monopoly Power of a Public Bureau, Southern Economic Journal 47, 229–233.

Sørensen, R. 1986: Byråkrati og veksten i de offentlige utgiftene, Nordisk Tidsskrift for Politisk Økonomi, 28–40..

Thompson, E. 1973: Review of: Bureaucracy and Representative Government, Journal of Economic Literature 11, 950–953.

Toma, M. & Toma, E. 1980: Bureaucratic Responses to Tax Limitation Amendments, Public Choice 35, 333–348.

Wildavsky, A. 1964: The Politics of the Budgetary Process, Little, Brown & Co.

Williamson, O. 1964: The Economics of Discretionary Behaviour: Managerial Objectives in a Theory of the Firm, Prentice–Hall, N.J.

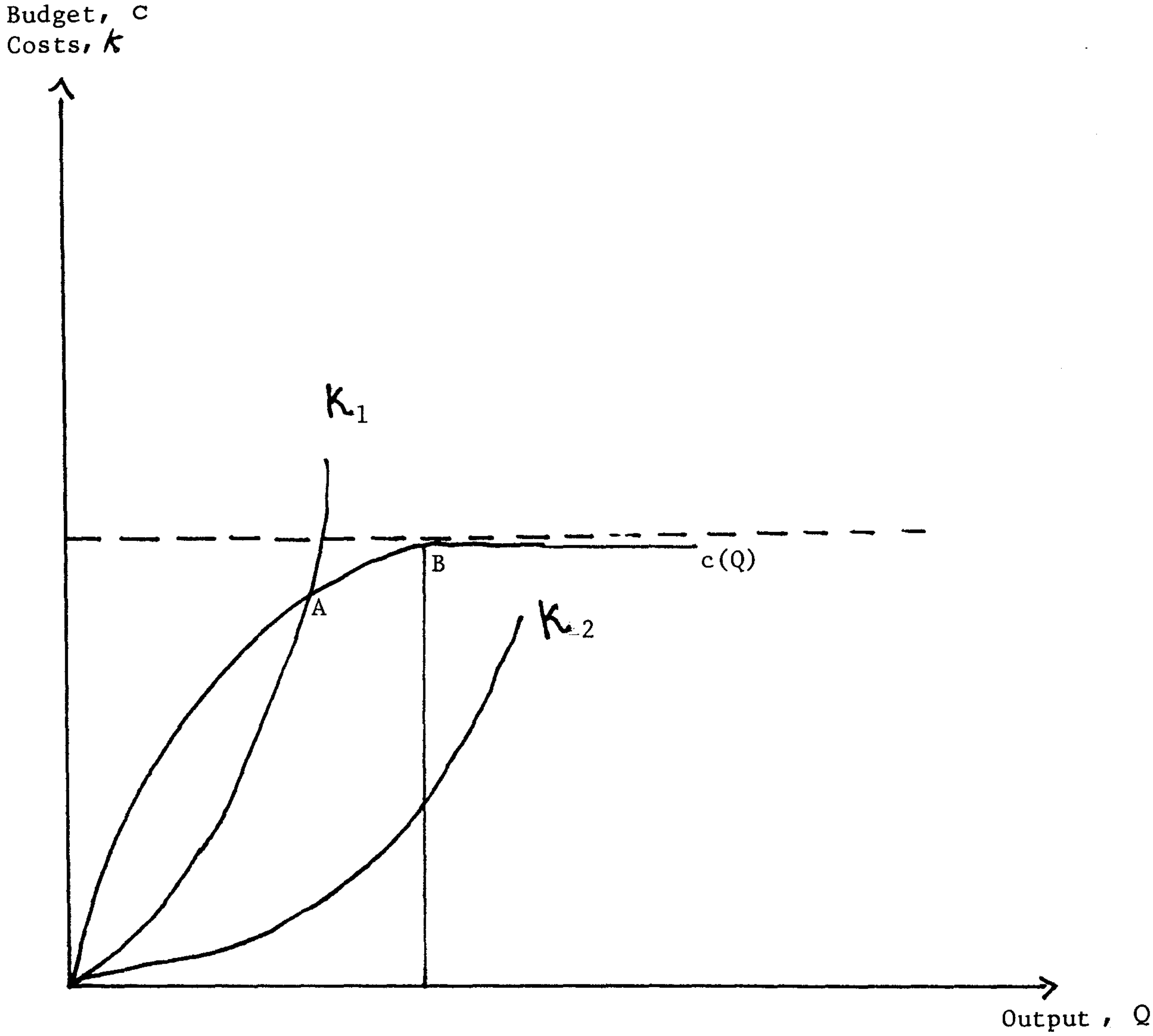

Figure 2.1: Equilibria of the Niskanen (71) model for different cost functions

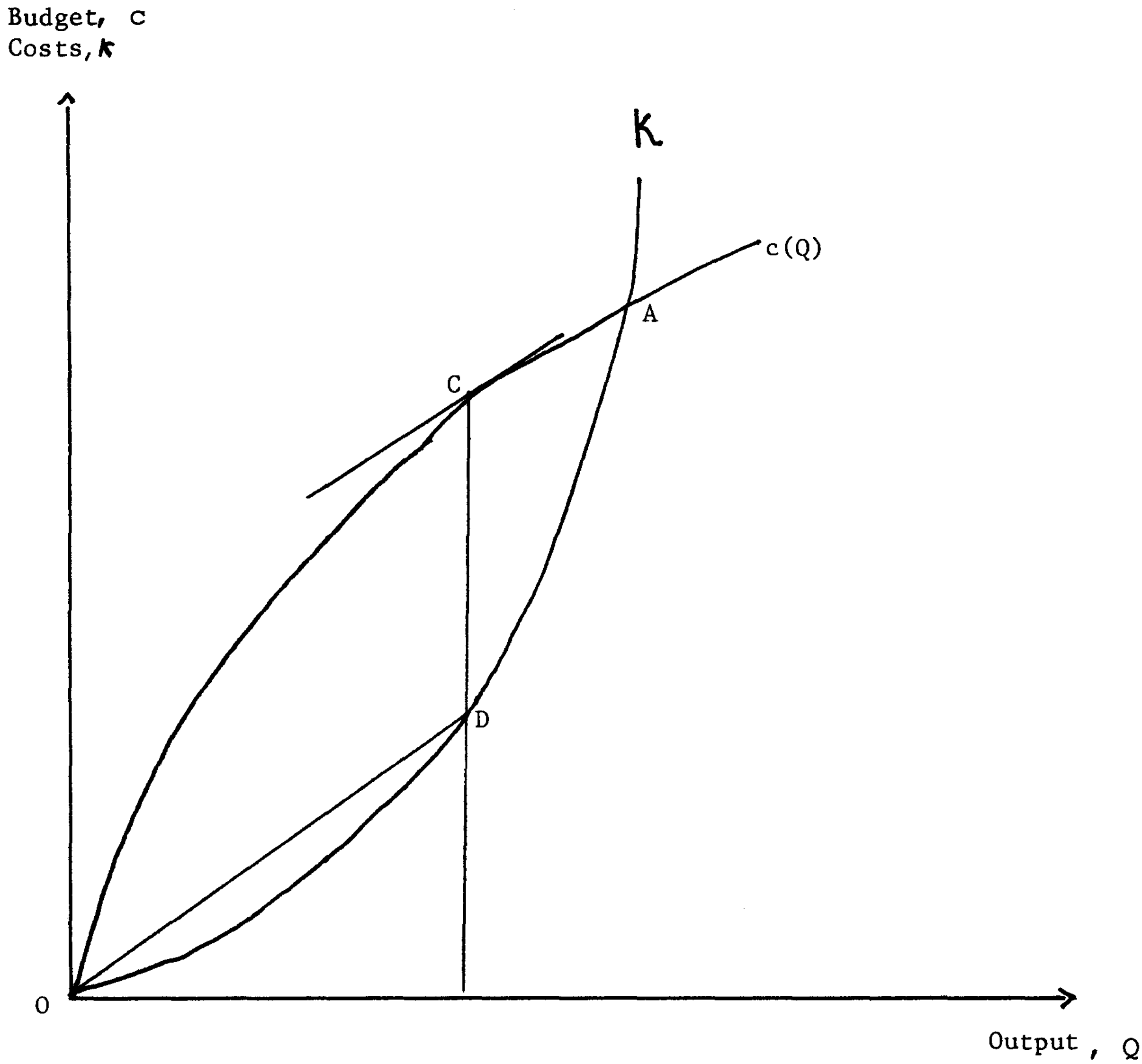

Figure 2.2: Spencer´s version of Niskanen´s basic model (A.2)

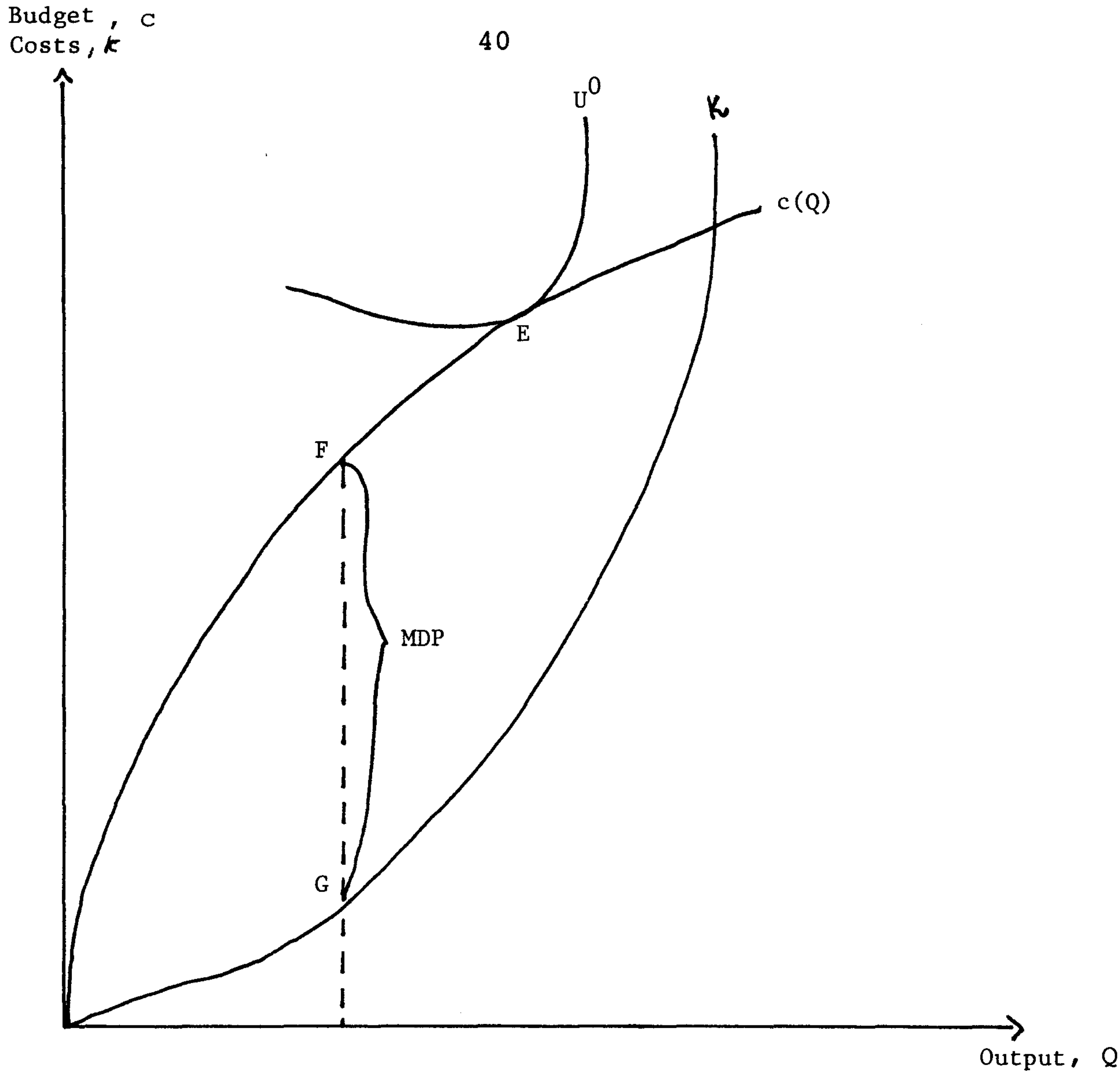

Figure 2.3: Outcome of models A.3 - A.5

E - Outcome when the bureau's utility function is V (Q,MDP)

F - Outcome when the bureau's utility function is V (MDP)

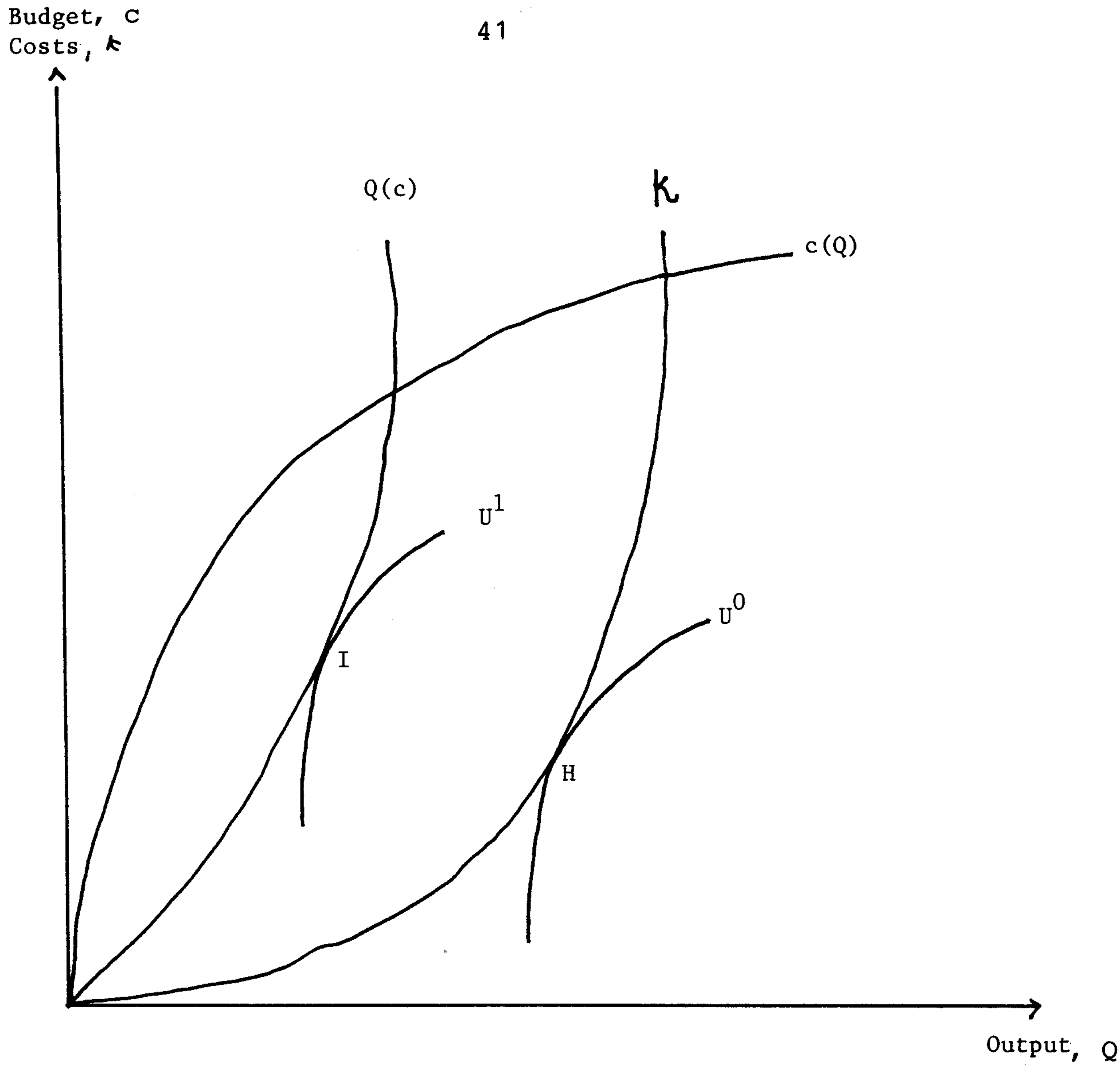

Figure 2.4: Outcome of models B.1 and C.1

		A	B	C	D	E	F	G
Simultaneous moves	V(Q,MDP)	0 (A.5)	+ (B.2)	(C.3)	0 (D.1)	+ (E.2)		0 (G.1)
Sponsor moves first	V(Q,MDP)		+ (B.1)	0 (C.1)		0 (E.1)		
	V(c)							
Bureau moves first	V(Q,MDP)	0 (A.3)		+ (C.2)	0 (D.2,D.5)			
	V(MDP)	- (A.4)			- (D.3)			
	V(Q,1)	0 (A.6)						
	V(c)	+/0 (A.1,A.2)			+ (D.4)			
Other settings	V(c)						? (F.1)	

Table 2.1: Summary of the models of bureau and sponsor

+ - efficient production

0 - some inefficiency in production

- - very inefficient production

CHAPTER 3

THE BASIC ONE–PERIOD GAMES

3.1 INTRODUCTION

In 3.2, we restate the one–period basic model and make assumptions about the players' utility functions. In section 3.3, we compute the equilibrium values of c, e and Q for the three basic noncooperative games and compare the outcome with Pareto–optimal cooperative solutions. In 3.4, we explore how the three noncooperative solutions are affected by changes in the agents' utility of output. In 3.5, we summarize the results and relate them to other bureaucracy models and some empirical studies of the public sector.

3.2 THE BASIC ONE–PERIOD MODEL

The basic model is:

$$Q = c + e \qquad (3.1)$$

$$U = U^1(Q) - U^2(c) \qquad (3.2)$$

$$V = V^1(Q) - V^2(e) \qquad (3.3)$$

We use the following notation for the first and second derivatives of the utility functions:

$\partial U / \partial Q = U^1_Q$, $\partial^2 U / \partial Q^2 = U^1_{QQ}$, and similarly for the other derivatives.

The assumptions of the basic model are:

A1: $U^1_Q > 0$, $U^1_{QQ} < 0$

A2: $U^2_c > 0$, $U^2_{cc} > 0$

A3: $V^1_Q > 0$, $V^1_{QQ} < 0$

A4: $V^2_e > 0$, $V^2_{ee} > 0$

The utility functions are cardinal. For both sponsor and bureau, the marginal utility of output is positive and decreasing in output. The marginal utility of grants/effort is negative and decreasing in c/e.

In the context of public production of services, the assumptions state that both the authorities and the institution derive positive marginal utility from the institution's output and the magnitude of the marginal benefits decreases with increasing output.

The marginal cost of granting funds for the authorities increases with higher grants. This is in accordance with the theory of taxation. The society's welfare loss from taxes increases progressively with the tax rates. The marginal costs of effort for the institution increases with effort.

A numerical example

We will use a numerical example in the forthcoming chapters. The example helps us to illustrate the conclusions of the general analysis. For some of the models, we can not find analytical expressions to characterize the outcomes. In these circumstances, we solely compute numerical solutions. We use the following numerical utility functions:

$$U = \ln(Q) - c^2/4 \qquad (3.2')$$

$$V = \ln(Q) - e^2/4 \qquad (3.3')$$ [1]

(3.1), (3.2') and (3.3') constitute the basic numerical model. The numerical utility functions satisfy the requirements of the assumptions A1–A4.

For both agents, marginal utility of output equals the logarithm of output. This is an assumption which has a parallel in the portfolio theory, where it is often assumed that the utility of money is equal to the logarithm of money (See Arrow (71), pp. 36–38 for a justification of this utility function).

The bureau's disutility of effort is quadratic, which is a common assumption in the agency literature (see for instance Freixas et al (85) and Holmstrøm (79)).

In the following chapters we will frequently compute and compare the numerical values of effort. It is the relative ranking of the effort values of the solutions which has economic meaning, not the absolute value of effort.

3.3 SOLUTIONS TO THE BASIC ONE–PERIOD GAMES

We compute and compare the noncooperative equilibrium solutions of the three basic games and the cooperative bargaining solution. Since we frequently will return to these solutions later, we give them their own superscripts:

c^B, e^B, Q^B – a cooperative bargaining solution

c^N, e^N, Q^N – the Nash–Cournot solution

c^S, e^S, Q^S – the Stackelberg solution when the sponsor leads

$c^{\bar{S}}$, $e^{\bar{S}}$, $Q^{\bar{S}}$ – the Stackelberg solution when the bureau leads

Throughout the chapter we apply the following definitions:

DET – the determinant of the Jacobian matrix.

$e_c = \partial e/\partial c$ – the derivative of the static reaction function when the sponsor is the leader

$c_e = \partial c/\partial e$ – the derivative of the static reaction function when the bureau is the leader

e_{cc}, c_{ee} – the second derivatives of the static reaction functions

Cooperative solution

An efficient cooperative solution is Pareto–optimal. The Pareto–optimal combinations of c and e are found by maximization of:

$$W = U(Q,c) + \lambda V(Q,e) \qquad (3.4)$$

with respect to c and e.

First order conditions (FOC):

$$W_c = 0 \rightarrow \lambda V^1_Q + U^1_Q - U^2_c = 0 \qquad (3.5)$$

$$W_e = 0 \rightarrow U^1_Q + \lambda V^1_Q - \lambda V^2_e = 0 \qquad (3.6)$$

Second order conditions (SOC):

$$W_{cc} = \lambda V^1_{QQ} + U^1_{QQ} - U^2_{cc} < 0 \qquad (3.7)$$

$$W_{ee} = U^1_{QQ} + \lambda V^1_{QQ} - \lambda V^2_{ee} < 0 \qquad (3.8)$$

$$W_{ce} = W_{ec} = U^1_{QQ} + \lambda V^1_{QQ}$$

$$DET = W_{cc} W_{ee} - W_{ce} W_{ec} = \lambda U^2_{cc} V^2_{ee} - (U^2_{cc} + \lambda V^2_{ee})(U^1_{QQ} + \lambda V^1_{QQ}) > 0 \quad (3.9)$$

(3.7) – (3.9) ensure that we have a maximum solution. The numerical solution for $\lambda = 1$ is:

$$c^B = e^B = 1.4142\ , \ Q^B = 2.8284 \qquad (3.10)$$

Since the utility functions of the agents are symmetric, (3.10) is the Nash bargaining solution.

The Nash–Cournot solution

FOC:

$$U_c = 0 \rightarrow U^1_Q - U^2_c = 0 \qquad (3.11)$$

$$V_e = 0 \rightarrow V^1_Q - V^2_e = 0 \qquad (3.12)$$

SOC:

$$U_{cc} = U^1_{QQ} - U^2_{cc} < 0 \qquad (3.13)$$

$$V_{ee} = V^1_{QQ} - V^2_{ee} < 0 \qquad (3.14)$$

$$U_{ce} = U^1_{QQ}$$

$$V_{ec} = V^1_{QQ}$$

$$DET = U_{cc} V_{ee} - U_{ce} V_{ec} = U^2_{cc} V^2_{ee} - (U^1_{QQ} V^2_{ee} + U^2_{cc} V^1_{QQ}) > 0 \qquad (3.15)$$

(3.13) – (3.15) ensure that we have a stable Nash–equilibrium (Dixit (86)). The numerical solution is:

$$c^N = e^N = 1 \ , \ Q^N = 2 \qquad (3.16)$$

When (3.5) – (3.6) are compared to (3.11) – (3.12), we find that either c^N is below c^B, or e^N is below e^B or both. The Nash–Cournot solution yields an output level which is below all Pareto–optimal output levels. This result is due to the external effects of each instrument variable on the other agent. Effort has a positive effect on the sponsor's utility, while grants are perceived as positive by the bureau. Therefore, both will tend to set their instrument variables too low in the Nash–Cournot game. Whether only one of the variables is too low or both variables are too low, depends on the Pareto–optimal solution with which we compare the Nash–Cournot solution. The results are illustrated in figure 3.1 for symmetric utility functions. The Nash–Cournot solution is located at N while the Pareto–optimal solutions are given by the curve M. The symmetric cooperative solution is at M'. e(c) and c(e) are the static reaction functions of the bureau and the sponsor, respectively.

It follows from (3.5) – (3.6) that U_c and V_e are negative for a cooperative solution. Consequently, both agents want to deviate from the cooperative solution. The agents' marginal utility of output are lower at the Pareto–optimal locus than at the Nash–Cournot solution. The differences between the marginal disutility of grants/efforts at the two solutions are not sufficient to stop the agents from deviating from the Pareto–optimal locus.

Both agents can gain from a coordinated move from the Nash–Cournot solution to a cooperative solution. In a Pareto improving allocation, both agents increase their instrument variables above c^N and e^N.

Our analysis suggests an interesting reason why many people feel that the level and quality of public services are too low. A general view is that the huge demand for public services is caused by the lack of charge of services. However, there is an alternative explanation. The supply of services may be lower than optimal because the budget process is noncooperative. The authorities and institutions distrust each other's incentives and therefore prefer to maximize their utility unilaterally rather than engage in a bargaining process. As a result, both efficiency and output are low. The general public and the institutions would be better off if they could agree to undertake a coordinated expansion of public services through higher grants and higher effort. However, we have argued in chapter 2 that neither output nor effort are verifiable. Even though the public authorities have a correct impression of an institution's efficiency, they can not enforce a cooperative agreement where the institutions promise to raise its efficiency.

<u>Sponsor as leader</u>

We now assume that the sponsor is the Stackelberg leader. It will use the budget as a strategic instrument to affect the effort of the bureau. The sponsor will calculate the reaction function of the bureau and maximize its utility given the bureau's reaction function. The reaction function is found directly from the first order condition of the follower:

$$V_e = 0 \rightarrow V^1_Q - V^2_e = 0 \qquad (3.17)$$

From (3.17), we compute e_c:

$$e_c = -V^1_{QQ} \,/\, (V^1_{QQ} - V^2_{ee}) \qquad (3.18)$$

Assumptions A3–A4 secure that $-1 < e_c < 0$. The negative sign of the derivative of the reaction function indicates that a reduction in the bureau's budget will be compensated with higher effort by the bureau. Lower grants yield lower output and increases the marginal benefit of effort. However, since both output and managerial discretionary profit are normal goods, the compensation is less than the cut in grants.

The first order condition of the sponsor's maximization problem is:

$$U_c = U_Q^1 (1 + e_c) - U_c^2 = 0 \qquad (3.19)$$

To compare the equilibrium values of c^S and c^N, we insert c^N and e^N in U_c from (3.19):

$$U_c(c^N, e^N) = U_Q^1 (Q^N) + U_Q^1 (Q^N) e_c(c^N) - U_c^2(c^N) < 0 \quad (3.20)$$

Since $U_Q^1 - U_c^2 = 0$ for the Nash–Cournot solution, it follows from (3.20) that the sponsor will lower grants below c^N. Effort will increase. The sponsor will cut the budget to force the bureau to increase efficiency. Effort will go up but not enough to prevent output from falling below the Q^N.

SOC:

The second order condition of the sponsor's maximization problem is:

$$U_{cc} = U_{QQ}^1 (1 + e_c)^2 + U_Q^1 e_{cc} - U_{cc}^2 \qquad (3.21)$$

$$e_{cc} = \left[V_{ee}^2 V_{QQQ}^1 (1 + e_c) - V_{QQ}^1 V_{eee}^2 e_c\right]/(V_{QQ}^1 - V_{ee}^2)^2 \qquad (3.22)$$

U_{cc} is ambiguous because e_{cc} depends on the sign of the third derivatives. If $U_{cc} > 0$ at a point where $U_c = 0$, we would have a local minimum point together with two local maximum points, as illustrated in figure 3.2. We will rule out solutions like B in figure 3.2.

When the numerical utility functions are applied, it turns out that the Stackelberg solution is unambiguously given by the first order condition, (3.19). We insert (3.2') – (3.3') in (3.17) – (3.19) to achieve the Stackelberg solution with sponsor as leader:

$$c^S = 0.6871, e^S = 1.1118, Q^S = 1.7989 \qquad (3.23)$$

The interpretation of the results for the public sector is straightforward. The authorities have incentives to cut budgets to force the public institutions to increase efficiency. Budget cuts are used as strategic instruments. The output of the Stackelberg solution will be lower than for the Nash–Cournot solution which in turn is lower than for the cooperative solution.

In our numerical example, effort for the Stackelberg game is lower than for the cooperative solution. Whether e^S is lower or higher than e^B depends on the form of the utility functions and λ. The value of e^S will be high if the absolute value of e_c is close to one because the institutions are very sensitive to budget cuts. If λ is high, society puts little emphasis on the utility function of the institutions and a cooperative solution will result in high efficiency.

Bureau as leader

Due to the symmetry of the production function and utility functions, the analysis of the Stackelberg game with bureau as leader is parallel to the preceding analysis. The bureau reduces effort to force the sponsor to increase the budget. This policy causes the output to be lower than for the Nash–Cournot solution. The first and second order conditions are the same as (3.17) – (3.19) & (3.21) – (3.22) if e/V is interchanged with c/U. The numerical solution is:

$$c^{\bar{S}} = 1.1118 \,,\ e^{\bar{S}} = 0.6871,\ Q^{\bar{S}} = 1.7989 \qquad (3.24)$$

We see from (3.24) that effort is very low. If the authorities are sensitive to pressure from the institutions, the resulting efficiency can be poor.

The two Stackelberg solutions are denoted as S and $\bar{S}$ in figure 3.3. N is the Nash–Cournot solution.

Summary

We can draw the following conclusions about the relationship between the solutions of three basic games and a cooperative solution based on the model given by (3.1) – (3.3) and assumptions A1 – A4:

$$c^S < c^N < c^{\bar{S}} \qquad (3.25)$$

$$e^{\bar{S}} < e^{N} < e^{S} \qquad (3.26)$$

$$Q^{S} < Q^{N} < Q^{B} \qquad (3.27)$$

$$Q^{\bar{S}} < Q^{N} < Q^{B} \qquad (3.28)$$

The numerical solutions of the three noncooperative games and the symmetric cooperative solution is given in table 3.1. We see that both agents will gain from moving to the cooperative solution, independent of the order of moves. For the Stackelberg game, the leader will increase its utility above the utility level of the Nash–Cournot solution by cutting its instrument variable. The follower's utility will fall below the utility of the Nash–Cournot solution.

3.4 COMPARATIVE STATICS

We will now modify the utility function (3.2) – (3.3) to be able to explore how changes in the benefit of output affect the equilibrium solutions for the four basic solutions. We introduce a parameter, β. A positive change in β denotes that the benefit of output increases. Let:

β – parameter which characterizes the benefit of output

$$U(Q, \beta, c) = U^{1}(Q, \beta) - U^{2}(c) \qquad (3.29)$$

$$V(Q, \beta, e) = V^{1}(Q, \beta) - V^{2}(e) \qquad (3.30)$$

We make the following assumptions of the utility functions in addition to A1 – A4:

A5: $U^{1}_{Q\beta} > 0$, $U^{1}_{QQ\beta} < 0$

A6: $V^{1}_{Q\beta} > 0$, $V^{1}_{QQ\beta} < 0$

A5 and A6 state that the marginal benefit of output increases with higher β and that the increase in marginal utility is greater for small output values. A positive change in the demand for public services will have stronger effects on the marginal evaluation of output if output is low than if output is high.

The signs of the third derivatives of $U^1(Q)$, $U^2(c)$, $V^1(Q)$ and $V^2(e)$ have significance for the conclusions of the comparative static analysis of the Stackelberg games. We will not make any a priori assumptions about the signs of the third derivatives. In regulation theory, it is not common to make ex ante assumptions concerning the third derivatives of the utility functions with respect to profit or effort.

We now explore how the solutions are affected by changes in β[2]

Cooperative solution

We undertake a total differentiation of the first order conditions (3.5) – (3.6):

$$\begin{bmatrix} W_{cc} & W_{ce} \\ W_{ec} & W_{ee} \end{bmatrix} \begin{bmatrix} dc^B \\ de^B \end{bmatrix} = - \begin{bmatrix} W_{c\beta}\, d\beta \\ W_{e\beta}\, d\beta \end{bmatrix} \qquad (3.31)$$

$$W_{c\beta} = W_{e\beta} = U^1_{Q\beta} + \lambda\, V^1_{Q\beta} \qquad (3.32)$$

We insert (3.7) – (3.9) in (3.31):

$$\begin{bmatrix} dc^B/d\beta \\ de^B/d\beta \end{bmatrix} = \frac{1}{DET} \begin{bmatrix} \lambda V^2_{ee}\, (U^1_{Q\beta} + \lambda V^1_{Q\beta}) \\ U^2_{cc}\, (U^1_{Q\beta} + \lambda V^1_{Q\beta}) \end{bmatrix} \qquad (3.33)$$

DET is the Jacobian determinant given by (3.9).

It follows from A2 and A4 – A6 that both $dc^B/d\beta$ and $de^\beta/d\beta$ are positive. When the marginal utility of output increases, the sponsor will grant a higher budget, and the bureau will provide more effort. Output will increase. The relative magnitude of the changes in c and e depends on λ, U^2_{cc} and V^2_{ee}. Effort will be raised more relative to grants the lower is λ, the lower is V^2_{ee} and the higher is U^2_{cc}.

The interpretation of this result is straightforward. If the demand for services of a public institution increases, the institution will respond by increased efficiency. The authorities will grant more money and output will be raised. The increase in efficiency will depend on the bargaining strength of the two agents and the increase in marginal costs of higher efficiency versus the increase in marginal costs of granting a higher budget.

The Nash–Cournot solution

We find the effect from changes in β by undertaking a complete differentiation of the first order conditions (3.11) – (3.12):

$$\begin{bmatrix} U_{cc} & U_{ce} \\ V_{ec} & V_{ee} \end{bmatrix} \begin{bmatrix} dc^N \\ de^N \end{bmatrix} = -\begin{bmatrix} U_{c\beta}\, d\beta \\ V_{e\beta}\, d\beta \end{bmatrix} \qquad (3.34)$$

$$U_{c\beta} = U^1_{Q\beta} \qquad (3.35)$$

$$V_{e\beta} = V^1_{Q\beta} \qquad (3.36)$$

$$U_{ce} = U^1_{QQ} \qquad (3.37)$$

$$V_{ec} = V^1_{QQ} \qquad (3.38)$$

We insert (3.13) – (3.14) and (3.35) – (3.38) in (3.34):

$$\begin{bmatrix} dc^N/d\beta \\ de^N/d\beta \end{bmatrix} = \frac{1}{\mathrm{DET}} \begin{bmatrix} (V^2_{ee} - V^1_{QQ})\, U^1_{Q\beta} + V^1_{Q\beta} U^1_{QQ} \\ (U^2_{cc} - U^1_{QQ})\, V^1_{Q\beta} + U^1_{Q\beta} V^1_{QQ} \end{bmatrix} \qquad (3.39)$$

DET is the Jacobian determinant given by (3.15).

$$dQ^N/d\beta = (dc^N + de^N)/d\beta = (U^2_{cc}\, V^1_{Q\beta} + U^1_{Q\beta}\, V^2_{ee}) \;/\; \mathrm{DET} \;> 0 \qquad (3.40)$$

Assumptions A1 – A6 are sufficient to state that output will increase when the marginal benefit of output increases. However, from (3.39) we find that the signs of $dc^N/d\beta$ and

$de^N/d\beta$ are ambiguous. Output will increase, but we cannot say whether this will be due to higher budgets, increased effort or both. An increase in β will increase the marginal utility of grants for a given effort level. But since effort is affected, we cannot tell a priori whether budgets will be raised. The same argument is valid for effort. The overall effects on grants and effort depends on the magnitudes of $U^1_{Q\beta}$ and $V^1_{Q\beta}$. If $U^1_{Q\beta}$ is high, effort can go down because the increase in marginal benefits of grants will increase the budget substantially.

The comparative analysis shows that for the Nash–Cournot game, increased demand for public services will not necessarily induce the institutions to provide services in a more efficient manner. If the utility of the authorities is strongly affected by the change in demand, efficiency can go down due to the increase in the budget.

Sponsor as leader

From (3.17) we find how e^S is affected by a change in β:

$$de^S/d\beta = e_\beta + e_c\,(dc^S/d\beta) \qquad (3.41)$$

$$e_\beta = \partial e^S/\partial\beta = -V^1_{Q\beta}\,/\,(V^1_{QQ} - V^2_{ee}) > 0 \qquad (3.42)$$

(3.42) follows from (3.30). The sign of e_β follows from A6. An increase in the marginal benefit of output will lead to higher effort for given c.

(3.41) states that the overall effect on effort depends on the change in grants. If grants are cut, effort will increase with certainty. If grants are increased, we cannot say a priori how effort will be affected.

The next step is to explore how c^S is affected. (3.18) – (3.19) give:

$$dc^S/\,d\beta = -U_{c\beta}\,/\,U_{cc} = -\left[(U^1_{Q\beta} + U^1_{QQ}\,e_\beta)\,(1 + e_c) + U^1_Q\,e_{c\beta}\right]/\,U_{cc} \qquad (3.43)$$

$$e_{c\beta} = \left[V^1_{QQQ}\,V^2_{ee}\,e_\beta + V^1_{QQ\beta}\,V^2_{ee} - V^2_{eee}V^1_{QQ}\,e_\beta\right]/\,(V^1_{QQ} - V^2_{ee})^2 \qquad (3.44)$$

We assumed that $U_{cc} < 0$ when we developed the Stackelberg solution. From (3.43), we see that the change in grants will depend on three terms. The first, $-U^1_{Q\beta}(1 + e_c) / U_{cc}$, is positive and reflects the direct effect on the marginal utility of output. The second, $-U^1_{QQ} e_\beta (1 + e_c) / U_{cc}$, which is negative, expresses the effect from changes in effort on the marginal benefit of output. The third, which contains $e_{c\beta}$, is due to the change in the strategic relationship between sponsor and bureau. From (3.44), it follow that this term can be either negative or positive depending on whether the increase in β strengthens or weakens the strategic position of the sponsor.

Based on (3.44), we now discuss how the sponsor's opportunity to use the budget as a strategic instrument is influenced by β. $e_{c\beta}$ consists of three terms. The sign of the first depends on the sign of V^1_{QQQ}. A positive V^1_{QQQ} indicates that the rate of change of marginal utility of output is smaller the higher is output. An increase in β will, for given c, induce the bureau to increase effort and therefore output. Higher output implies that the marginal utility of output is less elastic with respect to output if $V^1_{QQQ} > 0$. Therefore, a strategic budget cut will now have less impact on the bureau than before.

The second term of $e_{c\beta}$ is negative by A6. When $V^1_{QQ\beta} < 0$, an increase in β will have a direct effect on V^1_{QQ}. A reduction in V^1_{QQ} causes the bureau to be more sensitive to strategic cuts.

The third term reflects the indirect effect of β on the rate of change of the marginal costs of effort with respect to effort. Consider the case where the increase in marginal costs takes place at an increasing speed with respect to effort. Then V^2_{eee} is positive, and the third term is positive. This effect makes the bureau less sensitive to strategic cuts.

Since the sign of $e_{c\beta}$ is ambiguous and the other two terms of $dc^S/d\beta$ have opposite signs, we cannot draw any certain conclusion about how c^S will depend on β. Neither can we say whether e^S will be raised or lowered or whether output will increase or decrease.[3]

Since the utility functions are symmetric, we do not have to carry out the comparative statics for the setting with bureau as leader. Once again, we can interchange c/U with e/V in (3.41) – (3.44). We cannot tell whether grants, effort and output will increase or decrease due to a change in β.

The conclusion of the comparative statics analysis of the Stackelberg games, is that it is possible that efficiency will be reduced when the demand for public services are increased. This is due to two factors. First, higher utility from public services will induce the authorities to increase the budget for given level of effort. Second, the changes will affect the strategic relationship between the authorities and the institution. If the relative strength of the institution is improved, production might be less efficient.

If we contrast the solutions of the three noncooperative games with the cooperative solution, we see a striking difference regarding the change in efficiency. For the cooperative solution, we can say for sure that effort will be increased when the marginal utility of output increases. For the noncooperative games, the impact on effort is ambiguous. This conclusion shows that the setting may both affect the static solution and whether the long run tendency of the institutions will be towards more or less efficiency.

3.5 DISCUSSION

Section 3.5 consists of two parts. First, we discuss the relationship between our basic one–period games and some of the models surveyed in chapter 2. Then, we relate our results to empirical studies of the public sector.

Three of the papers surveyed in the preceding chapter present models which are sufficiently close to our model to make a comparison of the outcomes meaningful. These papers are Miller (77), Moene (86) and Chan & Mestelman (88). We will in turn consider how our three basic noncooperative games and the cooperative solution relate to some of their models.

Moene's model 3.1, which he names the "benchmark model", can be compared to our cooperative outcome. Moene assumes that the sponsor has complete information and power to set both budget and output. The sponsor choses the combination of output and budget which maximizes its utility. Managerially discretionary profit therefore equals zero. This outcome corresponds to a cooperative solution in our model, provided there is an upper limit to effort. The corresponding cooperative solution yields effort equal to e_{max}.

Models 3.1 and 3.3 by Chan & Mestelman (88) and the model of Miller (77) apply the one–shot Nash–equilibrium concept and let the players move simultaneously. First, we discuss model 3.1 of Chan & Mestelman (88). The sponsor sets the budget and the bureau sets output. The equilibrium outcome is that output and budget equal zero as explained in chapter 2, category C.3 of section 2.2.

The same conclusion can be drawn from our model if we modify it slightly. Consider a revised model where effort must be equal to or below e_{max}, and the bureau sets output. Furthermore, grants must be positive if output shall exceed zero, independent of the level of effort. We also assume that e_{max} is so high that the bureau will want to decrease effort below e_{max} when it takes the budget level as given. Hence, $V_e^2(e_{max})$ is sufficiently large and V_Q^1 $(c+e_{max})$ sufficiently small. The sponsor will want to set the budget equal to Q – e_{max} for a given output level in order to make effort equal to e_{max}. By assumption, the bureau will want to decrease output below $(c+e_{max})$ for a given level of grants. Thus, there is no combination of positive budget and output from which both players do not want to deviate. Therefore, zero budget and zero output is the only reasonable Nash–equilibrium of our revised model. Thus, we have shown that the conclusion of model 3.1 of Chan & Mestelman follows from our revised model.

This analysis illustrates that the choice of the bureau's instrument variable is important for the equilibrium outcome. When the bureau sets output instead of effort, the Nash–Cournot solution is radically changed. The difference between the Nash–Cournot solutions of our model and model 3.1 of Chan & Mestelman indicates that our model is the more realistic. On pp. 93, the authors write that model 3.1 is probably the most realistic of their models. However, the equilibrium outcome indicates that our model gives a better description of the budget process.

Model 3.3 of Chan & Mestelman (88) differs from their model 3.1 in that the bureau sets a supply price instead of output. The players move simultaneously. The bureau will set the supply price to ensure that there is some inefficiency. As in our model, output is below all Pareto–optimal output levels.

The model of Miller (77) is almost the same as model 3.3 of Chan & Mestelman. The bureau's choice variable is the percentage of the budget allocated to production of output. The Nash–Cournot solution yields some slack, that is, effort is below e_{max}.

We can conclude that – although model 3.3 of Chan & Mestelman (88) and the model of Miller (77) formally differ from our Nash–Cournot game – the intuition captured by the models is the same.

There is only one model comparable with our model where the sponsor is Stackelberg leader, model 4.1 of Moene (86). The sponsor sets the budget and the bureau sets output. As for model 3.1 of Chan & Mestelman (88), the difference between Moene's and our model is that his bureau sets output instead of effort. However, this difference has no significance when the bureau makes the last move. By setting effort, the bureau simultaneously sets effort and output, taking the budget as given. As seen from the sponsor, it does not matter whether the bureau formally sets output or effort. Therefore, the equilibrium outcome of Moene's model, that output is low and that there is some, but not necessarily very much, inefficiency, is parallel to the outcome of our model.

The last game to discuss is the Stackelberg game with bureau as leader. Two models can be compared to ours, models 3.3 and 4.2 of Moene (86). In model 3.3, the bureau sets the supply price, or rather, it gives information concerning its marginal costs. After the bureau's move, the sponsor sets grants/output. The bureau will set the supply price above its true marginal costs. Therefore, effort will be below e_{max} and output will be low. The outcome is therefore comparable to the solution of our model.

In model 4.2 of Moene (86), the bureau moves first by setting output instead of supply price. The outcome becomes quite different from the outcome of his model 3.3. The sponsor will not accept any inefficiency and will therefore set grants as low as feasible. Therefore, the bureau can only derive utility from output and it will set output high. Consequently, effort and output are high, which is the opposite of the outcome in our model.

The outcomes of models 3.1 of Chan & Mestelman (88) and 4.2 of Moene (86) illustrate that the influence on the outcome of the game may be radically changed if we let the bureau set output instead of effort. However, the importance of the choice of instrument variable for the bureau depends on the order of move of the game. When the sponsor moves first, the equilibrium outcome is independent of the bureau's choice variable. When the agents move simultaneously, the equilibrium outcomes are very different. Zero output and budget is likely to be the outcome when the bureau sets output. When the bureau moves first, effort will be low when the bureau sets effort and high when the bureau sets output.

In the second part of section 3.5, we will discuss the empirical implications of our model. Since we have studied a one–period game, while the budget process is repetitive in the real world, we would not expect to find empirical support for every implication of the model in this chapter. However, we would expect the basic conclusion of the chapter to hold, that there will be an inverse relationship between the level of grants and effort provided the interaction between the authorities and the institutions is noncooperative. If the institutions lead, grants will be high and efficiency low. When we move to a Nash–Cournot game, grants will decrease and efficiency increase. If the authorities lead, grants will be even lower and and efficiency higher than for the Nash–Cournot game. From our model, we can formulate the following hypothesis: The public sector efficiency is highest when grants are low. In the long run, efficiency is higher when the annual increase in grants is small than when the public sector expands fast.[4]

The last 20–25 years, we have seen big variations in the annual increases of the public budgets, both between countries and from year to year. It should be possible to carry out empirical research which can falsify the hypothesis that productivity is negatively correlated with the annual increases in the budgets. To my knowledge, no such comprehensive analysis has been carried out. However, for some countries, we have data which serve to support the hypothesis.

For Norway, Stm. 41 (87–88) Nasjonal Helseplan, gives a survey of the development for the years 1977–86 of the number of patients which has received medical treatment in Norwegian health institutions together with reports of the annual increases in the institutions' budgets. The data clearly supports the hypothesis. For the period 1977 – 81, the supply of resources to hospitals increased on average 3.1% annually. For the same period, the number of patients increased 1,1%.

For 1981–86, the average annual increase in resources was 2,6%, while the annual increase in the number of pasients increased to 1,9%. The same pattern appears when we survey the development of all health institutions. The annual increase in the budgets fell from 4,7% to 2,2% per year from the first to the second period, while the increase in number of patients was respectively 1,1% and 1,9%.

Murray (87) reports from a comprehensive study by ESO (Expertgruppen før studier i offentlig ekonomi) on the development of productivity in Sweden. The conclusion is that less resources lead to higher productivity. For the health sector, productivity was negative for the 1960–80 period, but slightly less negative for the latter part of the period, when the budgets were tighter. For the state sector, the annual increase in expenditures was approximately 6% from 1970 to 1975 and approximately 2% from 1975 to 1980. Productivity was higher in the last than in the first period. Murray quotes data from the beginning of the eighties which imply that the positive trend for productivity has continued.

Levitt & Joyce (87), pp. 72, refer to studies of productivity in the public sector in the US. Productivity rose slightly faster for 1977–83 compared to 1963–77. In the same period the increases in supply of resources to the public sector slowed down.

Although weak, these casual studies support our hypothesis. One warning is appropriate. All three studies find that the productivity of the public sector has increased. For the same period, the annual increase in expenditures has been reduced. That does not necessarily imply that there is a causal link between the two trends. There may be factors outside our model which are capable of explaining both trends.

Conclusion

We have solved for the Nash–equilibria of our three basic one–period games and compared the equilibrium solutions with the cooperative solution. The three games yield output levels which are below the cooperative output levels. There will in general be an inverse relationship between grants and effort. We have also shown that the equilibrium outcomes of our model are close to solutions of other bureaucracy models and that the choice of instrument variables is crucial for the model's outcome.

ENDNOTES

[1]The choice of 4 as the denominators in the second terms is due to the fact that the one–shot Nash–equilibrium will give 1,1 and 2 as values for c,e and Q, respectively.

[2]Outlines of comparative statics analysis are provided by Sydsæther (81), pp. 278–280 and Dixit (86).

[3]The proposition that the change in output is ambiguous follows from a closer investigation of (3.41) – (3.43).

[4]The proposition that the productivity of the public sector is high when the supply of resources to public institutions is tight, is supported by NOU (84), pp. 15. In june 1989, a former prime minister of Norway made a speech where he claimed that the public sector should not be allowed to expand too fast as keeping budgets tight is the only road to a more efficient public sector.

REFERENCES

Arrow, K. 1971: Aspects of the Theory of Risk–Bearing, Yrjø Jahnssonin Saatiø, Helsinki.

Dixit, A. 1986: Comparative Statics for Oligopoly, International Economic Review 27, 107–122.

Freixas, X, Guesnerie, R. & Tirole, J. 1985: Planning under Incomplete Information and the Ratchet Effect, Review of Economic Studies 52, 173–191.

Holmstrøm, B. 1979: Moral Hazard and Observability, Bell Journal of Economics 10, 74–91.

Levitt, M. & Joyce, M. 1987: The Growth and Efficiency of Public Spending, Cambridge University Press, Cambridge.

Moene, K. 1986: Types of Bureaucratic Interaction, Journal of Public Economics 29, 333–346.

Murray, R. 1987: Den offentliga sektorn – produktivitet och effektivitet, Bilaga 21 till Långtidsutredningen 1987, Finansdepartementet, Stockholm.

NOU 84:23 Produktivitetsfremmende reformer i statens budsjettsystem

Stm. 41 (87–88) Helsepolitikken mot år 2000 Nasjonal helseplan

Stm. 1 (89–90) Nasjonalbudsjettet 1990

Sydsæther, K. 1981: Matematisk analyse, Universitetsforlaget, Oslo.

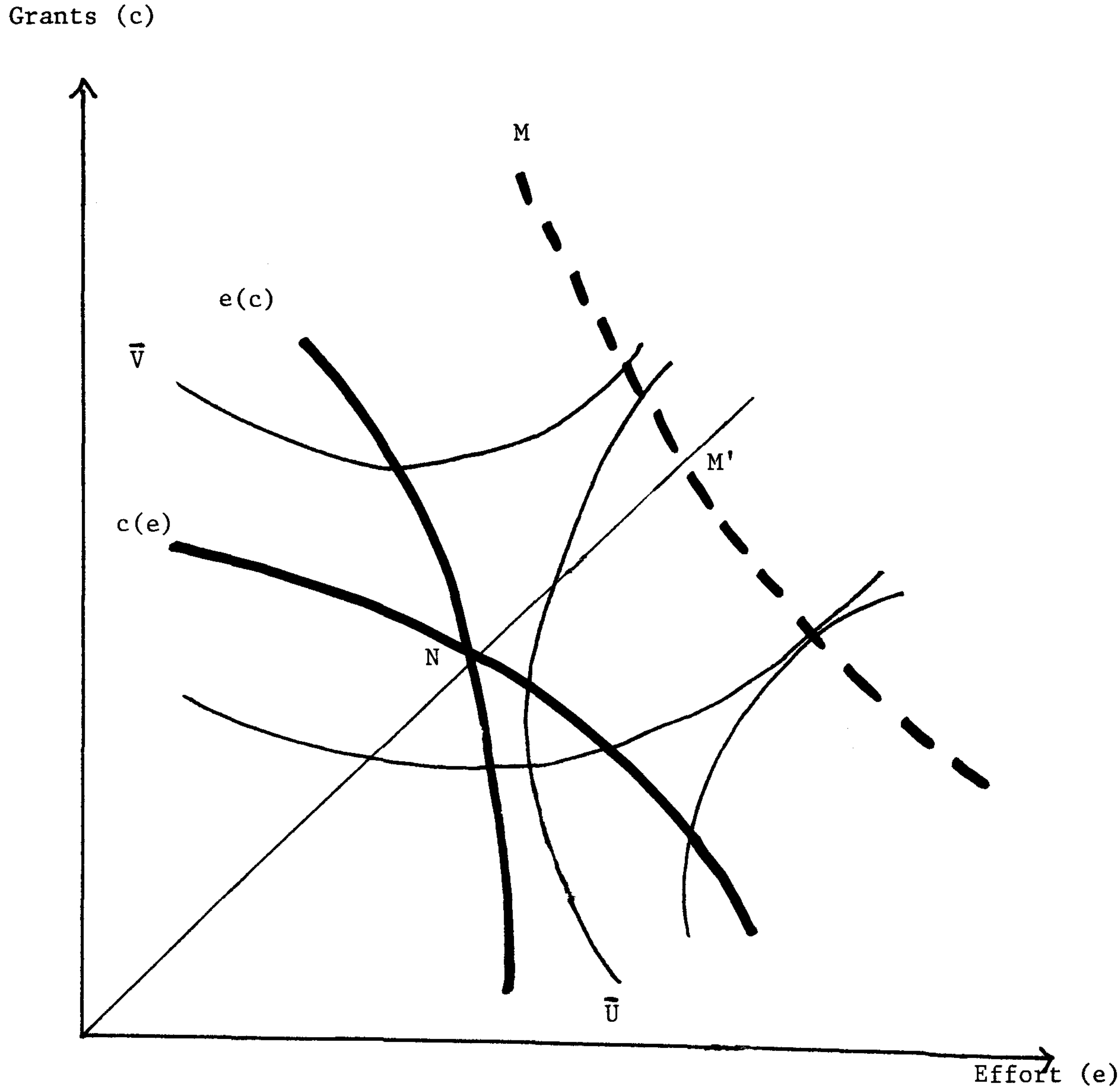

Figure 3.1: The Nash- Cournot solution (N) and the Pareto-optimal set (M)

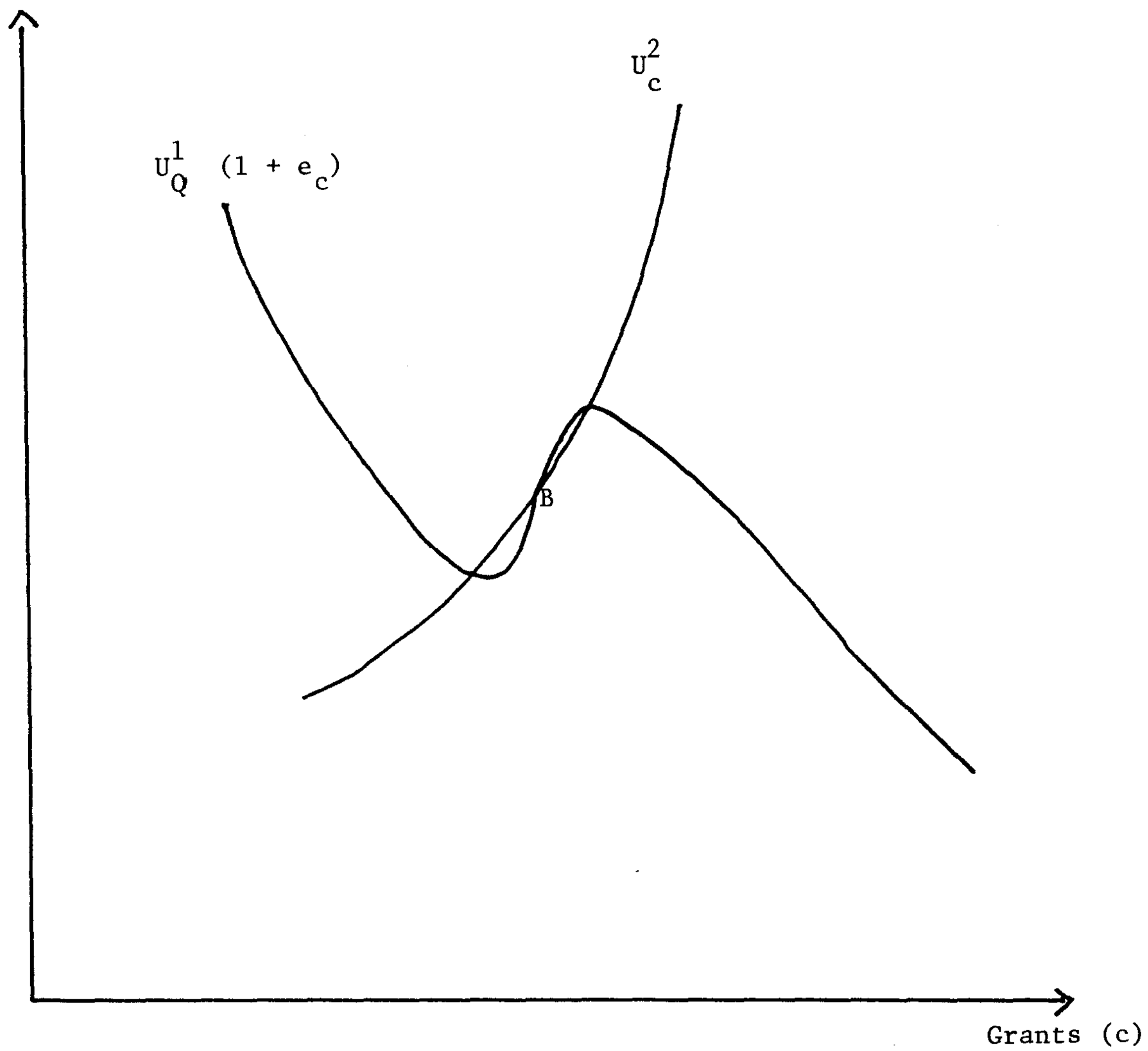

Figure 3.2: Multiple solutions in the Stackelberg-game with sponsor as leader

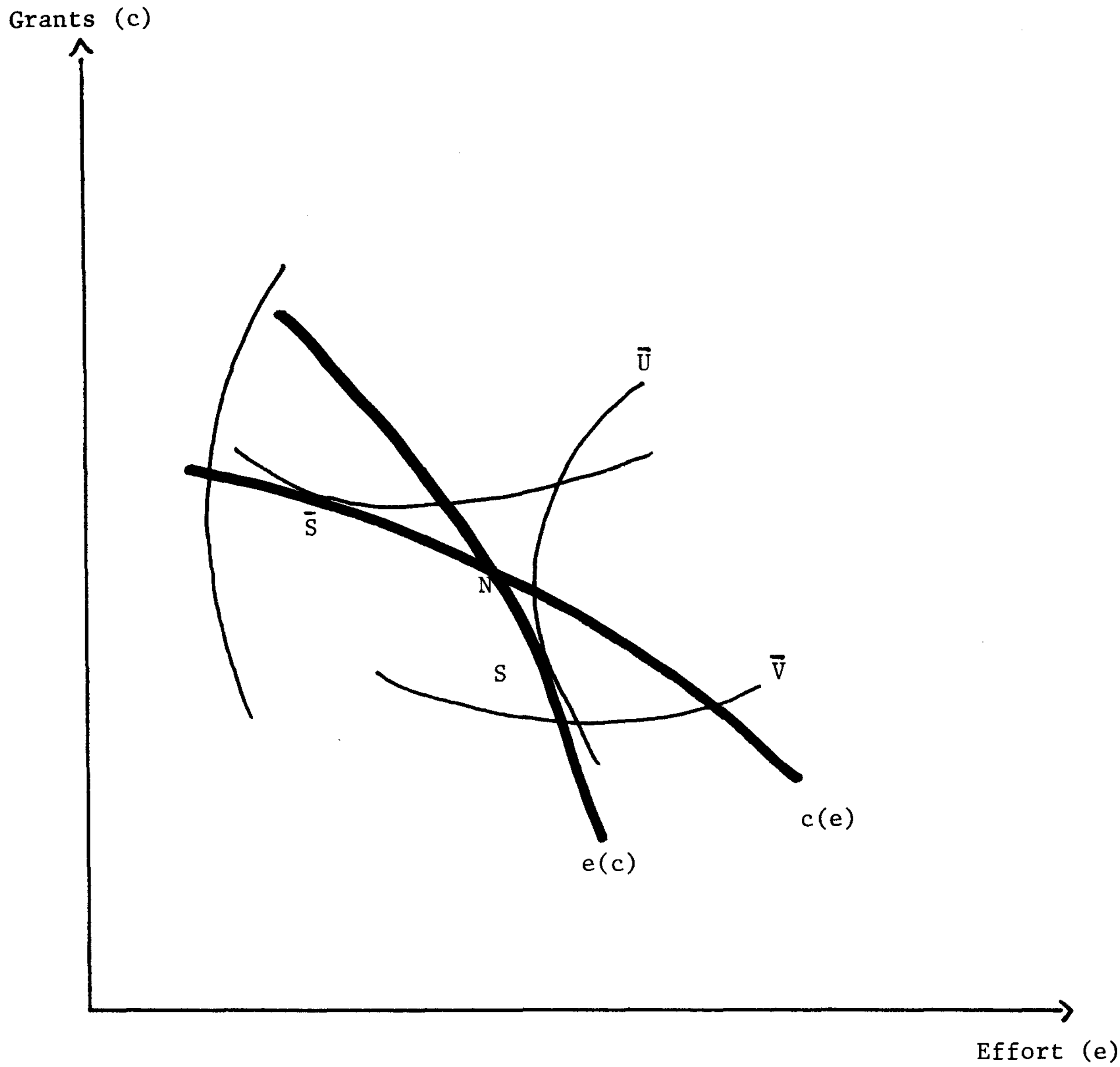

Figure 3.3: The Stackelberg solutions with sponsor as leader (S) and bureau as leader ($\bar{S}$)

	c	e	Q	U	V
Cooperative solution	1.4142	1.4142	2.8284	0.5397	0.5397
Nash- Cournot solution	1	1	2	0.4431	0.4431
Stackelberg sponsor leader	0.6871	1.1118	1.7989	0.4691	0.2782
Stackelberg bureau leader	1.1118	0.6871	1.7989	0.2782	0.4691

Table 3.1: Summary of numerical solutions for the basic games

CHAPTER 4

MULTI–PERIOD GAMES BETWEEN THE SPONSOR AND THE BUREAU

4.1 INTRODUCTION

In chapter 4, we retain the assumption of perfect information and explore how the equilibrium solutions are affected when the interaction between sponsor and bureau takes place over many periods.

In chapter 3, we concluded that the outcome of the one–period game crucially depends on the order of move of the agents. Hence, the ability of the agents to undertake commitments is important. In general, an agent gains from being able to fix its policy variable for some duration of time because the commitment affects the opponent's move. The leader in the relationship can use its instrument variable strategically to change the opponent's variable in the desired direction.

In real life, the interaction between the authorities and the institutions is repeated. It is therefore important to explore how the conclusions of chapter 3 are affected by extending the basic games to a multi–period setting.

It is fair to say that the theory of multi–period games with full certainty has not turned out to be a satisfactory tool for the understanding of repetitive games. The equilibrium outcomes of such games have some unpleasant characteristics once we impose the requirement of subgame perfectness. Finite games have only one subgame perfect equilibrium, the one–shot Nash–equilibrium for every period, provided this equilibrium is unique. This is seen if we compute the equilibrium of the last period, which must be a Nash–equilibrium, and unravel the solution backwards. Since both agents know that the equilibrium of the last period is independent of their second last moves, the equilibrium of the second last period is also the one–period Nash–equilibrium, and so on.

Infinite supergames with simultaneous moves have an infinity of subgame perfect equilibria (Fudenberg & Maskin (86)). The equilibrium space depends on the players' discount factors. If both discount factors equal unity, any outcome is a subgame perfect equilibrium.

From these results, it follows that the equilibrium solution of a finite, multi–period game, where a basic game is repeated, is the same as for the corresponding one–period game. When the agents move simultaneously, the Nash–Cournot solution is the only subgame perfect equilibrium outcome since it is unique in the one–period game. When one of the players is able to commit itself for a period, the Stackelberg solution will be the equilibrium outcome of every period in the multi–period game.

When the basic, simultaneous–move game is repeated infinitely many times, the agents can sustain a noncooperative equilibrium where both are better off than in the Nash–Cournot solution. The higher is the discount factor, the better are the sustainable equilibrium solutions. Above a certain discount factor, a Pareto–optimal, cooperative solution is sustainable.

To summarize: The theory predicts that when the horizon is infinite, almost any outcome is an equilibrium. When the horizon is finite, although possibly very long, the equilibrium solution is identical to the equilibrium outcome of the one–period game.

These results are not very helpful, neither are they satisfactory. We would expect the equilibrium outcome of multi–period games to differ from single period games even though the horizon is finite. A way to avoid this problem is to assume that only one player can move in each period. It turns out that this reformulation of the game has a radical impact on the game's equilibrium outcome. In section 4.2 we explore this line of reasoning. Section 4.3 contains a discussion of the role of commitment in the interaction between the authorities and public sector institutions with particular emphasis on the local sector.

4.2 NUMERICAL COMPUTATION OF THE SUBGAME EQUILIBRIUM FOR AN ALTERNATING–MOVE GAME

In this section, we change the assumptions concerning the agents' moves. Instead of depicting the basic game as consisting of two moves in each period, we assume that both are able to make short–run commitments for two periods. The players move alternately. Hence, one of the players moves at the beginning of a period. The opponent moves in the next period, and so on. When working backwards, we are able to compute numerically the subgame perfect equilibrium of a long but finite game where the players move alternately. This game can be regarded as the finite game counterpart of infinite games where the players apply Markov strategies. The Markov equilibrium concept was introduced by Maskin & Tirole (87,88a,b) in a series of papers on oligopoly theory. We will argue that this equilibrium concept and its finite game counterpart reflect important aspects of the dynamic relationship between the agents.

In the real world, the agents' actions can be regarded as affected by two motives. When making their moves, the agents react to the other agents' decisions and at the same time seek to affect the future behaviour of the other agents. This dual nature of an agent's actions is not captured by the basic one–period games or by their multi–period extentions.

The Markov perfect equilibrium concept neatly incorporates these two motives guiding a player's strategy. Maskin & Tirole consider an infinite game where the two players move alternately. One player moves in each period. The innovation by Maskin & Tirole is that the players' strategy spaces are restricted so that a player's move in a period only depends on the opponent's last move. The players' strategies are therefore dynamic reaction functions. A Markov perfect equilibrium consists of dynamic reaction functions which are subgame perfect equilibrium strategies for both players. At each stage, an agent maximizes its discounted sum of one–period utilities, assuming that the opponent does the same at each move for the rest of the game.

The game decribed by Maskin & Tirole gives a realistic picture of the relationship between the authorities and public bureaus. The authorities' budget proposals depend on past actions taken by the bureaus. But the budget itself does also affect the bureaus' actions. Hence, the authorities set the budget partly to accomodate the bureaus' past moves and partly to affect the bureaus' future actions. The bureaus also act according to two motives. Partly, they react to the budget proposal, partly they try to influence future budgets.

For the local sector in Norway, the budget process is a never ending story. For a budget period, each party presents a number of proposals and counterproposals. The agents are adjusting to the present budget and preparing for the next simultaneously. Each move is partly intended to allocate resources today and partly meant to give signals which they hope will make the adversary behave more "friendly" in the future.

The reaction functions which form the Markov perfect equilibrium can only be found analytically when the agents' utility functions are of particularly simple forms. In chapter 7, we consider a variant of the basic game for which this is the case. In this chapter, we compute numerically the subgame perfect equilibrium for a long but finite game where the agents move alternately for our basic numerical utility functions (3.2') and (3.3'). The players only apply deterministic strategies.

We consider a finite game of alternating moves, as illustrated in figure 4.1. The last period is denoted period T. In the beginning of the last period, one of the agents, randomly chosen to be the bureau, sets effort, e_T. The players' one–period utilities in the last period depend on e_T and the last move of the sponsor, c_{T-1}. The bureau's optimal move is solely a function of c_{T-1}. The bureau's reaction function $e_T(c_{T-1})$ is identical to the bureau's static reaction function of the one–period game.

In the beginning of period T–1, the sponsor sets c_{T-1}. Its optimal move depends on e_{T-2}. The sponsor will take into account the bureau's reaction to its move, $e_T(c_{T-1})$. Hence, the sponsor's move depends both on the bureau's last move and on the bureau's reaction. The sponsor will set c_{T-1} to maximize its discounted sum of one–period utilities for period T–1 and T:

$$c_{T-1}(e_{T-2}) = \max_c U^1(c+e_{T-2}) - U^2(c) + \delta U^1(c+e_T(c)) - \delta U^2(c) \qquad (4.1)$$

In period T–2, the bureau's move depends on the sponsor's move in period T–3. The bureau sets e_{T-2} to maximize its discounted sum of one–period utilities for periods T–2, T–1 and T. By working backwards, we can find the players' optimal reaction functions for the whole finite game. At each stage, the player in the move maximizes its discounted sum of one–period utilities, taking into account both players' optimal reactions until the end of the game. As for the Markov perfect equilibrium concept, the subgame perfect equilibrium strategies of the players reflect the trade–off between accomodation and acting strategically.

The strategies of the subgame perfect equilibrium do only depend on the opponent's last move. However, contrary to what is the case for the Markov perfect equilibrium concept, we do not have to restrict the players' strategy space in order to achieve this result. Since the game is finite, the principle of optimization ensures that a player's optimal move solely depends on the opponent's last move and not on what happened more than one period ago.

If the reaction functions converge as we move backwards, it is reasonable to assume that they approach the dynamic reaction functions of a Markov perfect equilibrium. However, such a result has not been proved except for linear reaction functions (Maskin & Tirole (87)).

For our numerical calculations, we set the discount factor equal to 0.8 for each agent. We compute a pair of reaction functions, $c^*(e)$ and $e^*(c)$, so that the reaction functions $c_{T-j}(e_{T-j-1})$ and $e_{T-j+1}(c_{T-j})$, calculated in period T–j and T–j+1, converge towards $c^*(e)$ and $e^*(c)$ as j moves towards infinity. The long–run equilibrium solutions, c^* and e^* are given by:

$$c^*(e^*) = c^* \qquad (4.2)$$

$$e^*(c^*) = c^* \qquad (4.3)$$

The subgame perfect equilibrium solution, the Nash–Cournot solution and the Stackelberg solutions are given in table 4.1. Since the production function and the utility functions are symmetric, the subgame perfect equilibrium gives equal values for budget and effort.

We see that the subgame perfect solution for each variable is somewhere between the Nash–Cournot solution and the Stackelberg solution with the executor of each variable as leader. We will give an intuitive explanation of why the equilibrium values of both variables are below the value of the variables in Nash–Cournot solution. Consider the sponsor. At (c^N, e^N), the first derivative of the sponsor's one–period utility function with respect to grants is zero. The loss from a deviation is of the second order. A reduction in grants will increase the bureau's marginal utility of effort and induce it to increase effort in the next period. The sponsor's gain in the next period is therefore of the first order. Hence, the sponsor will want to reduce grants below c^N. A parallel argument is valid for the bureau.

Our results illustrate the dual motives guiding the players' strategies in the alternating–move game. In the Nash–Cournot game, both players' strategies are based on the perceived move of the opponent. Accomodation is the only motive of the player since its move is not observed by the opponent before the opponent makes its move. In the Stackelberg game, the leader's strategy depends on the follower's reaction function but not on what happened last period. When the players move alternately, a player's strategy depends both on the opponent's last move and on the opponent's reaction function. Hence, the player's strategies in the alternating–move game can be viewed as mixing elements from the Nash–Cournot game and one of the Stackelberg games.

In Carlsen & Haugen (91), we show that these results hold for more general utility functions. The relationship between the variables is as follows:

$$c^N > c^* > c^S \qquad (4.4)$$

$$e^N > e^* > e^S. \qquad (4.5)$$

From (4.4) and (4.5) we see that output is below the output level of the Nash–Cournot game. It is straightforward to see that both players are worse off in the alternate–move game than in the Nash–Cournot game. c^N is the sponsor's preferred choice when effort equals e^N. Since, $e^* < e^N$, the sponsor's one–period utility is maximized for a level of grants above c^N. We name the sponsor's optimal move, c'. Hence, the sponsor prefers (c',e^*) to (c^*,e^*). However, the outcome (c',e^*) is obviously worse for the sponsor than (c^N,e^N) since $e^* < e^N$. Thus, the sponsor's one–period utility is lower for (c^*,e^*) than for (c^N,e^N). A similar argument shows that also the bureau is worse off in the alternate–move game than in the Nash–Cournot game.

In Carlsen & Haugen (91), we show that the subgame perfect equilibrium solutions of grants and effort decrease as the discount factor increases. Hence, when the agents become more patient, the equilibrium outcome moves away from the Pareto–optimal contract curve. This conclusion is opposite to what we know about infinite supergames with simultaneous moves. In such supergames, the ability to sustain a cooperative outcome becomes better as the discount factor increases. The opponent is stopped from deviating by the threat of costly punishment if it deviates. When the agents care much about the future, the threat is effective in disciplining the agents. In the finite alternating–move game, patient players put more emphasis on affecting the opponent's future moves. Therefore, patient players will behave aggressively, causing the utility of both players to decline.

An important question is how an agent's utility is affected by a change in its discount factor provided the opponent's discount factor is constant. We have stated that an agent looses from an increase in the discount factor of both agents. However, in Carlsen & Haugen (91), we show that an agent will gain if its discount factor increases unilaterally (this conclusion is of course sensible only when the one–period utilities of agents with different discount factors are comparable). If the sponsor's discount factor is constant, an increase in the bureau's discount factor leads to lower effort and output and higher grants. An unilateral increase in the sponsor's discount factor leads to lower grants and output and higher effort. Being more patient induces an agent to apply a more aggressive strategy as seen by the opponent.

Suppose that there are two stages in the game between the agents. First, both agents take preparatory actions which affect their discount factors for the next stage. Such steps might be institutional reforms which influence the internal decision process of the agents. The next stage is the alternating–move game. Our results show that for each agent, it is a dominant strategy to implement reforms which induces it to behave patiently in the alternating–move game. The agents are therefore in a prisoners' dilemma situation. Although both have incentives to carry out reforms which increase their discount factors, they could gain by collectively abstaining from undertaking such reforms.

The results of this section parallel our conclusion in chapter 3 that the order of move of the game is important for the equilibrium outcome. The order of move of the game depends on the agents' ability to undertake commitments. Since the willingness to undertake commitments is closely related to the time preferences of an agent, the intuition captured by the model of section 4.2 is the same as in the basic game. Improving the ability to undertake commitments increases an agent's utility but does also move the equilibrium outcome away from the Pareto–optimal set.

4.3 DISCUSSION

We start the discussion by relating our analysis to the debate on rules and discretion in macroeconomic theory. Then, we discuss the ability of the authorities and the institutions to undertake commitments in real life.

Barro & Gordon (83a,b) study a model of stabilization policy where the macroeconomic performance of the country depends on the outcome of the interaction between the government and private sector agents. The government has incentives to increase the money supply unexpectedly to ride the Philips curve and achieve high employment due to low real wages. This is the first best solution. They further assume that the private agents anticipate the government's move. The private sector therefore sets wage demands high, which in turn forces the government to reflate. The outcome is low employment and high inflation, which Barro & Gordon denote the third best solution.

The second best solution is a tight monetary policy where the government announces a tight policy and is believed because it has not discretion to reflate. The second best solution gives low inflation and low employment. Barro & Gordon argue that the first best solution is not sustainable. The government can achieve the second best policy by refraining from discretionary policy. If the government wants flexibility, the outcome will be third best. The government should therefore let its hands be tied to achieve the second best policy.[1]

The analysis of Barro & Gordon has relevance for our model. The sponsor's preferred solution is to make the bureau believe that the budgets will be tight and then reflate afterwards. This policy is not sustainable because the outcome is not a subgame perfect equilibrium of a multi–period game. The second best policy for the sponsor in our basic model is to enforce the Stackelberg solution through the application of rules which commits the sponsor to a tight budgetary policy. For the game described in section 4.2, the second best policy recommended by Barro & Gordon corresponds to institutional reforms which make the sponsor more patient, thus bringing about a Stackelberg–like solution in the alternate–move game.

We now discuss the ability of the agents to undertake commitments. Public institutions do not make formal decisions about the effort level. The institutions' efficiency depends on a large number of conditions. Improvement of the efficiency of an organization requires a reorganization of the production which is often time–consuming. Hence, the effort level can only be changed slowly. Having an instrument variable which is inflexible, gives the institutions a strategic advantage. Threatening to maintain the present level of effort is a credible threat simply because it is not feasible to undertake major organizational changes in a short time.

As seen by the authorities, improving an institution's efficiency to some degree depends on the institution's willingness to obey the authorities' orders. Typically, the authorities and the institution disagree on whether new services should be covered by additional grants or by giving less attention to present activities. The institution often argues against giving less priority to present tasks in order to induce the authorities to grant additional funds. The credibility of the institution's stance can be enhanced by electing militant leaders or carrying out other institutional reforms which make obedience to the authorities less likely.

The policy of the authorities is the outcome of negotiations between a number of budget process participants. Undertaking a commitment implies that the budget policy can not be changed for some duration of time. That necessarily implies som kind of limitation on the budget participants' discretion. However, the budget process participants of the public sector will be sceptical to subordinate themselves to a common long–run policy.

As pointed out by Brennan & Buchanan (1985, pp. 75–79), an agreement on a durable policy requires each participant to believe that short–run sacrifice will pay off in the long run. But each agent knows that the other agents may have other motives for adhering to the common policy. Even though all budget participants agree on the first steps of the policy, they will probably disagree on how to proceed after the contracts have expired and on how to interpret the non–specified or non–verifiable parts of the bureaus' contracts. Hence, each agent in the political decision process is inclined to go for its preferred short–run alternative, making it unlikely that the participants will agree on which long–term policy to follow.

Long–run commitments imply that politicians have limited discretion to redistribute funds between bureaus in the short–run. Politicians will want to retain this discretion, partly to outdo other politicians in the popularity race, partly because flexibility is valuable when future needs cannot be assessed with certainty.

We have argued that the nature of the political decision process introduces a short–term bias which weakens the strategic position of the authorities. However, the authorities can carry out reforms which strengthen their position. First, the authorities can make their policy more credible by signing formal contracts which assign grants to the different institutions. To some degree, the authorities have power to undermine the intention of the contract ex post. A public bureau often performs multiple activities. If some activities are regulated through a contract and some activities are not, the authorities can obtain approximately the same outcome by increasing/decreasing revenues for nonregulated activities and permitting internal cross–subsidies as they would have done by explicitly breaching the contract. The scope for undertaking such unverifiable breaches of contracts is high in the public sectors which produce multi–dimensional output that is hard to define, e.g. in hospitals and schools, but lower in other sectors, such as transportation and culture.

Second, during the seventies and eighties, we have seen a large number of budget reforms which aim at making it harder for governments to increase public expenditures. These measures include setting ceilings on expenditures, for instance as a percentage of the national product, giving the Ministry of Finance more say in cabinet decisions and imposing outside expert influence on the government's budget (see Tarschys (85) for a survey). Such steps can interpreted within the context of our model. When the bureau moves first, it will cut effort to force the sponsor to increase grants. The reforms we have mentioned, can be viewed as measures which change the sponsor's reaction function by restricting the increase in grants for a given move by the bureau. If the public institutions perceive the reform to change the authorities' reaction to reductions in effort, they will change their behaviour. Our model predicts that public institutions will increase their efficiency when the reforms induce a lower growth rate in public expenditures. In other words, budget reforms can be viewed as responses by the authorities to mitigate the consequences of their own weak strategic position.

At the municipal level, political bodies often delegate substantial power to administrative officers. Norwegian counties/municipalities have given the Executive Officer a very strong position in the budget process. The political parties are careful not to change his/her budget proposals drastically. By giving power to an officer that does not have to worry about reelection, the politicians raise the credibility of the local authorities.[2]

The credibility of the budget policy depends on the financial situation of the authorities. The institutions would probably be convinced that there was no more money for them if the shape of the nation's and/or public finances were such that big increases in spending is out of the question. The empirical studies we referred to in chapter 3, showed that public sector efficiency seems to increase when a country is running a deficit on the current account. The country's deficit gives a tough policy more credibility.

The credibility of the local authorities is affected by federal regulations. If the federal authorities set limits on the local authorities' tax revenues and regulate their opportunity to finance spending with loans, the local authorities have limited discretion to decide on the level of expenditures. Tight regulations restrict the authorities' freedom to allocate resources and represent in that respect a welfare loss for society. However, regulations can be advantageous for local authorities because they improve the strategic position of the authorities in the negotations with their institutions. Federal regulations can help local politicians convince schools and hospitals that efficiency is the only road to higher output.

The degree of freedom of the local authorities varies between the European countries.[3] In some European countries, the municipalities have freedom to set the tax rates. In other countries, they can not influence their revenues. The fiscal freedom of the local sector depends on the income–elasticity of their revenues. Progressive income taxes are often very elastic because taxpayers move into higher tax brackets as the general income level rises. When the general income level increases, the municipalities will receive higher revenues. Property taxes are inelastic and provide the local sector with little financial freedom. Kristensen (87) provides evidence that the local sector increases expenditures faster if its revenues are income–elastic.

In most countries, the federal government tries to control the expenditure level of local authorities, even in countries where the local sector in principle has fiscal freedom.[4] Generally, the government's justification for its interference has been concern about employment, inflation or the current account, not to improve the credibility of a tough policy versus the local sector institutions. The conservative government in UK can be said to represent an exception.[5]

The lack of discretion to set taxes is clearly enhancing the credibility of Norwegian counties/municipalities[6]. However, the local authorities still have discretion to decide on the level of expenditures. They can set the revenue forecasts unrealistically high and thus run an operating deficit, or they can finance investments with loans, which is legal. The regulation of the debt policy of the counties/municipalites has been lax. Neither has the federal government tried to restrict the annual increases in expenditures[7].

We have argued that an active policy by the state will help the local authorities to resist pressure from the institutions. However, the argument can also be turned the other way around. If the state accepts the responsibility for the economy of the municipalities, the institutions and the local authorities will be united as an agent in the game with the state. Low efficiency will increase the pressure on the state and improve the strategic situation of the institutions / local authorities versus the state. It is therefore not obvious that interventions from the state encourage the efficiency of the local sector institutions.[8]

This ambiguity is clearly present for the question of whether federal transfers to the local sector should be earmarked or not. Earmarked transfers reduce the discretion of the local authorities and are therefore very unpopular among local sector politicians. The transfer system of 1986 reduced the number of earmarked grants substantially. Today, most of the transfers are bloc grants. The new system gives more scope for lobbying by the institutions directed at the municipalities, but less scope for exerting strategic pressure upon the federal authorities.[9]

Conclusion

The multi–period models we have presented, do not change the main conclusion of chapter 3, that the agents' ability to undertake long–term commitments is crucial to the equilibrium outcome of the game. We have discussed whether the agents can formulate and sustain a long–run policy in practice. While institutions can only change their policy variable gradually, the authorities formally can change the budget of the institutions much faster. However, the authorities can undertake measures to increase the credibility of a tight budgetary policy. In many European countries including Norway, the bulk of the production of public services takes place in the local sector. Hence, federal regulations of the local sector affect the ability of the authorities to pursue a consistent, long–run budget policy.

ENDNOTES

[1]The articles by Barro & Gordon (83a,b) and Kydland & Prescott (77) have inspired Europeans to study macroeconomic policy as a game between the government and the trade unions (Calmfors & Horn (85,86) and Hersoug (85)). In the European setting, the government uses policy instruments to change the unions' policy.

[2]This argument is parallel to the argument in the literature on stabilization policy that the money supply should be controlled by a "conservative" central banker whose decisions cannot be overruled by the government (Rogoff (85)).

[3]Sharpe (81), pp. 7–9 gives an outline of the central government's control with local finances in some European countries. The most restrictive policy is found in the UK, Irland, Austria, Belgium, France and the Netherlands. Switzerland, Denmark and Sweden have a liberal policy where the local authorities can decide on the level of the income taxes. The author claims that Norway is in a middle position. The municipal sector gets its revenues from income taxes but has not discretion to increase the tax rates. Every county and municipality in Norway apply the highest legal tax rate (NOU 88:38).

[4]In Denmark, the federal authorities have used a variety of instruments during the eighties to restrict local sector spending. These efforts include fees on expenditures and limits on the tax rates (Schou (87), pp. 17–23, and Bogason (87)). In Sweden, the government negotiates with the municipalities' organization about annual increase in expenditures (Brunsson & Rombach (82), pp. 9–24, and Lane & Magnussen (87)).

[5]The Thatcher government has argued ideologically that public spending should be restrained to allow for an expansion of the private sector and has imposed very detailed regulations on the local sector. A discussion of the effect of the Thatcher government policy on the efficiency of public institutions is given by Levitt & Joyce (87), pp. 29–30. A survey of the Thatcher government's regulations of the local sector is provided by Ascher (87), pp. 213.

[6]Brunsson (86), pp. 172 reports from a study of a Swedish municipality with big financial problems. Its institutions were asked to provide the output with less input to save money. However, the municipality's administration was unable to put forward proposals that were accepted by the political bodies. Instead, taxes were increased.

[7]The counties' budgets must be approved by the central authorities. Even though the regulation of the local investment policy has been very lax, the Executive Officer of Sør–Trøndelag County frequently uses the federal regulations as an argument against higher expenditures.

[8]Discussions of the strategic game between the state and the local sector in Norway are given by Sørensen (87,89) and Hansen & Sørensen (88).

[9]The idea that earmarked revenues reduce waste is put forward by Brennan & Buchanan (78).

REFERENCES

Ascher, K. 1987: The Politics of Privatization, MacMillan, London.

Barro, R. & Gordon, D. 1983a: A Positive Theory of Monetary Policy in a Natural Rate Model, Journal of Political Economy 91, 589–610.

Barro, R. & Gordon, D. 1983b: Rules, Discretion and Reputation in a Model of Monetary Policy, Journal of Monetary Economics 12, 101–122.

Bogason, P. 1987: Denmark, in Page, E. & Goldsmith, M. (ed): Central and Local Government Relations, SAGE Publications.

Brennan, G. & Buchanan, J. 1978: Tax Instruments as a Constraint on the Disposition on Public Expenditures, Journal of Public Economics 9, 301–318.

Brennan, G. & Buchanan, J. 1985: The Reason of Rules, Cambridge University Press.

Brunsson, N. 1986: Organizing for Inconsistencies: On Organizational Conflict, Depression and Hypocricy as Substitutes for Action, Scandinavian Journal of Management Studies, 165–185.

Brunsson, N. & Rombach, B. 1982: Går det att spare?, Doxa, Lund.

Calmfors, L. & Horn, H. 1985: Classical Unemployment, Accomodation Policies and the Adjustment of Real Wages, Scandinavian Journal of Economics 87, 234–261.

Calmfors, L. & Horn, H. 1986: Employment Policies and Centralized Wage–setting, Economica 53, 281–302.

Carlsen, F. & Haugen, K. 1991: Numerical Computation of Subgame Perfect Equilibria in a Game Between a Sponsor and a Bureau, mimeograph, Department of Economics, University of Trondheim.

Fudenberg, D. & Maskin, E. 1986: The Folk Theorem in Repeated Games with Discounting and with Incomplete Information, Econometrica 54, 533–554.

Hansen, T. & Sørensen, R. 1989: The Growth of Local Government in Norway, mimeograph, Inst for statsvitenskap, Universitetet i Oslo.

Hersoug, T. 1985: Workers Versus Government, Who Adjusts to Whom, Scandinavian Journal of Economics 87, 270–292.

King, D. 1984: Fiscal Tiers: The Economics of Multi–Level Government, George Allen & Unwin, London.

Kristensen, O. 1987: Væksten i den offentlige sector. Institusjoner og politik, Jurist– og økonomforbundets forlag, København.

Kydland, F. & Prescott, E. 1977: Rules Rather than Discretion: The Inconsistency of Optimal Plans, Journal of Political Economy 85, 473–495.

Lane, J. & Magnussen, T. 1987: Sweden, in Page, E. & Goldsmith, M. (ed): Central and Local Government Relations, SAGE Publications.

Levitt, M. & Joyce, M. 1987: The Growth and Efficiency of Public Spending, Cambridge University Press, New York.

Maskin, E. & Tirole, J. 1987: A Theory of Dynamic Oligopoly, III: Cournot Competition, European Economic Review 31, 947–968.

Maskin, E. & Tirole, J. 1988a: A Theory of Dynamic Oligopoly, I: Overview and Quantity Competition with Large Fixed Costs, Econometrica 56, 549–569.

Maskin, E. & Tirole, J. 1988b: A Theory of Dynamic Oligopoly, II: Competition, Kinked Demand Curves and Edgeworth Cycles, Econometrica 56, 571–599.

NOU 88:38 Nye mål og retningslinjer for reformer i lokalforvaltningen

Rogoff, K. 1985: The Optimal Degree of Commitment to an Intermediate Monetary Target, Quarterly Journal of Economics 100, 1169–1189.

Schou, B. 1988: Frihed under ansvar, COS forskningsrapport 2/1988, Center for offentlig organisation og Styring, Handelshøyskolen i København, København.

Sharpe, L. 1981: Is There a Fiscal Crisis in Westerm European Local Government? A First Appraisal. In Sharpe, L. (ed): The Local Fiscal Crisis in Western Europe, Sage Publications.

Sørensen, R. 1987: Spillet mellom stat og kommune: Finansieringssystem og styringsproblemer, Norsk Statsvitenskapelig Tidsskrift 1, 65–81.

Sørensen, R. 1989: Financial Control of Local Government, paper presented at the ECPR Joint Session, Workshop in "The Politics of Finance: Financial Decision–Making in Western European Governments" Paris april 89, Bedriftsøkonomisk Institutt, Sandvika.

Tarschys, D. 1985: Curbing Public Expenditures: Current Trends, Journal of Public Policy 5, 23–67.

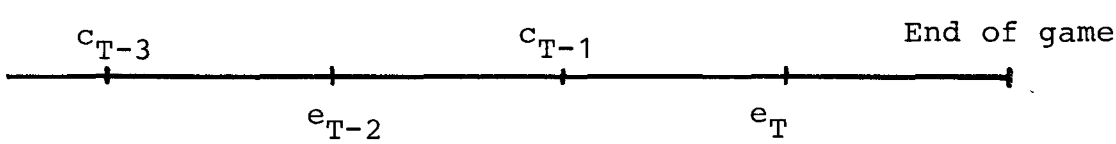

Figure 4.1: The end of the finite game with alternating moves.

	Budget	Effort	Output
Nash-Cournot	1.00	1.00	2.00
Stackelberg sponsor	0.69	1.11	1.80
Stackelberg Bureau	1.11	0.69	1.80
Subgame perfect solution	0.95	0.95	1.90

Table 4.1: The subgame perfect solution of the long, finite game compared with the solutions of the basic one-period games

CHAPTER 5

ONE–PERIOD GAMES WITH OUTPUT UNCERTAINTY

5.1 INTRODUCTION

So far, we have assumed that the interaction between bureau and sponsor takes place under full certainty. This assumption is unrealistic. There will be many dimensions of uncertainty to consider even if the game is played only once.

There are several ways to categorize the different types of uncertainty. It is convenient to start with the basic model, (3.1) – (3.3), and interpret types of uncertainty as incomplete information about the variables and functions of the model. We divide uncertainty into three types, which we name output uncertainty, cost uncertainty and preference uncertainty. We discuss them in turn.

When there is output uncertainty, grants and effort can be observed while output can not. Information about grants and effort is not sufficient to infer output. Effort is not verifiable. Causes of output uncertainty include incomplete knowledge about the true demand for services and the presence of complex, multi–dimensional products. We would expect output uncertainty to be particularly prevalent in the health sector. The product of an health institution, "the health status of the area's population", is very difficult to measure. Even though the authorities can observe an institution's actions, it is hard to assess the impact of these actions on the quality and volume of the institution's true output.

The consequences of output uncertainty depends on when the uncertainty is resolved and how quickly the production decisions can be adjusted. The current demand for services is observable for the institution while future demand is uncertain. How the uncertainty affects the institution's behaviour depends on its production technology and the precision with which the institution can predict future demand. If the production can be adjusted both cheaply and instantaneously, uncertainty matters less than when the production capacity must be planned long before production takes place.

The second category of uncertainty is cost uncertainty. Output and grants can be observed, but not effort. Cost uncertainty is present when the product is well defined but where the production process is highly complex. Costs per unit output can be measured, but it is difficult to assess how efficient the bureau is. The amount of slack can not be observed. Cost uncertainty is present for a variety of public services where the authorities are able to evaluate the output of the institutions but not whether output is efficiently produced.

Uncertainty about preferences is present when an agent does not know the true utility function of the other agent. The institutions have incomplete knowledge about the authorities' utility for different products. Neither do the institutions have complete information about the financial situation of the authorities, and they are therefore uncertain about the authorities' readiness to expand public expenditures. The authorities do not know the institutions' preferences about the composition and volume of services.

It follows from the discussion that we distinguish between uncertainty about the production function and uncertainty concerning the preferences of the agents. Uncertainty about the production function is either output uncertainty when output can not be observed, or cost uncertainty when effort is unobservable.

The three types of uncertainty are treated in three different chapters. In this chapter, we focus on output uncertainty. We extend the basic noncooperative one–period games of chapter 3 by assuming that one or both agents do not know the true production function. In chapter 6, we deal with uncertainty about the agents' preferences. When an agent's preferences are private information, the agent has incentives to hide its true preferences to gain a reputation for toughness. In chapter 6, we compute equilibria in multi–period games with reputation building. In chapter 8, we consider optimal schemes when output can be observed by the authorities but effort can not. In all three cases, the information structure is common knowledge. Both agents know whether the other agent has private information.

Formally, we write the production function in the same way for output and cost uncertainty. What differs is the interpretation concerning which parts of the production function that are observable.

$$Q = c + e + \varphi \qquad (5.1)$$

φ is a stochastic variable with probability density $f(\varphi)$. The sponsor and the bureau agrees on the probability function; the probability beliefs are homogenous. For most of the models, including the models of this chapter, we will apply a simplified density function, where φ can take one of two values, $\pm\,\theta$:

$$f(\theta) = 0.5 \qquad (5.2)$$

$$f(-\theta) = 0.5 \qquad (5.3)$$

With (5.2) – (5.3), the production function is:

$$Q = c + e \pm \theta \quad , \theta > 0 \qquad (5.4)$$

We will use the terms "favourable" and "unfavourable" to characterize the two possible realizations of the production function. When the production function is unfavourable ($\varphi = -\theta$), the utility of a given level of grants and effort is low compared to the situation where the production function is favourable. The marginal utility of output will be high when the production function is unfavourable. This follows from assumptions A1 and A3. We will also refer to the two production functions as reflecting "high demand" ($-\theta$) and "low demand " ($+\theta$).[1]

The next question concerns the information sets of the sponsor and the bureau when there is output uncertainty. Since the bureau is the agent that produces the services, it is reasonable to assume that it has more information about output than the sponsor. However, the bureau must also make many production decisions without complete knowledge about the relevant factors which make output valuable, for instance future demand. We will consider two different information structures. In case A, both grants and effort are set under uncertainty. Neither the sponsor nor the bureau knows the true production function when they make their moves. In case B, the bureau has private information about the production function. Grants are set under uncertainty while effort is not. In sections 5.2–5.4, we explore the equilibrium outcomes of the three basic games for both assumptions concerning the information structure of the games. Hence, we compute six different equilibrium outcomes.

For all but one of these six games, the relevant equilibrium concept is the Bayesian equilibrium concept and the equilibrium outcome is easily found. The equilibrium outcome will be close to the outcome of the corresponding one–period game with certainty. However, when the bureau moves first and has private information, the nature of the game changes. The interaction will now be a signalling game. Since effort is observable, and the bureau knows φ when it moves, the sponsor may infer information about the true production function from the bureau's move. Hence, we must use the perfect Bayesian equilibrium concept to find an equilibrium solution. Signalling games generally have a plethora of perfect equilibria. By applying the "intuitive criterion", developed by Cho & Kreps (87), we are able to eliminate all but one equilibrium solution.

Elections represent a special kind of uncertainty. The bureau does not know whether the present political party/coalition will continue to control the sponsor after the election.

Even if the bureau knows the preferences of the present sponsor, it has not complete information about the sponsor's future preferences. When the sponsor is a political organization, for instance a government, the sponsor's preferences in the future depends crucially on the outcome of forthcoming elections. In section 5.5, we show that this kind of uncertainty yields effort and output levels which vary over time. Finally, we relate the model to some business cycle theories.

When the bureau knows the true production function, we denote the corresponding equilibrium values, e^H and e^L, when the production function is unfavourable and favourable, respectively.

For given grants and effort, average output will be independent of θ, but the variance of output will increase with increasing θ. By varying θ, we can explore how the equilibrium solutions are affected by a mean–preserving increase of the variance of the output level. For most of the models, we will study the effects from marginal increases in θ above zero. The utility functions of the agents can therefore be Taylor–expanded around the equilibrium solution for the corresponding game without output uncertainty. We denote the latter equilibrium outcome the certainty solution.

We have to make an important assumption regarding the utility functions of the agents. So far, the concept of rationality has implied that the agents maximize their utility functions. We will assume that the relevant utility functions still are (3.2) – (3.3) and (3.2') – (3.3'). They represent von Neumann – Morgenstern cardinal utility functions. The agents will make choices that maximize their expected utility. The utility functions are concave in output. This implies that both agents are risk averse with respect to output.[2]

To distinguish between the derivatives of the utility functions at the high demand and low demand states, respectively, we use the following notation for the bureau:

$$V^1_{QH} = \partial V^1(c+e-\theta)/\partial Q$$

$$V^1_{QL} = \partial V^1(c+e+\theta)/\partial Q$$

$$V^1_{QQH} = \partial^2 V^1(c+e-\theta)/\partial Q^2$$

$$V^1_{QQL} = \partial^2 V^1(c+e+\theta)/\partial Q^2$$

$V^1_Q = \partial V^1(c+e)/\partial Q \quad V^1_{QQ} = \partial^2 V^1(c+e)/\partial Q^2$

A parallel notation is used for the sponsor.

The sign of the third derivatives of $U^1(Q)$ and $V^1(Q)$ expresses whether the marginal utility of output is concave or convex in output. In chapter 5, we will assume that the marginal utility of output is concave in output. Hence, the third derivatives of $U^1(Q)$ and $V^1(Q)$ are positive. This assumption implies that a mean–preserving increase in the variance of output increases the average marginal utility of output. We also assume that the disutility of grants/effort has zero third derivatives. Both assumptions are true for the numerical utility functions (3.2') – (3.3').

A7: $U^1_{QQQ} > 0$

A8: $V^1_{QQQ} > 0$

A9: $U^2_{ccc} = 0$

A10: $V^2_{eee} = 0$

A positive third derivative is a necessary but not a sufficient condition for utility functions to exhibit decreasing absolute risk aversion (DARA) (Fishburn & Vickson (78)). Examples of utility functions for which the third derivatives are positive, are ln (Q), $-e^{-Q}$ and Q^{γ}, $\gamma < 1$. Assumptions A9 – A10 hold for quadratic utility functions.

5.2 THE NASH–COURNOT GAME

First, we compute the Bayesian equilibrium solution when both players set their instrument variables under uncertainty. Then, we allow the bureau to have private information about the true production function.

<u>A. Grants and effort are set under uncertainty</u>

Both set their instrument variable to maximize expected utility:

$$c^* = \text{argmax}_c\ 0.5\Big[\ U^1(c+e+\theta) + U^1(c+e-\theta)\ \Big] - U^2(c) \qquad (5.5)$$

$$e^* = \text{argmax}_e\ 0.5\Big[\ V^1(c+e+\theta) + V^1(c+e-\theta)\ \Big] - V^2(e) \qquad (5.6)$$

F.O.C:

$$\text{c:}\quad 0.5\ U^1_Q\ (c^*+e^*+\theta) + 0.5\ U^1_Q\ (c^*+e^*-\theta) - U^2_c\ (c^*) = 0 \qquad (5.7)$$

$$\text{e:}\quad 0.5\ V^1_Q\ (c^*+e^*+\theta) + 0.5\ V^1_Q\ (c^*+e^*-\theta) - V^2_e\ (e^*) = 0 \qquad (5.8)$$

PROPOSITION 5.1: When both agents set their instrument variables under uncertainty in a Nash–Cournot game, grants and effort may be higher or lower compared to the Nash–Cournot solution under certainty. The expected equilibrium output will be higher than the equilibrium output under certainty.

The proof is given in the chapter's appendix.

Uncertainty will affect the agents' behaviour in two ways. First, since the players' expected marginal benefit of output is raised, both agents will want to increase their instrument variables. Second, each agent anticipates that the opponent will contribute more to output due to the presence of uncertainty. This provides an incentive for lower grants/efforts. If one of the agents is particularly sensitive to uncertainty, it may well be that only that agent's instrument variable goes up while the variable of the other agent decreases. However, expected output will always increase.

We apply (3.2') – (3.3') in the first order conditions (5.7) – (5.8):

$$0.5/(c^*+e^*+\theta) + 0.5/(c^*+e^*-\theta) = c^*/2 \qquad (5.7')$$

$$0.5/(c^*+e^*+\theta) + 0.5/(c^*+e^*-\theta) = e^*/2 \qquad (5.8')$$

(5.7') – (5.8') for $\theta = 0.1$ yield:

$$c^* = e^* = 1.0010 \quad E(U) = E(V) = 0.4425 \qquad (5.9)$$

Due to the symmetric utility functions, both will increase their instrument variables to the same extent. The expected utility of both agents will be smaller than under certainty.

B. Grants are set under uncertainty

c^*, e^L, e^H – the equilibrium solution when only the sponsor sets grants under uncertainty

The bureau knows the true production function as effort is set. The Bayesian equilibrium of the Nash–Cournot game is given by maximization of the expected utility of the sponsor and the utility of the bureau for the two alternative states of nature:

$$e^H = \text{argmax}_e \, V^1(c^*+e-\theta) - V^2(e) \qquad (5.10)$$

$$e^L = \text{argmax}_e \, V^1(c^*+e+\theta) - V^2(e) \qquad (5.11)$$

$$c^* = \text{argmax}_c \, 0.5\left[U^1(c+e^L+\theta) + U^1(c+e^H-\theta) \right] - U^2(c) \qquad (5.12)$$

F.O.C:

$$e^H: V_Q^1(c^*+e^H-\theta) - V_e^2(e^H) = 0 \qquad (5.13)$$

$$e^L: V_Q^1(c^*+e^L+\theta) - V_e^2(e^L) = 0 \qquad (5.14)$$

$$c^*: 0.5\left[U_Q^1(c^*+e^L+\theta) + U_Q^1(c^*+e^H-\theta) \right] - U_c^2(c^*) = 0 \qquad (5.15)$$

A full comparative statics analysis of (5.13) – (5.15) gives us proposition 5.2:

PROPOSITION 5.2: When grants are set under uncertainty in the Nash–Cournot game, grants and effort may be higher or lower compared to the equilibrium solution under certainty. The expected equilibrium output will be higher than the equilibrium output under certainty.

The proof is given in the chapter's appendix.

We insert the numerical utility functions (3.2') – (3.3') in (5.13) – (5.15) to compute the new equilibrium solution. The first order conditions are:

$$1/(c^{*}+e^{H}-\theta) = e^{H}/2 \qquad (5.13')$$

$$1/(c^{*}+e^{L}+\theta) = e^{L}/2 \qquad (5.14')$$

$$0.5/(c^{*}+e^{L}+\theta) + 0.5/(c^{*}+e^{H}-\theta) = c^{*}/2 \qquad (5.15')$$

For $\theta = 0.1$, the solution to (5.13') – (5.15') is:

$c^{*} = 1.0006$ $e^{L} = 0.9672$ $e^{H} = 1.0339$ $E(e) = 1.0006$ $E(U) = 0.4429$ $E(V) = 0.4426$
(5.16)

Compared to the setting where both instrument variables are set under uncertainty, both variables will decrease on average. Average output will therefore also decrease. The bureau will use its flexibility to smooth some of the variation in output. This causes the expected utility of the bureau to be less than the expected utility of the sponsor. However, the bureau's expected utility is higher than for case A. Compared to case A, the bureau gains from being more flexible, but the sponsor gains even more from the bureau's flexibility. Grants will go down compared to case A because the sponsor can trust the bureau to smooth output. Expected effort also decreases due to the bureau's discretion to set effort in each period.

5.3 THE SPONSOR MOVES FIRST

A. Grants and effort are set under uncertainty

First, we consider the setting where the sponsor moves first and both must set their instrument variables before the true production function is known. We show in the appendix that we cannot say for sure what the effect of uncertainty will be on the equilibrium solution:

PROPOSITION 5.3: When both agents set their instrument variables under uncertainty, the equilibrium may yield higher or lower grants, effort and output compared to the Stackelberg–solution under certainty.

As for the Nash–Cournot game, uncertainty affects the sponsor in two ways which pull the level of grants in different directions. Because of the form of the production function, uncertainty will increase the average gain from additional grants. However, from the point of view of the bureau, the marginal benefit of effort will increase for the same reason. Increased effort leads to lower grants.

There is also a third effect, which we can call the strategic effect. The incentives of the sponsor to cut grants strategically depends on e_c, which again is a function of θ. However, as shown in the appendix, variations in θ cause a change in e_c of the second order. Therefore, a small increase in θ above zero will only have a minor effect on the sponsor's incentives to cut its budget strategically.

We can therefore conclude that the intuition of the equilibrium solution is the same as for the Nash–Cournot game. We can not say whether uncertainty will increase or decrease grants and effort. Contrary to what we found in section 5.2, we can not draw any conclusions about the direction of the change in output.

We compute the first order conditions for the equilibrium for the numerical utility functions. The first order condition of the bureau is:

$$0.5/(c+e+\theta) + 0.5/(c+e-\theta) = e/2 \qquad (5.17)$$

The bureau's reaction function, e(c) follows from (5.18). The derivative of the static reaction function is:

$$e_c(c) = 1/c_e(e) \ , \ c_e(e) = \theta^2/\mathrm{sqrt}(1+e^2\theta^2) - \mathrm{sqrt}(1+e^2\theta^2)/e^2 - 1/e^2 - 1 \quad (5.18)$$

The first order condition of the sponsor is:

$$(0.5/(c^*+e^*+\theta) + 0.5/(c^*+e^*-\theta))(1+e_c(c)) = c/2 \qquad (5.19)$$

The numerical equilibrium solution is obtained when we set $c = c^*$, $e = e^*$ and $\theta = 0.1$ in (5.17) – (5.19):

$c^{*} = 0.6866$ $e^{*} = 1.1141$ $E(Q) = 1.8007$ $E(U) = 0.4688$ $E(V) = 0.2764$ (5.20)

Grants are decreased, and effort is increased compared to the game with no uncertainty. Expected output increases. Hence, the second of the two effects on the sponsor dominates for our numerical utility functions. The expected utility of both agents decreases when uncertainty is introduced.

B. Grants are set under uncertainty

PROPOSITION 5.4: In a one–period game where the sponsor moves first and the bureau knows the correct production function, grants will be lower and expected effort higher than under certainty. The effect on expected output is ambiguous.

The proof is given in the appendix.

The bureau's information monopoly makes it weaker as seen by the sponsor. The sponsor knows that the bureau will increase effort when demand is high. Therefore, the argument in favour of higher grants no longer bites. The sponsor will cut the budget more than under certainty, knowing that the bureau will increase effort extra when the production function is unfavourable.

The general expression for the equilibrium solution when we apply the numerical utility functions (3.2') – (3.3') and set $\theta = 0.1$ is computed in the appendix.

$c^{*} = 0.6868$ $e^{L} = 1.0745$ $e^{H} = 1.1509$ $E(e) = 1.1127$ $E(Q) = 1.7995$ (5.21)

The overall impression from sections 5.2–5.3 is that uncertainty has a small effect on the resulting equilibrium. The major conclusions of chapter 3 are still valid. The numerical values of the effort level of the equilibrium solutions are not significantly affected. It turns out that this is no longer true when we move to the last setting, where the bureau moves first.

5.4 THE BUREAU MOVES FIRST

When neither of the agents has information about the correct production function and the separating, the low–demand bureau will set effort equal to e_*^L. Therefore, we can conclude that the unique equilibrium outcome is the separating equilibrium where the low–demand bureau plays e_*^L and the high–demand bureau sets e^H so that the low–demand bureau is indifferent betwen e_*^L and e^H.[3]

We are now ready to state the equilibrium conditions. Let:

$c^j(e)$, $j = H,L$ – the sponsor's optimal choice of grants if it believes that the true state of nature is j. The choice of grants depends on the bureau's effort level.

Consider first the situation where the production function is favourable (demand is low). The bureau always sets effort as if there were common knowledge about the production function.

$$e^L = \operatorname{argmax}_e V^1(c^L(e)+e+\theta) - V^2(e) \qquad (5.22)$$

$$c^L(e) = \operatorname{argmax}_c U^1(c+e+\theta) - U^2(c) \qquad (5.23)$$

(5.22) – (5.23) yield $e^L = e_*^L$ as the outcome.

The strategy of the high–demand bureau depends on the size of θ. When θ is sufficiently large, none of the bureaus will want to deviate from the perfect information solution. In that case, the outcome is the same as in the perfect information game for the high–demand bureau and $e^H = e_*^H$.

$$e^H = \operatorname{argmax}_e V^1(c^H(e)+e-\theta) - V^2(e) \qquad (5.24)$$

$$c^H(e) = \operatorname{argmax}_c U^1(c+e-\theta) - U^2(c) \qquad (5.25)$$

When θ is lowered, we will reach a step value where the low–demand bureau prefers to play e_*^H rather than e_*^L in order to benefit from higher grants. However, the high–demand bureau will increase e^H to stop the low–bureau from pooling. The unique separating equilibrium solution will now be given by the conditions:

$$e^L = \text{argmax}_e \; V^1(c^L(e)+e+\theta) - V^2(e) \qquad (5.26)$$

$$c^L(e) = \text{argmax}_c \; U^1(c+e+\theta) - U^2(c) \qquad (5.27)$$

$$V^1(c^L(e^L)+e^L+\theta) - V^2(e^L) = V^1(c^H(e^H)+e^H+\theta) - V^2(e^H) \qquad (5.28)$$

$$c^H(e) = \text{argmax}_c \; U^1(c+e-\theta) - U^2(c) \qquad (5.29)$$

(5.26) – (5.29) constitute the equilibrium solution when the perfect information solution is not sustainable. It turns out that the perfect information solution is not sustainable for $\theta = 0.1$. By inserting the numerical utility functions in (5.26) – (5.29) and letting $\theta = 0.1$, we find that:

$$e^L = 0.6816 \;\; e^H = 1.0233 \;\; E(e) = 0.8524 \;\; c^H = 1.0260 \;\; c^L = 1.0764 \;\; E(c) = 1.0512$$
$$E(Q) = 1.9036 \;\; E(U) = 0.3770 \;\; E(V) = 0.4545 \qquad (5.30)$$

From (5.29), we see that the average equilibrium effort level is considerably higher for setting B than for setting A and for the basic Stackelberg game without output uncertainty. Average output will also be increased. This is due to the signal effect of the bureau's move. A low effort level signals that times are good and causes the sponsor to decrease grants. In order to communicate the true state of nature to the sponsor, the bureau will raise effort in bad times. The bureau's expected utility is decreased compared to case A.

Whether expected effort will be higher than in the game where the sponsor knows the true production function, depends on the type of solution. When θ is sufficiently high, the low–demand bureau does not want to deviate from the full information equilibrium because the costs of deviating exceed the gains from receiving higher grants. In this case, the outcome of the two games will not differ. When θ is small, private information matters. A small difference between the two production functions implies that e_*^H and e_*^L are close to each other. Hence, the costs of deviation will be small compared to the benefits. Therefore, a small difference in the production function combined with private information for the bureau lead to a separating equilibrium where expected effort is high compared to the game where the sponsor knows the true production function.

This result is what Gal–Or (87) denotes the "first–mover–disadvantage". Gal–Or models a two–stage game between two firms, where the leader has private information concerning the true demand for the firms' goods. The leader's move gives the second firm information concerning the true state of nature. Gal–Or shows that private information is disadvantageous to the leading firm due to the effect we have discussed.

The sponsor's move is relatively independent of the bureau's move. Either the sponsor believes that the production function is favourable while observing that the effort level is low, or the sponsor observes that the effort level is high and believes that the production function is unfavourable. The two factors tend to balance each other and cause the sponsor's move to be relatively independent of the bureau's move. When the sponsor's move is insensitive to the bureau's move, the scope for strategic cuts in effort are smaller and the average equilibrium values of grants and effort will be closer to the Nash–Cournot solution.

Table 5.1 summarizes the numerical results for the six games which have been dealt with in 5.2–5.4. We also list the equilibrium solutions of the corresponding games without output uncertainty. Except for setting B when the bureau moves first, there are only minor deviations from the equilibria of the basic games under certainty. We have also found that output uncertainty causes the average effort and output level to increase. Our results should be interpreted with causion as we have mainly studied the effects of small deviations from certainty.

5.5 VARIATIONS IN EFFORT LEVEL DUE TO ELECTIONS

Elections represent extrinsic uncertainty for the public sector institutions. The political parties have different preferences concerning the level of public expenditures. The future budget levels depend on the outcomes of future elections. If it takes time to adjust the institutions' effort levels, the equilibrium outcome will depend on whether there is a forthcoming election or not. When an election is just around the corner, the effort level for the next period must be set by the institution under uncertainty concerning the authorities' preferences.

The effects of the uncertainty depend on how fast the new administration can change the budget. If it takes longer time for the sponsor to change the budget than for the institution to change the effort level, the presence of output uncertainty will not affect the institution's choice of effort.

Here, we will make the assumption that budgets can be changed immediately but that the effort level must be set for a budget period. The election takes place at the beginning of a budget period. There are two political parties with different utility functions which compete to gain control of the sponsor. The two parties are named "tough" and "soft", respectively. The winning party sets the budget level after the election but cannot observe the effort level of the bureau. Therefore, the bureau can not set the effort level strategically to affect the behaviour of the winning party. We apply the noncooperative one–period Bayesian–equilibrium concept for the budget period which starts with an election. Outside the election period, the equilibrium outcome equals the Nash–Cournot solution. The equilibrium outcome for a budget period can be one of four, which we will label from 1 to 4:

1: There is no election and the tough party is in office

2: There is no election and the soft party is in office

3: There is an election and the tough parti wins

4: There is an election and the soft party wins

We will compute the equilibrium outcomes for the four possible situations. Let:

π , $0 < \pi < 1$ – the bureau's probability belief that the tough party will win if there is an election

c^t, e^t, Q^t – equilibrium outcome for setting 1, tough party in office

c^s, e^s, Q^s – equilibrium outcome for setting 2, soft party in office

c_e^t, e_e, Q_e^t – equilibrium outcome for setting 3, tough party wins election

c_e^s, e_e, Q_e^s – equilibrium outcome for setting 4, soft party wins election

Since the bureau sets effort before it knows the result of the election, the equilibrium effort levels of settings 3 and 4 are equal. Let:

$U^t = U^1(Q) - U^2(c)$ – the utility function of the tough party

$U^s = U^1(Q) - U^2(\alpha c)$, $0 < \alpha < 1$ – the utility function of the soft party

$V = V^1(Q) - V^2(e)$ – the utility function of the bureau

The utility functions of the tough party and the bureau are the same as we have applied for the sponsor and the bureau earlier. Since $\alpha < 1$, the soft party is relatively more inclined to increase public expenditures than the tough party. The sponsor's utility function is equal to the utility function of the victorious party for the budget period after the election and otherwise equal to the utility function of the party in office. We compute the first order conditions of the four possible equilibria:

1.

c: $U^1_Q(Q^t) - U^2_c(c^t) = 0$ (5.45)

e: $V^1_Q(Q^t) - V^2_e(e^t) = 0$ (5.46)

2:

c: $U^1_Q(Q^s) - \alpha U^2_c(\alpha c^s) = 0$ (5.47)

e: $V^1_Q(Q^s) - V^2_e(e^s) = 0$ (5.48)

3:

c: $U^1_Q(Q^t_e) - U^2_c(c^t_e) = 0$ (5.49)

e: $\pi\left[V^1_Q(Q^t_e) - V^2_e(e_e)\right] + (1-\pi)\left[V^1_Q(Q^s_e) - V^2_e(e_e)\right] = 0$ (5.50)

4:

c: $U^1_Q(Q^s_e) - \alpha U^2_c(\alpha c^s_e) = 0$ (5.51)

$$e: \pi \left[V_Q^1 (Q_e^t) - V_e^2 (e_e) \right] + (1-\pi) \left[V_Q^1 (Q_e^s) - V_e^2 (e_e) \right] = 0 \qquad (5.52)$$

A comparison of (5.45) – (5.46) and (5.47) – (5.48) yields that $c^t < c^s$ and $e^t > e^s$. When the tough party is in office, the budgets are lower and the effort level higher than when the soft party controls the sponsor. From the first order condition of the bureau, we know that the whole reduction in the budget will not be compensated by increase in effort. Therefore, output will be higher when the soft party is in power.

From (5.49) – (5.52), it follows that e_e is less than e^t but greater than e^s. If e_e were equal to e^t, the tough party would set $c_e^t = c^t$ after an election victory. That implies that the first parenthesis of (5.50) would be zero. However, if the soft party wins, grants will be higher than c^t. The second parenthesis will therefore be negative. For $e_e = e^t$, the marginal benefit of a reduction in effort exceeds the marginal cost and the bureau will decrease effort below e^t. A parallel argument shows that e_e is higher than e^s, thus; $e^s < e_e < e^t$.

Let us now assume that the tough party wins the election. Since the equilibrium effort level of the election period is less than e^t, the sponsor will set grants above c^t. But from the analysis of the sponsor's utility function in chapter 3, we know that the increase in grants will not be sufficient to compensate for the reduction in effort. Therefore, the output level for the period following an election will be lower than the output level when the tough party is permanent in office.

The argument is parallel for the outcome where the soft party wins the election. Grants will be set below c^s since effort is above. It follows from a differentiation of (5.51) that the reduction in grants is less than the increase in effort:

$$dc/de = - U_{QQ}^1 \,/\, (U_{QQ}^1 - \alpha\, U_{cc}^2) > -1 \qquad (5.53)$$

Output will be higher during a budget period following an election where the soft party wins than when there is no uncertainty regarding the soft party's control of the sponsor.

The last result we need to state, is that $c_e^s > c_e^t$ and $Q_e^s > Q_e^t$ which follows directly from the fact that the effort level following an election is independent of the winning party.

The equilibrium outcomes of the four possible settings are summarized below:

$$c^t < c_e^t < c_e^s < c^s$$

$$e^s < e_e < e^t \qquad (5.54)$$

$$Q_e^t < Q^t < Q^s < Q_e^s$$

(5.54) illustrates that both effort level and output will fluctuate. During election periods, the effort level will be somewhere between the equilibrium levels outside election periods. The contrary is the case for output. Output will be highest for the election period when the soft party wins and lowest for election periods when the tough party wins.

The predictions of the model concerning grants/effort and output can be compared to models which seek to explain variations in macroeconomic variables due to the existence of parties which compete at elections. Two of the most important theories are the so–called political business cycle theory (PBC) and the partisan theory (PT).

Important contributions to the political business cycle theory are given by Nordhaus (75) and MacRae (77). The party in office will use policy instruments between the elections to maximize the probability of being reelected. This gives rise to cyclical variations in growth and monetary/fiscal policy.

The partisan theory, as presented for instance by Alesina (87) and Alesina & Sachs (88), explains variations in the governments' policy as the result of differences between the preferences of political parties.

Our model is clearly within the PT–tradition. The innovation of our model is that the variations are caused by considerations regarding the output and efficiency of the public sector instutions, while the former contributions have primarily been concerned with macroeconomic variables.

With regard to testing of alternative theories, it is hard to get information about effort and output levels of public institutions. Higher output will not necessarily be reflected in the national accounts. We must therefore rely on grants in order to test the model. Our model predicts that grants will differ for all the four phases described above. The predictions of the PCB theory are clearly different. The models predict that public budgets will be expanded before an election. The PT–models predict that the government's policy will vary according to the political party in power. Both Alesina (87) and Alesina & Sachs (88) deal with monetary policy, but their arguments may equally well be applied to fiscal policy. The model of the former reference predicts that grants will only depend on which party is in power, there is no difference between pre– and postelection periods. The second reference predicts variations similar to our model.

Empirical tests of the PT– and PCB–hypotheses for Norway are provided by Madsen (81) and Sørensen (85). Both studies fail to find significant effects of the political party in power on the unemployment/the growth in public expenditures, respectively. There is some evidence that the growth in local sector expenditures is higher in election years (Fevolden & Sørensen (87)).

APPENDIX

The proofs are based on Taylor–expansions of the agents' utility functions. We explore how a small increase in θ above zero affects the equilibrium outcome. By assumptions A9 – A10, $U^2_{ccc} = V^2_{eee} = 0$, implying that U^2_{cc} and V^2_{ee} are invariant to changes in c/e. Therefore, deviations from the certainty solution will not affect U^2_{cc} and V^2_{ee}.

<u>**Proof of proposition 5.1**</u>

Total differentiation of (5.7) – (5.8) give us:

$$\left[0.5\,U^1_{QQL}(c^*+e^*+\theta) + 0.5\,U^1_{QQH}(c^*+e^*-\theta) - U^2_{cc}\right] dc^* +$$

$$\left[0.5\,U^1_{QQL}(c^*+e^*+\theta) + 0.5\,U^1_{QQH}(c^*+e^*-\theta)\right] de^* +$$

$$\left[0.5\,U^1_{QQL}(c^*+e^*+\theta) - 0.5\,U^1_{QQH}(c^*+e^*-\theta)\right] d\theta = 0$$

(A.5.1)

$$\left[0.5\,V^1_{QQL}(c^*+e^*+\theta) + 0.5\,V^1_{QQH}(c^*+e^*-\theta)\right] dc^* +$$

$$\left[0.5\,V^1_{QQL}(c^*+e^*+\theta) + 0.5\,V^1_{QQH}(c^*+e^*-\theta) - V^2_{ee}\right] de^* +$$

$$\left[0.5\,V^1_{QQL}(c^*+e^*+\theta) - 0.5\,V^1_{QQH}(c^*+e^*-\theta)\right] d\theta = 0$$

Next, we Taylor–expand U^1_{QQL}, U^1_{QQH}, V^1_{QQL} and U^1_{QQH}:

$$U^1_{QQL}(c^*+e^*+\theta) = U^1_{QQ}(c^*+e^*) + \theta\,U^1_{QQQ}(c^*+e^*)$$

$$U^1_{QQH}(c^*+e^*-\theta) = U^1_{QQ}(c^*+e^*) - \theta\,U^1_{QQQ}(c^*+e^*)$$

(A.5.2)

$$V^1_{QQL}(c^*+e^*+\theta) = V^1_{QQ}(c^*+e^*) + \theta\,V^1_{QQQ}(c^*+e^*)$$

$$V^1_{QQH}(c^*+e^*-\theta) = V^1_{QQ}(c^*+e^*) - \theta\,V^1_{QQQ}(c^*+e^*)$$

We insert (A.5.2) in (A.5.1) and omit all arguments:

$$\begin{bmatrix} U^1_{QQ} - U^2_{cc} & U^1_{QQ} \\ V^1_{QQ} & V^1_{QQ} - V^2_{ee} \end{bmatrix} \begin{bmatrix} dc^* \\ de^* \end{bmatrix} = - \begin{bmatrix} U^1_{QQQ}\cdot\theta\cdot d\theta \\ V^1_{QQQ}\cdot\theta\cdot d\theta \end{bmatrix}$$

$$\Downarrow$$

$$\begin{bmatrix} dc^*/d\theta \\ de^*/d\theta \end{bmatrix} = \frac{\theta}{DET} \begin{bmatrix} -U^1_{QQQ}(V^1_{QQ}-V^2_{ee}) + V^1_{QQQ}U^1_{QQ} \\ U^1_{QQQ}V^1_{QQ} - V^1_{QQQ}(U^1_{QQ}-U^2_{cc}) \end{bmatrix} \tag{A.5.3}$$

$$DET = (U^1_{QQ} - U^2_{cc})(V^1_{QQ} - V^2_{ee}) - U^1_{QQ}V^1_{QQ} > 0$$

From (A.5.3), it follows that the signs of $dc^*/d\theta$ and $de^*/d\theta$ are ambiguous. Average output equals c^*+e^*. $d(c^*+e^*)/d\theta$ is:

$$d(c^*+e^*)/d\theta = \frac{\theta}{DET}[U^1_{QQQ}V^2_{ee} + V^1_{QQQ}U^2_{cc}] > 0 \tag{A.5.4}$$

(A.5.4) states that expected output will increase due to output uncertainty.

Q.E.D.

<u>Proof of proposition 5.2</u>

We undertake a complete differentiation of (5.13) – (5.15) and insert first–order Taylor–expansions for the derivatives. We omit all addends of second order in θ or higher. Total differentiation of (5.13) – (5.15) give:

$$\begin{bmatrix} V^1_{QQH}-V^2_{ee} & 0 & V^1_{QQH} \\ 0 & V^1_{QQL}-V^2_{ee} & V^1_{QQL} \\ 0.5U^1_{QQH} & 0.5U^1_{QQL} & U^1_{QQ}-U^2_{cc} \end{bmatrix} \begin{bmatrix} de^H \\ de^L \\ dc^* \end{bmatrix} = \begin{bmatrix} V^1_{QQH} & d\theta \\ -V^1_{QQL} & d\theta \\ -U^1_{QQQ} & \theta(1+e_c)d\theta \end{bmatrix} \tag{A.5.5}$$

$$\Downarrow$$

$$\begin{bmatrix} de^H/d\theta \\ de^L/d\theta \\ dc^*/d\theta \end{bmatrix} = \frac{1}{DET} \begin{bmatrix} (V^1_{QQL}-V^2_{ee})(U^1_{QQ}-U^2_{cc})-0.5U^1_{QQL}V^1_{QQL} & 0.5U^1_{QQL}V^1_{QQH} \\ 0.5U^1_{QQH}V^1_{QQL} & (V^1_{QQH}-V^2_{ee})(U^1_{QQ}-U^2_{cc})-0.5U^1_{QQH}V^1_{QQH} \\ -0.5U^1_{QQH}(V^1_{QQL}-V^2_{ee}) & -0,5U^1_{QQL}(V^1_{QQH}-V^2_{ee}) \end{bmatrix}$$

$$\begin{bmatrix} -V^1_{QQH} & (V^1_{QQL}-V^2_{ee}) \\ -V^1_{QQL} & (V^1_{QQH}-V^2_{ee}) \\ (V^1_{QQH}-V^2_{ee})(V^2_{QQL}-V^2_{ee}) & \end{bmatrix} \begin{bmatrix} V^1_{QQH} \\ -V^1_{QQL} \\ -U^1_{QQQ}\,\theta(1+e_c) \end{bmatrix} \tag{A.5.6}$$

$$DET = (V^1_{QQH}-V^2_{ee})[(V^1_{QQL}-V^2_{ee})(U^1_{QQ}-U^2_{cc}) - 0,5U^1_{QQL}V^1_{QQL})]$$

$$-0{,}5(V^1_{QQL}-V^2_{ee})U^1_{QQH}V^1_{QQH} \tag{A.5.7}$$

The expression for the determinant is simplified by inserting first order Taylor–expansions for the derivatives of the utility functions. We omit addends which include θ^2.

$$DET = (V^1_{QQ}-V^2_{ee})[(U^1_{QQ}-U^2_{cc})(V^1_{QQ}-V^2_{ee}) - U^1_{QQ}V^1_{QQ}] < 0 \tag{A.5.8}$$

Assumptions A1 – A4 imply that the determinant is negative. We now multiply the matrices of (A.5.6) and carry out the same simplifications as for the determinant. The computations give:

$$de^H/d\theta = \frac{V^1_{QQ}}{V^1_{QQ}-V^2_{ee}} + \frac{V^2_{ee}\ \theta(1+e_c)}{DET}[(U^1_{QQ}-U^2_{cc})V^1_{QQQ} - V^1_{QQ}U^1_{QQQ}] \tag{A.5.9}$$

$$de^L/d\theta = -\frac{V^1_{QQ}}{V^1_{QQ}-V^2_{ee}} + \frac{V^2_{ee}\ \theta(1+e_c)}{DET}[(U^1_{QQ}-U^2_{cc})V^1_{QQQ} - V^1_{QQ}U^1_{QQQ}] \tag{A.5.10}$$

$$dc^*/d\theta = \frac{V^2_{ee}\ \theta(1+e_c)}{DET}[(V^1_{QQ}-V^2_{ee})U^1_{QQQ} - U^1_{QQ}V^1_{QQQ}] \tag{A.5.11}$$

$$dE(e)/d\theta = 0{,}5(e^H+e^L)/d\theta = \frac{V^2_{ee}\ \theta(1+e_c)}{DET}[(U^1_{QQ}-U^2_{cc})V^1_{QQQ} - V^1_{QQ}U^1_{QQQ}]$$
(A.5.12)

$$dE(Q)/d\theta = d(E(e) + c^*)/d\theta = \frac{V^2_{ee}\ \theta(1+e_c)}{DET}[-V^2_{ee}U^1_{QQQ} - U^2_{cc}V^1_{QQQ}] > 0$$
(A.5.13)

(A.5.9) – (A.5.10) state that the bureau will use effort to compensate for variations in the production function. For small values of θ, $-de^H/d\theta = de^L/d\theta \approx -V^1_{QQ}/(V^1_{QQ}-V^2_{ee})$ which is the expression for the static reaction functions under certainty, (e_c). The change in c^* will be small. A change in θ has therefore approximately the same effect on effort as a change in grants under certainty.

(A.5.11) states that the effect on grants is ambiguous. The change in grants will be more positive the higher is U^1_{QQQ} and the lower is V^1_{QQQ}. These results are in accordance with intuition.

(A.5.12) states that the effect on average is ambiguous. The effect of the magnitude of the derivatives on the sign of $dE(e)/d\theta$ is the opposite of the effect on $dc^*/d\theta$.

(A.5.13) states that expected output increases.

Q.E.D.

Proof of proposition 5.3

The bureau's optimization problem yields:

$$e = \text{argmax}_e\ 0{,}5[V^1(c+e+\theta) + V^1(c+e-\theta)] - V^2(e) \qquad \text{(A.5.14)}$$

$$\Downarrow$$

$$0{,}5[V^1_{QL}(c+e+\theta) + V^1_{QH}(c+e-\theta)] - V^2_e(e) = 0 \qquad \text{(A.5.15)}$$

We differentiate (A.5.15):

$$de = -\frac{V^1_{QQL} + V^1_{QQH}}{V^1_{QQL}+V^1_{QQH}-2V^2_{ee}}\,dc - \frac{V^1_{QQL} - V^1_{QQH}}{V^1_{QQL}+V^1_{QQH}-2V^2_{ee}}\,d\theta \qquad \text{(A.5.16)}$$

We Taylor–expand the second derivatives and insert in (A.5.16):

$$de = -\frac{V^1_{QQ}(c+e)}{V^1_{QQ}(c+e)-V^2_{ee}(e)}\,dc - \frac{\theta V^1_{QQQ}(c+e)}{V^1_{QQ}(c+e)-V^2_{ee}(e)}\,d\theta$$
(A.5.17)

It follows from (A.5.17) that e_c does not depend on θ for sufficiently small values of θ (e_c is of the second order in θ).

The sponsor's maximization problem is:

$$c = \text{argmax}_c\ 0{,}5[U^1(c+e(c,\theta)+\theta) + U^1(c+e(c,\theta)-\theta)] - U^2(c)$$

where $e(c,\theta)$ is the solution of the bureau's optimization problem and given by (A.5.15).
The first order condition of the sponsor's optimization problem is:

$$0{,}5[U^1_{QL}(c+e(c,\theta)+\theta) + U^1_{QH}(c+e(c,\theta) - \theta)][1+e_c(c)] - U^2_c(c) = 0 \qquad \text{(A.5.18)}$$

We differentiate (A.5.18):

$$\{[U^1_{QQH}(c+e(c,\theta)-\theta)+U^1_{QQL}(c+e(c,\theta)+\theta)][1+e_c(c)]^2 \quad +$$
$$U^1_{QH}(c+e(c,\theta)-\theta)+U^1_{QL}(c+e(c,\theta)+\theta)]e_{cc}(c) - U^2_{cc}(c)\}dc +$$

$\{(1+e_\theta(c,\theta))U^1_{QQL}(c+e(c,\theta)+\theta) + (-1+e_\theta(c,\theta))U^1_{QQH}(c+e(c,\theta)-\theta)\}(1+e_c)d\theta = 0$
(A.5.19)

$e_\theta(c,\theta)$ is given by (A.5.17). It follows from the assumption we made in chapter 3, section 3.3, that the parenthesis before dc, which we named U_{cc}, is negative.

We insert (A.5.17) into (A.5.19) and Taylor–expand U^1_{QH}, U^1_{QL}, U^1_{QQH} and U^1_{QQL}:

$$dc/d\theta = \frac{[U^1_{QQ}(c+e(c))][1+e_c)]\theta}{U_{cc}(c+e(c))}\left[-\frac{U^1_{QQQ}(c+e(c))}{U^1_{QQ}\ (c+e(c))} + \frac{V^1_{QQQ}(c+e(c))}{V^1_{QQ}(c+e(c))-V^2_{ee}(e)}\right]$$
(A.5.20)

The sign of $dc^*/d\theta$ is ambiguous and depends on how the agents' marginal benefit of output is affected by the introduction of risk.

Q.E.D.

<u>Proof of proposition 5.4</u>

The technique of the proof is to derive the first order condition of the sponsor and show that marginal utility of grants is negative at the Stackelberg solution under certainty. We start by calculating how the bureau will react to a marginal change in grants when $c = c^S$.

Q^S, c^S, e^S – the Stackelberg solution under certainty.

$e^j(c^S,\theta)$, j = H, L – effort level in respectively bad times (e^H) and good times (e^L).

$$e^H(c^S,\theta) = \text{argmax}_e\ V^1(c^S+e-\theta) - V^2(e) \qquad (A.5.21)$$

$$e^L(c^S,\theta) = \text{argmax}_e\ V^1(c^S+e+\theta) - V^2(e) \qquad (A.5.22)$$

$$\Downarrow$$

$$V^1_{QH}(c^S+e^H-\theta) - V^2_e(e^H) = 0 \qquad (A.5.23)$$

$$V^1_{QL}(c^S+e^L+\theta) - V^2_e(e^L) = 0 \qquad (A.5.24)$$

It follows from (A.5.23) – (A.5.24) that e^H and e^L are solely functions of $(c^S-\theta)$ and $(c^S+\theta)$, respectively. The derivatives of the bureau's reaction functions are found by differentiation of (A.5.23) – (A.5.24):

$$e_c^H(c^S-\theta) = \frac{-V^1_{QQH}(c^S-\theta+e^H(c^S-\theta))}{V^1_{QQH}(c^S-\theta+e^H(c^S-\theta)) - V^2_{ee}} \tag{A.5.25}$$

$$e_c^L(c^S+\theta) = \frac{-V^1_{QQL}(c^S+\theta+e^L(c^S+\theta))}{V^1_{QQL}(c^S+\theta+e^L(c^S+\theta)) - V^2_{ee}} \tag{A.5.26}$$

The next step is to carry out first order Taylor–expansions for $e^H(c^S-\theta)$ and $e^L(c^S+\theta)$:

$$e^H(c^S-\theta) = e^S - \theta\, e_c(c^S) \tag{A.5.27}$$

$$e^H(c^S+\theta) = e^S + \theta\, e_c(c^S) \tag{A.5.28}$$

Since $e^H(c^S) = e^L(c^S) = e^S$ and $e_c^H(c^S) = e_c^L(c^S)$, we have omitted the superscripts of the right–hand–sides of (A.5.27) and (A.5.28). We use (A.5.27) – (A.5.28) to Taylor–expand $V^1_{QQH}(c^S-\theta+e^H(c-\theta))$ and $V^1_{QQL}(c^S+\theta+e^L(c+\theta))$ around (c^S,e^S):

$$V^1_{QQH}(c^S-\theta+e^H(c^S-\theta)) = V^1_{QQ}(c^S+e^S) - \theta(1+e_c(c^S))V^1_{QQQ}(c^S+e^S) \tag{A.5.29}$$

$$V^1_{QQL}(c^S+\theta+e^H(c^S+\theta)) = V^1_{QQ}(c^S+e^S) + \theta(1+e_c(c^S))V^1_{QQQ}(c^S+e^S) \tag{A.5.30}$$

We now insert (A.5.29) – (A.5.30) in (A.5.25) – (A.5.26):

$$e_c^H(c^S-\theta) = \frac{-V^1_{QQ}(c^S+e^S) + \left[V^1_{QQQ}(c^S+e^S)\right]\theta(1+e_c^S(c^S))}{V^1_{QQ}(c^S+e^S)-[V^1_{QQQ}(c^S+e^S)]\,\theta[1+e_c(c^S)] - V^2_{ee}} \tag{A.5.31}$$

$$e_c^L(c^S+\theta) = \frac{-V^1_{QQ}(c^S+e^S) - \left[V^1_{QQQ}(c^S+e^S)\right]\theta(1+e_c(c^S))}{V^1_{QQ}(c^S+e^S)+[V^1_{QQQ}(c^S+e^S)]\,\theta[1+e_c(c^S)] - V^2_{ee}} \tag{A.5.32}$$

From (A.5.31) – (A.5.32) it follows that $e_c^H(c^S-\theta) < e_c^L(c^S+\theta)$. The bureau is more exposed to strategic cuts when demand is high than when demand is low. We are now ready to solve the sponsor's maximization problem.

$$c = \text{argmax}_c\ 0{,}5[U^1(c+e^H(c-\theta)-\theta) + U^1(c+e^L(c+\theta)+\theta)] - U^2(c) \tag{A.5.33}$$

$$\Downarrow$$

$$E[U_c(c)] = 0 \rightarrow 0.5\left[(1+e_c^H(c-\theta))\, U^1_{QH}(c+e^H(c-\theta)-\theta) + (1+e_c^L(c+\theta))\, U^1_{QL}(c+e\,(c+\theta)+\theta)\right] - U_c^2 = 0 \qquad \text{(A.5.34)}$$

where $U_c(c) = dU(c)/dc$. By checking the sign of $E[U_c(c^S)]$ we find whether the sponsor wants to increase or decrease grants when starting from c^S. We first Taylor–expand $U^1_{QH}(c^S+e^H(c^S-\theta)-\theta)$ and $U^1_{QL}(c^S+e^L(c^S+\theta)+\theta)$ around (c^S,e^S):

$$U^1_{QH}(c^S+e^H(c^S-\theta)-\theta) = U^1_Q(c^S+e^S) - (1+e_c(c^S))\,\theta\, U^1_{QQ}(c^S+e^S) \qquad \text{(A.5.35)}$$

$$U^1_{QL}(c^S+e^L(c^S+\theta)+\theta) = U^1_Q(c^S+e^S) + (1+e_c(c^S))\,\theta\, U^1_{QQ}(c^S+e^S) \qquad \text{(A.5.36)}$$

Finally, we insert (A.5.31) – (A.5.32) and (A.5.35) – (A.5.36) in (A.5.34):

$$E[U_Q(c^S)] = 0.5\Bigg\{[U^1_Q-U^1_{QQ}\theta(1+e_c)]\left[\frac{-V^2_{ee}}{V^1_{QQ} - V^1_{QQQ}\theta(1+e_c) - V^2_{ee}}\right] + [U^1_Q+U^1_{QQ}\theta(1+e_c)]\left[\frac{-V^2_{ee}}{V^1_{QQ} + V^1_{QQQ}\theta(1+e_c) - V^2_{ee}}\right]\Bigg\} - U_2 \qquad \text{(A.5.36b)}$$

(A.5.36b) is simplified to:

$$E[U_Q(c^S)] = \frac{[\theta(1+e_c)\,]^2 V^1_{QQQ} V^2_{ee} U^1_{QQ}}{(V^1_{QQ} - V^2_{ee})^2} < 0 \qquad \text{(A.5.37)}$$

where we have omitted addends of the second order in θ in the denominator. (A.5.37) states that marginal utility of grants will be negative at c^S. Therefore, for small θ, the sponsor will set c below c^S.

Effort will on average be higher than e^S. The introduction of uncertainty and the low value for c are both factors that induce the bureau to increase average effort.

Q.E.D.

__Computation of (5.21)__

For a given c, e^H and e^L are given by the bureau's first order conditions:

$$e^H\!: 1/(c+e^H-\theta) = e^H/2 \Rightarrow e^H = 0{,}5[\sqrt{(c-\theta^2)+8} - c + \theta] \qquad \text{(A.5.38)}$$

$$e^L:\ 1/(c+e^L+\theta) = e^L/2 \Rightarrow e^L = 0{,}5[\sqrt{(c+\theta)^2+8} - c - \theta] \qquad (A.5.39)$$

The sponsor's maximization problem is:

$$c^* = \mathrm{argmax}_c\, 0{,}5[\ln(c+e^H(c)-\theta) + \ln(c+e^L(c)+\theta] - \frac{c^2}{4} \qquad (A.5.40)$$

where $e^H(c)$ and $e^L(c)$ are given by (A.5.38) – (A.5.39). The first order condition given by (A.5.40) is:

$$\frac{1+(c^*-\theta)/\sqrt{(c-\theta)^2+8}}{c^*-\theta+\sqrt{(c^*-\theta)^2+8}} + \frac{1+(c^*+\theta)/\sqrt{(c^*+\theta)^2+8}}{c^*+\theta+\sqrt{(c^*+\theta)^2+8}} = c^* \qquad (A.5.41)$$

(5.21) follows from (A.5.38), (A.5.39) and (A.5.40) when setting $c = c^*$ in (A.5.38) – (A.5.39) and (A.5.41).

ENDNOTES

[1]The utility of a given grant/effort level will be lower the higher is the need for the bureau's services. When the demand is high, the grant/effort level must be high to achieve a given utility level. Therefore, high demand corresponds to a disadvantageous production function.

[2]It is not obvious that the utility functions should be the same when we move from certainty to uncertainty. Keeney & Raiffa (76), chapter 4, discusses the relationship between the relevant utility functions for the two situations. Keeney & Raiffa conclude that they do not have to be identical.

[3]The reader can argue that the high–demand bureau may want to play e_*^L if the costs of e^H are sufficiently high, for instance because the disutility of high effort values is large. However, this possibility is ruled out by the single crossing property (Gjesdal (88)). If the low–demand bureau is indifferent between e^H and e_*^L, the high–demand bureau will strictly prefer e_*^H. Although the marginal disutility of effort is equal for the two bureaus, the marginal utility of output is higher when the production function is unfavourable.

REFERENCES

Alesina, A. 1987: Macroeconomic Policy in a Two–Party System as a Repeated Game, Quarterly Journal of Economics 102, 651–678.

Alesina, A. & Sachs, J. 1988: Political Parties and the Business Cycle in the United States, 1948–1984, Journal of Money, Credit and Banking 20, 63–82.

Cho, I. & Kreps, D. 1987: Signaling Games and Stable Equilibria, Quarterly Journal of Economics 102, 179–221.

Fevolden, T. & Sørensen, R. 1987: Norway, in Page, E. & Goldsmith, M. (ed): Central and Local Government Relations, SAGE Publications.

Fishburn, P. & Vickson, R. 1978: Theoretical Foundations of Stochastic Dominance. In Whitmore, G. & Findlay, M. (ed): Stochastic Dominance, Lexington Books.

Gal–Or, E. 1987: First Mover Disadvantages with Private Information, Review of Economic Studies 53, 85–92.

Gjesdal, F. 1988: Piecewise Linear Incentive Schemes, Scandinavian Journal of Economics 90, 305–328.

Keeney, P. & Raiffa, H. 1976: Decisions with Multiple Objectives: Preferences and Value Tradeoffs, John Wiley & Sons Inc., N.Y.

MacRae, D. 1977: A Political Model of the Business Cycle, Journal of Political Economy 85, 239–264.

Madsen, H. 1981: Partisanship and Macroeconomic Outcomes: A Reconsideration, in Hibbs, D. & Fassbender, H. (ed): Contemporary Political Economy, North–Holland.

Nordhaus, W. 1975: The Political Business Cycle, Review of Economic Studies 42, 169–190.

Sørensen, R. 1985: Modeller i studiet av offentlig økonomi, Ph.D. thesis, University of Oslo.

Tirole, J. 1988: The Theory of Industrial Organization, MIT Press, Cambridge, Ma.

Table 5.1: Equilibrium outcomes for the three basic games when there is certainty (invariant production function) and imperfect information, cases A and B

Expected Grants	Nash-Cournot game	Sponsor leader	Bureau leader
Certainty	1.0000	0.6871	1.1118
Case A	1.0010	0.6866	1.1140
Case B	1.0006	0.6868	1.0512

Expected Effort	Nash-Cournot game	Sponsor leader	Bureau leader
Certainty	1.0000	1.1118	0.6871
Case A	1.0010	1.1140	0.6866
Case B	1.0006	1.1127	0.8524

Expected Output	Nash-Cournot game	Sponsor leader	Bureau leader
Certainty	2.0000	1.7989	1.7989
Case A	2.0020	1.8006	1.8006
Case B	2.0012	1.7995	1.9036

CHAPTER 6

REPUTATION BUILDING IN DYNAMIC GAMES

6.1 INTRODUCTION

Chapter 5 dealt with output uncertainty. One or both of the agents did not have complete information about the production function. In particular we studied how uncertainty concerning the value of output influences the equilibria.

The game between the authorities and public institutions is also characterized by the presence of uncertainty about the agents' preferences. The agents do not know exactly what decision the adversary would make, even if the production function were known with certainty. This intrinsic uncertainty is due to the complex decision processes in organizations. The government's decision to grant funds is the result of a complicated process where many individuals participate in forming the final outcome. The preferences and division of power between the administration and the politicians influence the character of the budget. For outsiders (and even for insiders) the outcome of the budget process is difficult to anticipate.

The outcome of the decision process in a public institution is also uncertain. The attitude and skills of the institutions' employees and management affect the efficiency of the institution and how it responds to alternative moves by the government. Hence, the authorities can not possibly have precise knowledge about the institution's preferences.

Preference uncertainty creates scope for reputation manipulation. Both the government and an institution have incentives to create a reputation for toughness. Both parts want to convince the adversary that output can only be increased if the other's contribution is raised.

The government wants to convey a signal of fiscal prudence in order to force the institution to increase effort. However, as we have discussed in former chapters, this signal is not credible if the verbal message is not incentive compatible. With perfect information, an institution may hope that it could force the government to leave its tight policy by ignoring the signal. However, the signal can be made more credible if it is supplemented by tough actions. By cutting the budgets for some periods, the government can build a reputation as having strong preferences for low expenditures. With uncertainty about the government's preferences, a weak government has an incentive to mimic tough governments to enjoy a better reputation than it should have if its preferences were revealed.

The institution also has incentives to build a reputation of toughness. By refusing to accept the government's budget proposal and waging strikes, demonstrations and by cutting effort, the institution can manipulate its reputation. Its actions will affect the government's perception of the institution's preferences.

Even institutions with strong preferences for the output of its services may engage in reputation building. For instance, imagine a hospital where the doctors and nurses are genuinely concerned with the quality of the hospital's services. Under full certainty, they would respond to budget cuts by increasing effort to avoid that patients are hurt by the cuts. However, this response from the hospital would reveal their preferences to the government. Consequently, the hospital would receive tight budgets in the future because the government has incentives to exploit their "caring" attitude. If, on the contrary, the hospital chooses the tough line, it would perhaps be able to convince the government that cuts have no positive effect on effort and the government would be more inclined to refrain from cuts. A generous budget would be to the advantage of the hospital's patients. So even though the hospital staff were solely concerned with the patients welfare, it is still possible that it would choose the hard line in the short run to secure long term grants.

To model a multi–period game with preference uncertainty, we will draw on a variant of a standard paradigm in game theory, named the "war–of–attrition". In a typical war–of–attrition, two players fight for a highly valued prize. One will have to yield if the good shall be to the other's advantage. Both faces the choice of whether to fight on and risk inflicting heavy costs or to give in and lose the prize. This model has been applied for instance to wars between firms for a monopoly (Kreps & Wilson (82) and Fudenberg & Tirole (86)), the provision of public goods in groups (Bliss & Nalebuff (84)), monetary policy (Backus & Driffill (85a,b)) and bargaining (Ordover & Rubinstein (86)). In some of the models, one of the players has private information. In other models, there is uncertainty concerning the preferences of all players.

We will use a variant of these models which focuses on the reputation building of agents with unknown preferences. Such models have been extensively applied within industrial organization and macroeconomics recently. Examples of such models where there is uncertainty on one side, is Kreps & Wilson (82) who model entry–deterring behaviour as a game where the incumbent tries to build a reputation as a tough firm which will fight any entrant. Backus & Driffill (85a), Barro (86) and Rogoff (87) have modelled monetary policy as a game where the government tries to build a reputation as a non–inflationary government by following prespecified rules for expansion of the money base. Its reputation will then affect people's expectations of inflation and moderate wage demands.

In this chapter, we present two models. In section 6.2, we assume that only one of the agents, the sponsor, has private information about its preferences. In section 6.3, none of the agents know the opponent's preferences with certainty. In both models, the players move simultaneously. In section 6.2, the number of budget periods is finite and the bureau behaves myopically. It maximizes the expected utility for each budget period. To be able to compute an equilibrium when both players have private information, we assume in section 6.3 that the policy variables can be adjusted continuously and that the game is infinite. When effort is adjusted continuously, it is not sensible to assume that the bureau is myopic. Hence, in section 6.3, both players maximize a discounted sum of expected utilities.

In each budget period, budget and effort can have one of two values, high and low:

$$c = c^H \vee c^L \quad , c^H > c^L$$

$$e = e^H \vee e^L \quad , e^H > e^L$$

Hence, there are four possible outcomes. The production function is (3.1).

In section 6.2, we assume that there are two types of sponsor. The bureau does not know the sponsor's identity at the beginning of the game. A normal sponsor has the one–period utility function, (3.2), and applies a constant discount factor, δ.

The other type of sponsor is strong. A strong sponsor always chooses c^L. Consequently, if the bureau observes that the sponsor appropriates a high budget, it knows that the sponsor is of the normal type. This way to introduce uncertainty about an agent's preferences was pioneered by Kreps & Wilson (1982). We can regard the strong type as a sponsor that for some reason is irrevocably committed to a tough budget policy but that the commitment can not be observed by the bureau. For instance, a strong sponsor is a government that is ideologically opposed to public spending or that has delegated power to a conservative administration. A normal government has either a more social democratic ideological basis or has retained enough discretion to be able to set the grant level during each budget–period.

Next, we assume that c^H is the dominant policy for the normal sponsor in the one–period game. The bureau prefers e^L when grants are high and e^H when grants are low. Hence, the one–shot Nash–equilibrium is (c^H,e^L). The sponsor would prefer to be able to commit itself to play c^L, provided the bureau increases effort to e^H. These preferences can be justified by reference to the short–run bias of the political decision process. For a single budget period, the benefits of setting grants high always exceed the costs. The bureau knows that c^H is a dominant policy and sets effort equal to e^L in a one–period game.

The sponsor would prefer to pursue a tight budgetary policy if the bureau was convinced that the sponsor really intended to carry out the policy. But since setting grants high is a dominant policy, fiscal prudence can not be part of a subgame perfect equilibrium of a finite game with perfect information. Hence, the normal sponsor faces a credibility problem. In section 6.2, we shall see that the sponsor can mitigate this problem by exploiting uncertainty about its preferences.

In section 6.2, the bureau behaves myopically. Alternatively, we could assume that the bureau acts strategically to force the sponsor to reveal its true preferences. Our assumption can be justified in two ways.

First, if there are many bureaus, each bureau will feel that it has only a minor influence on the sponsor's decision to reveal its type or not. Collectively, the bureaus would gain from cooperating to affect the sponsor's behaviour. But each bureau has insufficient incentives to make short–run sacrifices which benefit the other bureaus as well.

Second, the model can be interpreted as a game between one sponsor and many bureaus taking place successively. The experiences of a bureau influence the strategy of the succeeding bureau. Of course, the discount factor must then be given a different interpretation. It depends on the weights assigned by the sponsor to the bureaus' output.

In section 6.3, we introduce uncertainty about the bureau's preferences. A strong bureau always plays e^L while the normal bureau's preferences are as in section 6.2. The bureau no longer behaves myopically. The preferences of the two types of sponsors are as in section 6.2. Both players have incentives to manipulate their true preferences. We shall see that introducing uncertainty about the bureau's preferences and giving it discretion to act rationally for the game as a whole drastically changes the conclusions of section 6.2.

6.2 A MULTI–PERIOD GAME WHERE THE SPONSOR'S PREFERENCES ARE PRIVATE INFORMATION

We first state and explain some assumptions concerning the one–period utility functions of a normal sponsor and the bureau. These assumptions replace assumptions A1 – A9 of chapters 3–5. They are not inconsistent with the former assumptions, but they are tailored to suit the particular model we explore in this chapter.

6.A1: $U^1_Q(Q,c) > 0 \quad U^1_{QQ}(Q,c) < 0$

6.A2: $U^2_c(Q,c) > 0$

6.A3: $U(c^H,e^j) > U(c^L,e^j) \quad , j = H,L$

6.A4: $V(c^H,e^L) > V(c^H,e^H)$

6.A5: $V(c^L,e^H) > V(c^L,e^L)$

6.A6: $U(c^L,e^H) > U(c^H,e^L)$

6.A7: $$\frac{\left[U(c^H,e^L) - U(c^L,e^L)\right]}{\delta\left[U(c^H,e^H) - U(c^H,e^L)\right]} = k_L < 1$$

6.A1 – 6.A2 are a subset of the assumptions outlined in chapter 3. Assumption 6.A3 states that c^H dominates c^L for a single budget period. Assumptions 6.A4 – 6.A5 state that the bureau's best move depends on the sponsor's move. When grants are low, the bureau sets effort high. When the budget is raised, the bureau allocates some of the increase to slack. Hence, effort is decreased. It follows from 6.A3 – 6.A5, that the one–shot Nash–equilibrium is (c^H,e^L) when there is perfect information.

6.A6 states that the sponsor prefers (c^L,e^H) to the one–shot Nash–equilibrium. Hence, the sponsor wants to be able to commit itself to a low budget provided its move could be observed by the bureau. The sponsor's problem is that its commitment is not dynamically consistent in a finite game with simultaneous move when its preferences are known. The one–shot Nash–equilibrium is the only subgame perfect equilibrium in a finite game with perfect information. We shall show that preference uncertainty may allow the sponsor to sustain a better equilibrium.

Assumptions 6.A3 – 6.A6 are correct if, for instance, (c^H,e^L) and (c^L,e^H) represent the Nash–Cournot solution and the Stackelberg solution with sponsor as leader, respectively, for the numerical utility functions (3.2') – (3.3').

From assumptions 6.A1 and 6.A7, we can deduce the following relationship:

$$\frac{\left[U(c^H,e^H) - U(c^L,e^H)\right]}{\delta\left[U(c^H,e^H) - U(c^H,e^L)\right]} = k_H < k_L \quad (6.1)$$

Hence, $k_H < 1$. The inequality of (6.1) follows directly from the concavity of $U^1(Q)$. Assumption 6.A7 and its corollary, (6.1), are introduced to avoid that the sponsor always prefers to blow its reputation in a two–period game with the following characteristics; The bureau sets effort equal to e^H in the second period if the sponsor plays c^L in the first period. Otherwise, the bureau sets the second period effort level equal to e^L. The sponsor always plays c^H in the second period.

If both k_L and k_H are above one, the sponsor will blow its reputation in the first period of the game, independent of the bureau's first period move. We shall se that assumption 6.A7 facilitates the calculation of a perfect Bayesian equilibrium of the multi–period game.

We are now ready to compute a perfect Bayesian equilibrium of the finite multi–period game when the sponsor is normal. The game has T periods.

y_t – the probability that the sponsor plays c^L in period t

z_t – the probability that the bureau plays e^H in period t

π_t – the bureau's probability belief prior to period t that the sponsor is strong

c_t, e_t – the players' moves in period t

If the sponsor plays c^H before period t or in period t, the only subgame perfect equilibrium is $(y_\tau = 0,\ z_\tau = 0,\ \pi_t = 0)$, $\tau = t+1,T$. If the sponsor plays c^L, the bureau updates its probability beliefs according to Bayes' law. Hence:

$$\pi_{t+1} = \begin{cases} \pi_t/(\pi_t + (1-\pi_t)y_t) & \text{if } c_t = c^L \\ 0 & \text{if } c_t = c^H \end{cases} \qquad (6.2)$$

The bureau sets effort to maximize its expected one–period utility. The probability that the sponsor sets grants equal to c^L is $(\pi_t + (1-\pi_t)y_t)$. Hence:

$$e_t = \operatorname{argmax}_{e \in e^L \vee e^H} (\pi_t + (1-\pi_t)y_t)\ V(c^L,e) + (1-\pi_t)(1-y_t)\ V(c^H,e) \qquad (6.3)$$

$$\Downarrow$$

$$\pi_t > (\pi^* - y_t)/(1-y_t) \ \rightarrow\ z_t = 1$$

$$\pi_t = (\pi^* - y_t)/(1-y_t) \ \rightarrow\ 0 \leq z_t \leq 1 \qquad (6.4)$$

$$\pi_t < (\pi^* - y_t)/(1-y_t) \ \rightarrow\ z_t = 0$$

$$\pi^* = 1/(1+\kappa),\ \kappa = \left[V(c^L,e^L) - V(c^L,e^H)\right] / \left[V(c^H,e^H) - V(c^H,e^L)\right]$$

provided y_t is not equal to one. When $y_t = 1$, it follows directly from assumption 6.A5 that $z_t = 1$. The numerator and denominator of κ express the bureau's loss from playing e^L and e^H, respectively, when the opposite move ex post turns out to be optimal. Hence, the bureau's decision will depend on its probability assessment that the sponsor is strong, π_t, the equilibrium strategy of a normal sponsor, y_t, and the opportunity loss of making the wrong decision for the two feasible moves.

The sponsor sets y_t to maximize the discounted sum of expected one–period utilities, with (6.2) and (6.4) as restrictions. To find a perfect Bayesian equilibrium it is convenient to start by computing the conditions under which the sponsor will want to randomize for two following periods. We require that the sponsor is indifferent between $c_t = c^H$ and $c_t = c^L$ and between $c_{t+1} = c^H$ and $c_{t+1} = c^L$, provided c_t turned out to be c^L. To facilitate the argument concerning the sponsor's move in period t, we assume that $c_{t+1} = c^H$ turns out to be the outcome. Therefore, the sponsor's move in period t will only have consequences for the two first periods, period t and period t+1. From period t+2 and forward, the equilibrium outcome is (c^H,e^H). Hence, we can restrict ourselves to compare the discounted sum of expected one–period utilities for period t and t+1 for the two feasible moves. We name these $U_t^{tot}(c^L)$ and $U_t^{tot}(c^H)$, respectively:

$$U_t^{tot}(c^L) = z_t\, U(c^L,e^H) + (1-z_t)\, U(c^L,e^L) + \delta\, z_{t+1} U(c^H,e^H) + \delta\,(1-z_{t+1})\, U(c^H,e^L)$$

$$U_t^{tot}(c^H) = z_t\, U(c^H,e^H) + (1-z_t)\, U(c^H,e^L) + \delta\, U(c^H,e^L)$$

The sponsor is willing to randomize in period t if $U_t^{tot}(c^L) = U_t^{tot}(c^H)$. From the expressions for $U_t^{tot}(c^L)$ and $U_t^{tot}(c^H)$ we find that randomization may take place if:

$$z_{t+1} = z_t\, k_H + (1-z_t)\, k_L \qquad (6.5)$$

We see from (6.5) that assumptions 6.A1 and 6.A7 are sufficient to make randomization in period t a feasible strategy for the particular game we consider. If k_H and k_L both exceed one, there exists no perfect Bayesian equilibrium where the sponsor randomizes in two following periods, independent of z_t and z_{t+1}.

Next, consider the game where the sponsor randomizes in period t+1 and plays c^L with certainty in period t. By using a similar argument as above, we can show that this strategy is optimal if:

$$z_{t+1} > z_t\, k_H + (1-z_t)k_L \qquad (6.6)$$

We are now ready to state a perfect Bayesian equilibrium for the game. The players' strategies depend on the sponsor's reputation, π_t. Therefore, wc list the players' strategies for a period t, t = 1,T, depending on π_t. The following strategies, together with Bayes law, (6.2), constitute a perfect Bayesian equilibrium:

a) $\pi_t < (\pi^*)^{T-t+1}$

$$y_t = \frac{\pi_t}{1 - \pi_t} \frac{1 - (\pi^*)^{T-t}}{(\pi^*)^{T-t}}$$

$$z_t = 0$$

b) $\pi_t = (\pi^*)^{T-t+1}$

$$y_t = \frac{\pi_t}{1 - \pi_t} \frac{1 - (\pi^*)^{T-t}}{(\pi^*)^{T-t}}$$

$0 \leq z_t \leq 1$ for t = 1

$z_t = z_{t-1} k_H + (1-z_{t-1})k_L$ for t = 2,T

c) $(\pi^*)^{T-t+1} < \pi_t < (\pi^*)^{T-t}$

$$y_t = \frac{\pi_t}{1 - \pi_t} \frac{1 - (\pi^*)^{T-t}}{(\pi^*)^{T-t}}$$

$$z_t = 1$$

d) $\pi_t \geq (\pi^*)^{T-t}$

$$y_t = 1$$

$$z_t = 1$$

We give the proof below. But first, we explain by figure 6.1 how the game will develop. The broken curve is the double–mixed strategy path. When the sponsor's reputation is situated on the path, both players randomize. When the sponsor's reputation is below $(\pi^*)^{T-t}$, the sponsor will set y_t so that its reputation moves onto the curve in period t+1 if c_t turns out to be c^L. Then, from period t+1 and forwards, both randomize. Both players continue to randomize until the sponsor's reputation is blown.

When the sponsor's reputation is above $(\pi^*)^{T-t}$, the sponsor plays c^L with certainty. From Bayes' law, this implies that its reputation stays constant. Hence, the sponsor will continue to play c^L until $\pi_t < (\pi^*)^{T-t}$. From then on, it randomizes to get onto the double–mixed strategy path.

The bureau's move in period t is a simple function of the sponsor's reputation. The bureau plays e^H if $\pi_t > (\pi^*)^{T-t+1}$ and e^L when $\pi_t < (\pi^*)^{T-t+1}$. It randomizes when $\pi_t = (\pi^*)^{T-t+1}$. Along the double–mixed strategy path, we have to impose restrictions on the bureau's strategy to make sure that the sponsor is willing to randomize. From (6.5), we know that the bureau's strategy must satisfy

$$z_t = z_{t-1}\, k_H + (1-z_{t-1})\, k_L$$

along the double–mixed strategy path. Since this equation is recursive, the bureau's moves from period t and until the horizon must satisfy a system of recursive equations if $\pi_t < (\pi^*)^{T-t}$. These recursive equations have no degree of freedom except for the special case where $\pi_t = (\pi^*)^{T-t+1}$, where z_t can be chosen arbitrarily. It follows from (6.5) that z_τ, τ = t,T, converges towards $k_L/(1-k_H+k_L)$. Hence, along the double–mixed strategy path, the bureau randomizes with probabilities of approximately $k_L/(1-k_H+k_L)$ and $(1-k_H)/(1-k_H+k_L)$ of playing e^H and e^L, respectively.

Proof

It is straightforward to prove that the bureau's optimal strategy is given by a) – d) given the sponsor's strategy. If $y_t = 1$, both types of sponsors play c^L. Hence, the bureau's optimal move is e^H by assumption 6.A5. The sponsor's strategy for $\pi_t \leq (\pi^*)^{T-t}$ is:

$$y_t = \frac{\pi_t}{1 - \pi_t} \frac{1 - (\pi^*)^{T-t}}{(\pi^*)^{T-t}} \qquad (6.7)$$

We compute the bureau's optimal strategy by inserting (6.7) in (6.4). It turns out that:

$$\pi_t > (\pi^*)^{T-t+1} \rightarrow z_t = 1$$

$$\pi_t = (\pi^*)^{T-t+1} \rightarrow 0 \leq z_t \leq 1 \qquad (6.8)$$

$$\pi_t < (\pi^*)^{T-t+1} \rightarrow z_t = 0$$

which is the equilibrium strategy described in a) – c).

We now turn to the sponsor's optimal strategy. First, we show that the strategy given by (6.7) will move the players along the double–mixed strategy path until the sponsor's reputation is revealed. We combine Bayes' law and (6.7):

$$\pi_{t+1} = \pi_t/(\pi_t+(1-\pi_t)y_t) = (\pi^*)^{T-t} \qquad (6.9)$$

Hence, by playing c^L with the probability given by (6.7), the sponsor moves its reputation up along the double–mixed strategy path. Furthermore, since (6.7) is the sponsor's strategy for $\pi_t < (\pi^*)^{T-t}$, we have also shown that the sponsor will randomize to move onto the double–mixed strategy path from any π_t below $(\pi^*)^{T-t}$. From the argument leading to (6.5), we know that the sponsor will want to randomize in period t provided the bureau's strategy in period t and period t+1 satisfy equation (6.5). Since the perfect Bayesian equilibrium requires the bureau to randomize according to this equation when the players have moved onto or along the double–mixed strategy path, we have proved that the strategies given by a) – c) constitute a perfect Bayesian equilibrium.

The last step is to prove part d). Consider the interval $(\pi^*)^{T-t} \leq \pi_t < (\pi^*)^{T-t-1}$. If the sponsor plays $c_t = c^L$ with certainty, its reputation does not change. Since $\pi_{t+1} <$

$(\pi^*)^{T-(t+1)}$, the sponsor randomizes in period t+1. The bureau plays $e_{t+1} = e^H$ because $\pi_{t+1} \geq (\pi^*)^{T-t+1}$. Hence, $z_{t+1} = 1$. From (6.6), we know that this implies that the sponsor will not randomize in period t. The sponsor will set $c_t = c^L$.

Next, let $(\pi^*)^{T-t-1} \leq \pi_t < (\pi^*)^{T-t-2}$. From the preceding argument, we know that the equilibrium outcome in the next period is (c^L,e^H) if $c_t = c^L$. The sponsor's discounted sum of expected utilities by playing $c_t = c_{t+1} = c^L$ is therefore higher than if it plays $c_t = c^L$ and then randomizes. However, by applying an argument similar to that of the preceding paragraph, we can show that $c_t = c^L$ is optimal even though the sponsor chooses to randomize in period t+1. Since the sponsor can do better by not randomizing in period t+1, it does not want to give away its reputation in period t.

This argument can be repeated for every interval of π_t above $(\pi^*)^{T-t-2}$. The sponsor will prefer to play $c_t = c^L$ even if its reputation is blown in period t+1. However, since it does not pay to reveal its type in period t+1, and neither in period t+2, we can conclude that the sponsor will not blow its reputation in period t. This concludes our proof.

Q.E.D.

We are not able to claim that a) – d) represent the only perfect Bayesian equilibrium although this can be shown for a two–period game. However, we have illustrated that (c^L,e^H) is a subgame perfect equilibrium during the first part of the game, provided the sponsor's reputation is above a step value. Hence, uncertainty concerning its true preferences helps the sponsor to obtain a better outcome than the one–shot Nash–equilibrium. The step value depends on π^*, which is a function of the bureau's utility function, and the length of the game. When the game consists of a large number of periods, a normal sponsor can sustain (c^L,e^H) for a long period even though there is only a small probability that it is strong.

When the horizon of the game approaches, the sponsor will at some point start to randomize. In the first period of randomization, it sets y_t to jump onto the double–mixed strategy path. On this path, the sponsor sets c^L with probability:

$$(\pi^*)^{T-t+1}\left[1-(\pi^*)^{T-t}\right] \,/\, \left[1-(\pi^*)^{T-t+1}\right](\pi^*)^{T-t} = \qquad (6.10)$$

$$\pi^* \left[1-(\pi^*)^{T-t}\right] / \left[1-(\pi^*)^{T-t+1}\right]$$

which is approximately equal to π^* for T–t >> 0. If the sponsor has not played c^H until the last period, it will set $c_T = c^H$.

Roughly, we can divide the game into three phases. In the first part, the sponsor achieves the equilibrium outcome, (c^L,E^H), that it would prefer if it was able to commit itself to a tight policy. The bureau's budget is low and its efficiency is high. We can not in general state whether output is higher or lower than in the one–shot Nash–equilibrium, but it is reasonable to assume that it is lower. The bureau would not want to compensate the whole reduction in grants by raising effort.

In the next phase, the sponsor plays c^L and the bureau e^H with probabilities close to π^* and $k_H/(1-k_H+k_L)$, respectively, provided the sponsor does not reveal its true type when moving onto the double–mixed strategy path. Before the sponsor's reputation is blown, the outcome is either (c^L,e^L) or (c^L,e^H). The former outcome implies a very low output, which is highly unsatisfactory for the sponsor. In the last period of the second phase, the outcome of the sponsor's randomization turn out to be c^H and the outcome is (c^H,e^L) or (c^H,e^H). The latter outcome is very desirable for the sponsor since output is high.

In last phase of the game, which may not occur if the sponsor's initial reputation is very high or the game is very short, the equilibrium outcome is the one–shot Nash–equilibrium, (c^H,e^L).

Conclusion

We started out by assuming that the political decision process gives the sponsor strong incentives to expand the bureau's budget. The bureau channel a greater part of the budget to non–productive activities than it would do if the sponsor could commit itself to a tight budgetary policy.

In this section, we have shown that if there is some uncertainty concerning the true preferences of the sponsor – which there always will be in practice – the sponsor may want to maintain or build a reputation as hard–nosed to convince the bureau that it should increase its efficiency. Whether the sponsor finds it worthwhile to implement a tight policy, depends on the length of its relevant planning horizon, its intial reputation and the costs and benefits of reducing the budget.

Our model provides a simple explanation for political business cycles without resorting to government's motives about being reelected, as do the theories of Nordhaus (1975) and MacRae (1977). It is enough to assume that the government for some reason have a finite planning horizon which is not extended. During the first part of the government's time in office, it sets the public budgets tight to force its bureaus to become more efficient. It is willing to carry the political costs of fiscal discipline in order to benefit from a more efficient public sector. When the planning horizon approaches, it becomes more likely that public budgets will be increased. The government may briefly enjoy the benefits of expansive budgets and efficient institutions simultaneously. Eventually, the government turns to a policy of expansive budgets and the institutions reduce their efforts.

6.3 A MODEL WITH DOUBLE–SIDED UNCERTAINTY

We will now allow both agents to have preferences that are not known by the other agent. As for section 6.2, the players move simultaneously in each budget period. Both players can make one of two moves and both sponsor and bureau can be of one of two types.

– The sponsor can either be strong or normal. A strong sponsor always chooses c^L. A normal sponsor has the one–period utility function, (3.2).

– The bureau can either be strong or normal. A strong bureau always chooses e^L. A normal bureau has the one–period utility function, (3.3).

For the normal types, assumptions 6.A1 – 6.A7 hold. Contrary to 6.2, we will assume that the normal bureau does not behave myopically. If it behaves myopically in a simultaneous–move game, it does not have incentives to affect its future reputation. In order to model a game where both players have incentives to manipulate the opponent's beliefs, we assume that the bureau maximizes the discounted sum of expected one–period utilities, using the same discount factor as the sponsor, δ.

As for section 6.2, a normal sponsor has incentives to mimic a strong sponsor to persuade the bureau to play e^H if it is normal. A normal bureau will want to give the impression that it is strong in order to discourage a normal sponsor from hiding its true preferences.

We want to find a perfect Bayesian equilibrium for the game between two normal players. It turns out that it is very tricky to solve for a finite–period equilibrium with discrete moves. Kreps & Wilson (82) show that it is easier to solve for an equilibrium if we assume that the horizon is infinite and that grants and effort are set continuously. We let the length of each period be Δt, and find a perfect Bayesian equilibrium as $\Delta t \to 0$. Pure strategy equilibria are difficult to find. We will therefore only compute an equilibrium where both players apply mixed strategies.

The first step is to explore what the equilibrium outcome will be like if the preferences of one or both players are revealed. If one of the players chooses its "soft" move, c^H or e^H, its reputation is blown.

If the sponsor's reputation is blown, the bureau knows that c^H is a dominant strategy for the sponsor, and an equilibrium outcome for the rest of the game is (c^H,e^L). If the reputation of the bureau is blown, the game becomes identical to the game of section 6.2. Since the number of periods is infinite and the length of each period is very small, (c^L,e^H) is a perfect Bayesian equilibrium from that point on. To see this, consider an interval, Δt. The gain from a deviation is approximately $\Delta t \left[U(c^H,e^H) - U(c^L,e^H)\right]$. The loss will be of the magnitude $\left[U(c^L,e^H) - U(c^H,e^L)\right]/i$, where i is the interest rate, $i = -\ln \delta$. As the length of the interval approaches zero, the loss will exceed the gain. Hence, we will assume that the equilibrium outcome is (c^L,e^H) for the rest of the game when the bureau's reputation is blown.

If the reputation of both players are blown simultaneuously, (c^H,e^L) is a subgame perfect equilibrium. However, since the game is infinite, we know that there are a number of other subgame perfect equilibria. Hence, we stress that the perfect Bayesian equilibrium we find is not necessarily unique.

Let:

y_t – the probability per unit time that the sponsor plays c^H

z_t – the probability per unit time that the bureau plays e^H

$\pi_{t,j}$, j = s, b – the probability belief at time t of the bureau / sponsor that the sponsor / bureau is strong.

y_t and z_t represent the probability that the players' blow their reputation during a period. As the length of the period approaches zero, y_t and z_t must be interpreted as the probability density that the reputations will be blown at time t. Note that y_t has different interpretations in sections 6.2 and 6.3.

We start by computing the conditions for an equilibrium where the sponsor applies a mixed strategy. Consider a period of length Δt starting at t where the preferences of both players still are unknown. If the sponsor plays c^H, the equilibrium outcome for the periods after the present period is (c^H,e^L).

If the sponsor plays c^L, the expected utility of the first period depends on z_t. But contrary to the situation where the sponsor chooses c^H, the equilibrium outcomes of the following periods depend on the bureau's move. If the bureau chooses e^L, the game will be identical to the game faced by the agents one period ago. If the bureau plays e^H, the equilibrium outcome is (c^L,e^H) for the rest of the game. Let $U_t^{tot}(c^j)$, j = H,L, denote the sponsor's expected sum of discounted utilities if it plays c^j, j = H,L. The sponsor is willing to randomize if:

$$U_t^{tot}(c^L) = U_t^{tot}(c^H) \qquad (6.11)$$

$$U_t^{tot}(c^L) = \left[1-(1-\pi_{t,b})z_t\Delta t\right]\left[\Delta t\ U(c^L,e^L) + (1-i\Delta t)\ W_s(\pi_{t+\Delta t,s})\right] + \left[(1-\pi_{t,b})z_t\Delta t\right]\left[\ U(c^L,e^H)/i\right] \qquad (6.12)$$

$$U_t^{tot}(c^H) = \left[1-(1-\pi_{t,b})z_t\Delta t\right]\left[\Delta t\ U(c^H,e^L)\right] + \left[(1-\pi_{t,b})z_t\Delta t\right]\left[\Delta t\ U(c^H,e^H)\ \right] + (1-i\Delta t)\ U(c^H,e^L)/i \qquad (6.13)$$

– Since the interval, Δt, is short, we have set $e^{-i\Delta t} = 1 - i\Delta t$.

– $(1-\pi_{t,b})z_t\Delta t$ and $1-(1-\pi_{t,b})z_t\Delta t$ are the probabilities that the bureau will play e^H and e^L during Δt, respectively.

– The sponsor's utility from the present period is $\Delta t\ U(c_t,e_t)$

– The discounted present value of a game with full certainty is $U(c^H,e^L)/i$ as $\Delta t \to 0$.

$W_s(\pi_{t+\Delta t,s})$ is the expected sum of discounted one–period utilities of the sponsor at time $t+\Delta t$ if its reputation is updated by Bayes' law, provided $c_t = c^L$ and $e_t = e^L$. When $\Delta t \to 0$, the sponsor's expected sum of discounted utilities at t and $t+\Delta t$ will approach each other. Therefore, we set

$$W_s(\pi_{t+\Delta t,s}) = U_t^{tot}(c^L) \qquad (6.14)$$

as an approximation.

We now insert (6.14) in (6.12) and then (6.12) – (6.13) in (6.11). The resulting equation contains Δt as well as Δt^2. As Δt approaches zero, addends of second order in Δt are small compared to the other addends and are therefore deleted from the equation. (6.11) can be written as:

$$\left[U(c^L,e^L) + (1-\pi_{t,b})z_t U(c^L,e^H)/i\right] / \left[i + (1-\pi_{t,b})z_t\right] = U(c^H,e^L)/i \qquad (6.15)$$

We solve (6.15) to find z_t:

$$z_t = i\left[U(c^H,e^L) - U(c^L,e^L)\right] / \left[\left[U(c^L,e^H) - U(c^H,e^L)\right](1-\pi_{tb})\right] \qquad (6.16)$$

If the sponsor shall want to apply a mixed strategy, the bureau must follow the strategy given by (6.16). To find the equivalent equilibrium condition for the bureau, we repeat the computations through (6.11) – (6.16). If the bureau shall be indifferent between e^H and e^L at time t, the sponsor must apply the following strategy:

$$y_t = i\left[V(c^L,e^H) - V(c^L,e^L)\right] / \left[\left[V(c^H,e^L) - V(c^L,e^H)\right](1-\pi_{ts})\right] \qquad (6.17)$$

(6.16) – (6.17) can be given an intuitive interpretation. Consider the sponsor's decision. If it deviates, the short term gain per unit of time is approximately $\left[U(c^H,e^L) - U(c^L,e^L)\right]$. If it does not deviate, there is a probability $(1-\pi_b)\ z_t$ that the bureau blows its reputation. If the bureau blows its reputation, the sponsor's gain per unit time relative to playing c^H is approximately $\left[U(c^L,e^H) - U(c^H,e^L)\right]$ for the rest of the game. Hence, (6.16) states that the sponsor may randomize if the interest on the short term gain by playing c^H equals the expected long run gain by playing c^L. A parallel interpretation holds for (6.17).

The last step is to compute how the probability beliefs of the agents are revised by using Bayes' law when the decisions are made continuously. For the interval Δt, Bayes' law gives the following revision of the probability beliefs provided the agents play c^L and e^L, respectively:

$$\pi_{t+\Delta t,s} = \pi_{t,s}/(\pi_{t,s}+(1-\pi_{t,s})(1-y_t\Delta t)) \qquad (6.18)$$

$$\pi_{t+\Delta t,b} = \pi_{t,b}/(\pi_{t,b}+(1-\pi_{t,b})(1-z_t\Delta t)) \qquad (6.19)$$

$$(\pi_{t+\Delta t,s} - \pi_{t,s})/\Delta t = \left[\pi_{t,s}(1-\pi_{t,s})y_t\right] / \left[1-(1-\pi_{t,s})y_t\Delta t\right] \qquad (6.20)$$

$$(\pi_{t+\Delta t,b} - \pi_{t,b})/\Delta t = \left[\pi_{t,b}(1-\pi_{t,b})z_t\right] / \left[1-(1-\pi_{t,b})z_t\Delta t\right] \qquad (6.21)$$

The limits of the LHSs of (6.20) and (6.21) approach the derivatives of the probability beliefs as $\Delta t \to 0$:

$$\pi'_{t,s} = \pi_{t,s}(1-\pi_{t,s})y_t \qquad (6.22)$$

$$\pi'_{t,b} = \pi_{t,b}(1-\pi_{t,b})z_t \qquad (6.23)$$

$\pi'_{t,j}$, $j = s, b$ – the derivative of the reputation of the sponsor / bureau.

The equations (6.16) – (6.17) and (6.22) – (6.23) define the equilibrium path for a double mixed strategy equilibrium until one of the players' reputation is blown. The probability that a player will blow its reputation is low when the player is patient, the gain from forcing the opponent to deviate is high, the short term gain from deviating is small and one's initial reputation is high. When both players are patient, and have a reputation as being strong and furthermore have relatively much to gain by affecting the opponent, the equilibrium outcome (c^L,e^L) may be sustained for a long period of time. As seen by the sponsor, the outcome is undesirable since output is very low.

Preference uncertainty induces the agents to move (probabilistically) to an equilibrium that is Pareto–inferior compared to the one–shot Nash–equilibrium under certainty. Both agents prefer (c^H,e^L) to (c^L,e^L). The more patient are the players, the bigger is the probability of getting a Pareto–inferior outcome. This result is parallel to the conclusion of section 4.3. In the alternating–move game, an increase in the discount factor moves the equilibrium outcome away from the Pareto–optimal curve.

6.4 CONCLUSION

The conclusion of section 6.3 is qualitatively different from the results of section 6.2. This is hardly surprising since we have given the bureau private information and made it base its decisions on long–run considerations. As seen by the general public, the conclusions of section 6.3 are more pessimistic than those of section 6.2. In section 6.2, we found that the sponsor could counter its short–run bias by exploiting its information monopoly as long as the bureau behaves myopically. The sponsor was able to sustain an equilibrium outcome with lower grants and higher effort than the one–shot Nash–equilibrium. Hence, we could think of the outcome as close to the Stackelberg–solution although we did not state explicitly the values of the players' alternative moves. In section 6.3, both players act in a way that resembles the behaviour of a Stackelberg leader in the one–period game. Both players set their policy instruments low.

The public authorities face a difficult dilemma. A tough policy has a pretty good chance of succeeding if the authorities know the bureaus' preferences and if the bureaus behave myopically. However, if these assumptions are not fulfilled, the policy may fail, leading to low output without higher efficiency. As seen by the authorities, the desirability of the equilibrium outcomes of the two games in section 6.2 and 6.3 are vastly different. In real life, the authorities do not know the planning horizons of the bureaus, and there is also uncertainty regarding the bureaus' preferences. In addition, the preferences of the bureaus may change due to internal organizational processes. The authorities' decision on whether to launch a policy of tough fiscal discipline is therefore a risky one.

REFERENCES

Backus, D. & Driffill, J. 1985a: Inflation and Reputation, American Economic Review 75, 530–538.

Backus, D. & Driffill, J. 1985b: Rational Expectations and Policy Credibility Following a Change in Regime, Review of Economic Studies 52, 211–221.

Barro, R. 1986: Reputation in a Model of Monetary Policy with Incomplete Information, Journal of Monetary Economics 17, 3–20.

Bliss, C. & Nalebuff, B. 1984: Dragon–slaying and Ballroom Dancing: The Private Supply of a Public Good, Journal of Public Economics 25, 1–12.

Fudenberg, D. & Tirole, J. 1986: A Theory of Exit in Oligopoly, Econometrica 54, 943–960.

Kreps, D. & Wilson, R. 1982: Reputation and Imperfect Information, Journal of Economic Theory 29, 253–279.

MacRae, D. 1977: A Political Model of the Business Cycle, Journal of Political Economy 85, 239–264.

Nordhaus, W. 1975: The Political Business Cycle, Review of Economic Studies 42, 169–190.

Ordover, J. & Rubinstein, A. 1986: A Sequential Concession Game with Asymmetric Information, Quarterly Journal of Economics 51, 879–888.

Rogoff, K. 1987: Reputational Constraints on Monetary Policy, Carnegie–Rochester Conference Series on Public Policy 26, 141–182.

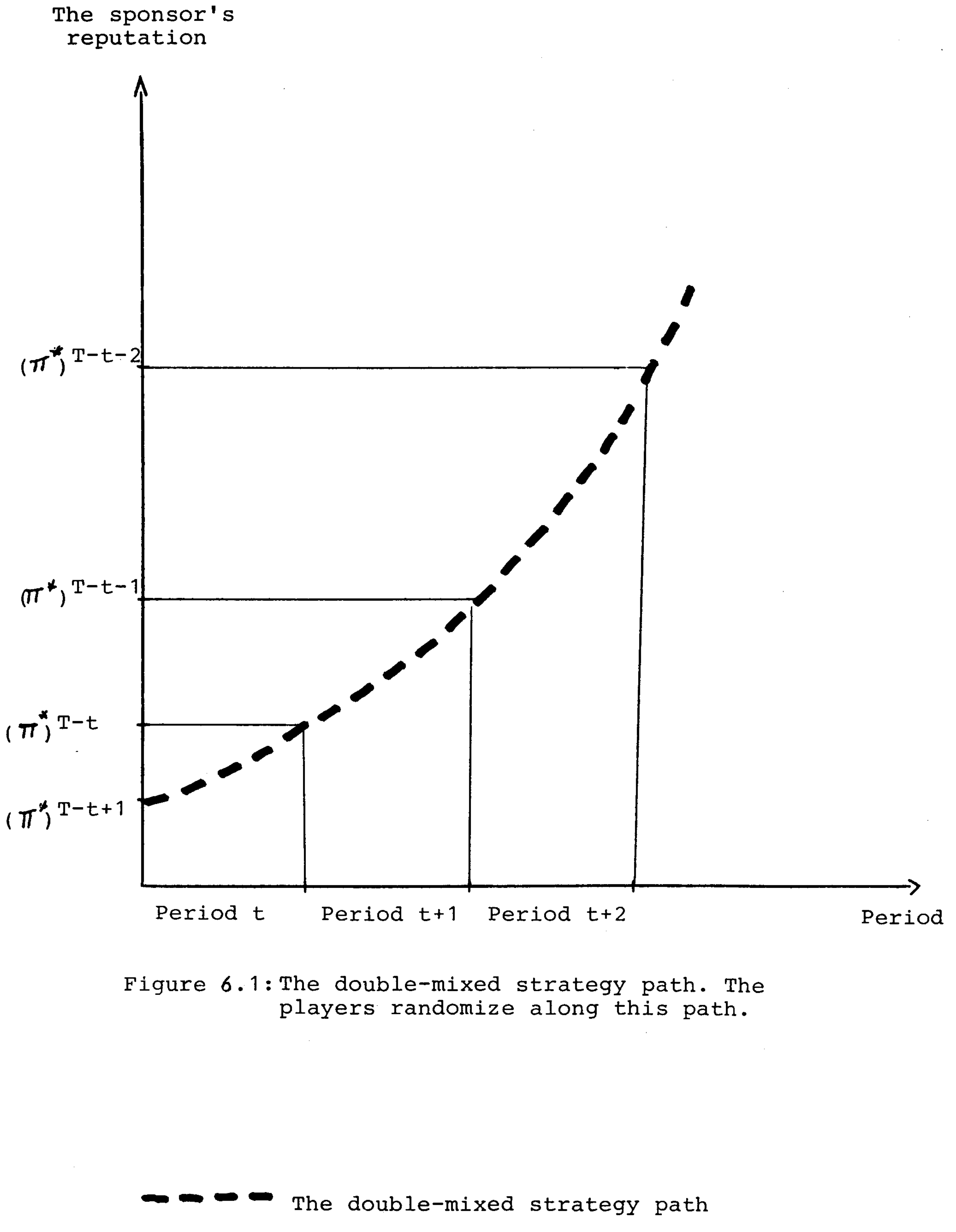

Figure 6.1: The double-mixed strategy path. The players randomize along this path.

CHAPTER 7

THE SPONSOR PAYS FOR OUTPUT

7.1 INTRODUCTION

So far, the sponsor's instrument variable has been the bureau's budget. In this chapter, we will assume that output is observable and verifiable. Therefore, the sponsor can construct a reward function in order to induce the bureau to increase effort.

Although much has been written on incentive schemes in the last twenty years, very little work has been done to investigate how the efficiency of public institutions can be improved by application of alternative reward functions. The branch of the incentives literature which is named "theory of regulation", deals mainly with regulation of profit–oriented public enterprises and the central question is how to prevent the enterprise from behaving as a monopolist without introducing adverse effects on efficiency (Besanko & Sappington (87) is a survey of this literature). I do not know of any attempt to combine elements from the theory of regulation with the theories of bureaucracy originating in Niskanen (71).

There are (at least) two different approaches to the question of how a sponsor can use output conditional schemes to improve the effort of the bureau. One approach, which is in the tradition of the theory of regulation, is to assume that the sponsor is the Stackelberg leader and that the incentive scheme is constructed by the sponsor to mitigate its informational disadvantage. This is the approach we will follow in chapter 8. We will explore the consequences of alternative incentive schemes when effort is not observable. The sponsor is a Stackelberg leader and has power to set the bureau's reward function before the bureau's move.

The weakness of this approach is that it assumes a priori that the authorities are the dominant partners in the relationship. The authorities' choice of incentive scheme is not influenced by the institutions' behaviour, at least not by the institutions' behaviour for the period for which the scheme applies.[1]

An alternative approach to the question of how incentive schemes affect institutions' efficiency is to consider how different schemes perform under alternative settings. A scheme might achieve good results when the government leads but perform badly when the institution moves first.

In his theory of Constitutional Government, James Buchanan distinguishes between the constitutional and parliamentary stage of the government's decision making.[2]In the first stage, the constitutional stage, the agents decide on some basic rules which will regulate their relationship in the second stage, the parliamentary stage.[3]

Buchanan's distinction between the two stages is relevant for our discussion of the effects of an incentive scheme. We can regard a scheme as a set of rules for the budget process which is not changed during the budget period (or for multiple–period games, rules which are not changed during the whole game). The details of the scheme is set by the government for each period. In the constitutional stage, the government decides on the principles of the incentive schemes. In the parliamentary stage, the government sets the parameters of the scheme. The outcome of the budget process depends both on the type of scheme and the setting of the game of the budget period.

The impact of the incentive scheme on the institutions' efficiency can be very different depending on the setting of the model. A scheme which is well suited to counter information advantages of the institutions when the government is the leader, can turn out to give low efficiency once we allow the institutions to move first.

In chapter 7 we shall discuss how incentive schemes perform for the three basic one–period games. In order to concentrate the analysis on the main question of this chapter, the performance of alternative incentive schemes under different settings, we will not introduce uncertainty.

We will explore how one particular output–conditional scheme, the piece–rate system, performs compared to the pure transfer system described in chapter 3. A transfer system is a scheme where the sponsor's role is solely to grant a budget and let the bureau dispose of it freely. Under the piece–rate system, the whole budget is predetermined to be payment for the output of the bureau. To use Buchanan's terminology, during the constitutional stage, the sponsor decides that the budget consists only of one figure, the price per unit output. During the next stage, when the production takes place, the sponsor is free to set the price.

The output of public services is generally difficult to agree on and evaluate. The products of public institutions, a high education level and general good health condition of the citizens, are hard to measure. Instead, the authorities must set a price on a surrogate output, like examination results or number of patients. When the reward is dependent on the proxy variable, the institutions have incentives to direct effort away from the real objectives of production. A crucial question is whether the gains from the introduction of a price system exceed the costs. It is probably fair to say that a dominant view among economists and politicians has been that public services were not ready for the introduction of a price system but that this is about to change.[4]

In practice, precise and operational output measures are seldom formulated and almost never tied to the budget of the institutions. Olson (89) claims that this is due to the nature of the political system. In order to legitimize their activities, the politicians must be careful not to formulate quantitative goals. Such goals will either be inconsistent and therefore cause criticism ex post because commitments implied by the budget are abandoned, or the goals are consistent, in which case they will upset a significant part of the electorate which does not agree with the budget's priorities. Since the demand for services directed at the public sector hugely exceeds the available resources, the politicians prefer to avoid clear formulations of objectives.

Hofstede (81) distinguishes between errors of type one and two in public organizations. An error of type one is to refrain from a quantitative control system when output can be measured. An error of type two is to introduce such a system when output can not be measured. In sections 7.2, we will illustrate how simple schemes which are based on output can improve the efficiency of a public institution. If our output variable reflects the authorities' preferences concerning public services accurately, maintaining a transfer system would be what Hofstede names a type one error. If output is a proxy variable which is not well suited for the purpose, the introduction of a price system would be a type two error.

The consequences of the two types of errors are qualitatively different. The use of output–conditional schemes when the production is not suited for such schemes, can lead the institution to deemphasize important aspects of its activity which are difficult to quantify.[5] On the other hand, neglect of the quantitative aspect of the production may lead to low efficiency. The important question is which of these errors is worse. Since the consequences of type one errors probably are more qualitative in nature than those of type two, it is difficult to build a mathematical model which describes the trade–off between the two errors. The models in sections 7.2–3 deal with quantitative aspects of an incentive scheme and the conclusions are therefore probably biased in favour of the output–related scheme.

In section 7.2, we shall compute the three basic one–shot noncooperative equilibria for the two alternative schemes. In addition, we are able to compute Markov perfect equilibria for the piece–rate system when the bureau's utility functions exhibit a special property. Section 7.3 discusses how parameters can be set when the government moves from the transfer to a piece–rate system. Section 7.4 discusses the relevance of the models for the public sector.

Since there is no uncertainty regarding the production function or the bureau's preferences, it is meaningless to discuss the concept of an optimal incentive scheme for a game where the government leads. The government can implement any outcome by threatening to cut budgets dramatically if the institution does not obey the government's instructions. However, we do not consider such forcing contracts.

7.2 COMPARISON OF THE PIECE–RATE AND THE TRANSFER SYSTEM

The basic rule of the price system is that grants must be proportional to output. For the transfer system, the model is as before given by (3.1) – (3.3). For the piece–rate system we also require that (7.1) holds:

$$c = p\,Q \qquad (7.1)$$

p , $0 < p < 1$ – the price per unit output

p must be below one for the production function to have meaning. Otherwise, effort must be negative for (7.1) to hold. If the price is close to one, a small increase in effort yields a large increase in output. Hence, a price approximately equal to one implies that the increase in output is almost fully provided for by the sponsor. The sponsor sets p for the piece–rate system and c for the transfer system. By combining (3.1) and (7.1), we get

$$Q = e/(1-p) \qquad (7.2)$$

$$c = pe/(1-p) \qquad (7.3)$$

For a given price, the bureau will extract a higher budget from the sponsor when effort is increased. Contrary to what is the case for the transfer system, the sponsor does not have to make a decision for grants to increase. The basic equations of the piece–rate system are therefore:

$$U(p,e) = U^1(e/(1-p)) - U^2(pe/(1-p)) \qquad (7.4)$$

$$V(p,e) = V^1(e/(1-p)) - V^2(e) \qquad (7.5)$$

The numerical utility functions (3.2') – (3.3') can be written as:

$$U(p,e) = \ln(e/(1-p)) - \left[pe/(1-p)\right]^2/4 \qquad (7.4')$$

$$V(p,e) = \ln(e/(1-p)) - e^2/4 \qquad (7.5')$$

We will denote the derivatives of U^1 / V^1 and U^2 / V^2 with the subscripts Q and c/e as for the transfer system (see section 3.2).

We will now compute the equilibrium solutions of the three basic noncooperative games and compare the outcomes to those of the transfer system. We will use the same notation as for the transfer system except that we use a subscript p to denote the equilibrium solution for the piece–rate system. For example, we will let

c_p^N, p_p^N, e_p^N, Q_p^N – denote the Nash–Cournot solution for the piece–rate system.

<u>The Nash–Cournot game</u>

The first order conditions for the Nash–Cournot solution are given by the following first order conditions:

$$p:\ U_p = \left[U_Q^1 - U_c^2\right] e_p^N/(1-p_p^N)^2 = 0 \qquad (7.6)$$

$$e:\ V_e = V_Q^1/(1-p_p^N) - V_e^2 = 0 \qquad (7.7)$$

The first order conditions for the transfer system, (3.11) – (3.12), are:

$$U_Q^1 - U_c^2 = 0 \qquad (7.8)$$

$$V_Q^1 - V_e^2 = 0 \qquad (7.9)$$

A comparison of (7.6) – (7.7) to (7.8) – (7.9) shows that

$$c_p^N < c^N \quad e_p^N > e^N \quad Q_p^N > Q^N \qquad (7.10)$$

(7.9) states that $V^1_Q = V^2_e$ at the Nash–Cournot solution for the transfer system. Hence, it follows from (7.7) that – for the piece–rate system – the bureau's marginal benefits of increased effort exceed the marginal costs at (c^N,e^N). The bureau will therefore increase effort above e^N, and the sponsor will react by decreasing grants (through adjustment of the price) but not so much that output decreases. The latter conclusion follows directly from (7.6).

Increased cost efficiency is the main justification for the introduction of a price system, the so called DRG–system, in the health service (Magnussen (88)). Our model predicts that the system will increase the bureau's effort.

It follows from (7.10) that the sponsor unambiguously prefers the piece–rate system to the transfer system. Output is higher and grants lower for the piece–rate system and both changes are perceived as positive by the sponsor.

The bureau prefers the transfer system. It will gain utility approximately equal to

$$(Q^N_p - Q^N)\ V^1_Q\ ((Q^N_p + Q^N)/2)$$

from the increase in output. The loss will be approximately

$$(e^N_p - e^N)\ V^2_e((e^N_p + e^N)/2).$$

Hence, the loss will exceed the gain since effort increases more than output and since V^1 is concave in Q and V^2 convex in e.

The second order conditions for stability of the Nash–Cournot solution are:

$$U_{pp} = \left[U^1_{QQ} - U^2_{cc}\right] (e^N_p)^2/(1-p^N_p)^4 < 0 \qquad (7.11)$$

$$V_{ee} = V^1_{QQ}/(1-p^N_p)^2 - V^2_{ee} < 0 \qquad (7.12)$$

$$U_{pe} = \left[U^1_{QQ} - p^N_p U^2_{cc}\right] (e^N_p)\ /(1-p^N_p)^3 \qquad (7.13)$$

$$V_{ep} = \left[V^1_Q + V^1_{QQ}\ e^N_p/(1-p^N_p)\right] /(1-p^N_p)^2 \qquad (7.14)$$

$$U_{pp}\,V_{ee} - U_{pe}\,V_{ep} =$$

$$\left[-U^2_{cc}V^1_{QQ}\,/(1-p^N_p) - (U^1_{QQ} - U^2_{cc})V^2_{ee} - (U^1_{QQ} - p^N_p U^2_{cc})V^1_Q\,/((1-p^N_p)e^N_p)\right]$$

$$(e^N_p)^2/(1-p^N_p)^4 > 0 \quad (7.15)$$

(7.11) – (7.12) and (7.15) ensure that we have a stable Nash–Cournot solution (Dixit (86)). We insert the numerical utility functions, (7.4') – (7.5'), in the first order conditions (7.6) – (7.7):

$$\text{p:}\ (1-p^N_p)/e^N_p - p^N_p e^N_p/2(1-p^N_p) = 0 \qquad (7.6')$$

$$\text{e:}\ 1/e^N_p - e^N_p/2 = 0 \qquad (7.7')$$

The equations, (7.6') – (7.7'), give the following Nash–Cournot solution:

$$c^N_p = 0.8740 \;\; p^N_p = 0.3820 \;\; e^N_p = 1.4142 \;\; Q^N_p = 2.2882$$

$$U(p^N_p,e^N_p) = 0.6368 \;\; V(p^N_p,e^N_p) = 0.3278$$

Sponsor as leader

The sponsor sets p to maximize its utility given the reaction function of the bureau. We start by finding the derivatives of the bureau's static reaction function. It is found by undertaking a total differentiation of the bureau's first order condition, (7.7):

$$\left[V^1_Q/(1-p)^2 + e\,V^1_{QQ}/(1-p)^3\right] dp + \left[V^1_{QQ}/(1-p)^2 - V^2_{ee}\right] de = 0 \qquad (7.16)$$

$$\rightarrow de/dp = e_p = -V^1_Q\,(1-r_Q)/\left[V^1_{QQ} - V^2_{ee}(1-p)^2\right] \qquad (7.17)$$

$$r_Q = -Q\,V^1_{QQ}/V^1_Q \qquad (7.18)$$

r_Q is the negative of the elasticity of the bureau's marginal utility of output. For cardinal von Neumann–Morgenstern utility functions which describe a person's attitude to risk, r_Q is the mathematical expression for the relative risk aversion when output is exchanged with income. However, we can not give r_Q a parallel interpretation since there is no uncertainty in our model.

It follows from assumption A3 that r_Q will be positive, but we can not say a priori whether it is above or below one. The sign of e_p is therefore ambiguous, while for the transfer system $e_c < 0$ with certainty. e_p is negative when $r_Q < 1$ and positive when $r_Q > 1$.

The reason why the sign of e_p is ambiguous, is that the variations in price have both an income and a substitution effect. When the price is raised, a marginal increase of effort will yield a higher marginal increase in output. This is a substitution effect that causes effort to be increased. But a higher price will also increase output for a given effort level. This is an income effect which makes the bureau better off and causes it to decrease effort. The total effect of the price on effort depends on the relative strength of the two effects.

When the absolute value of the elasticity of marginal utility of output is high, the income effect will dominate because the marginal utility of output varies significantly with the level of grants. When the bureau's r_Q is low, the substitution effect dominates. Hence, e_p is positive. Under the transfer system, there is only an income effect and e_c is therefore negative.

The sponsor will set p to maximize its utility while taking into account the static reaction function of the bureau.

$$p_p^S = \operatorname{argmax}_p \; U^1(e(p)/(1-p)) - U^2(pe(p)/(1-p)) \qquad (7.19)$$

where e(p) is given by (7.7). Computation of (7.19) gives:

$$U_p(p_p^S, e_p^S(p_p^S)) = \left[U_Q^1 - U_c^2\right] e_p^S/(1-p_p^S)^2 + \left[U_Q^1 - p_p^S U_c^2\right] e_p/(1-p_p^S) = 0 \qquad (7.20)$$

Whether the sponsor will want to set the price higher or lower than p_p^N, depends on the sign of e_p. For the Nash–Cournot solution, the first and second parentheses of (7.20) are zero and positive, respectively. Therefore, the sign of U_p at the Nash–Cournot solution is the same as the sign of e_p. If $e_p < 0$, the marginal change in utility with respect to the price is negative when evaluated at the Nash–Cournot solution and the sponsor will set p_p^S below

p_p^N.

The new effort level will be above the Nash–equilibrium effort level except when $e_p = 0$. When effort is independent of price, the two equilibrium solutions coincide. To compute how output varies with price, we set e = e(p) in (7.2) and differentiate output with respect to the price:

$$dQ/dp = e(p)/(1-p)^2 + e_p/(1-p) = \left[Q + e_p\right]/(1-p) \qquad (7.21)$$

When $e_p > 0$, output is increased above Q_p^N. When $e_p < 0$, there are two effects which draw the output level in different directions. From (7.17), we see that the absolute value of the numerator of e_p is less than Q V_{QQ}^1. The denominator's absolute value is greater than V_{QQ}^1. The absolute value of e_p is therefore less than Q, implying that dQ/dp > 0. Hence, we have found that $Q_p^S > Q_p^N$ when $e_p > 0$ and $Q_p^S < Q_p^N$ when $e_p < 0$. Since grants equal the product of price and output, c, p and Q will all move in the same direction.

We know that $Q_p^N > Q^N > Q^S$. Therefore, we can conclude that $Q_p^S > Q^S$ when $e_p > 0$. When $e_p < 0$, the relationship between Q_p^S and Q^S is ambiguous, because we can not say a priori whether $e_p \gtrless e_c$.

We can not draw any a priori conclusion as to whether the sponsor/ bureau prefers the piece–rate or transfer system when the sponsor leads. However, seen from the point of view of the bureau, the piece–rate system has the advantage that the sponsor's incentives to cut grants strategically are reduced.

The second order conditions of the sponsor's maximization problem contain expressions about which it is difficult to make a priori assumptions. We can therefore not rule out local minimum solutions which satisfy (7.17) – (7.20).

We are now ready to summarize the analysis of the Stackelberg game where the sponsor is leader:

$$r_Q \geq 1 \rightarrow c_p^S > c_p^N \quad e_p^S > e_p^N > e^N \quad Q_p^S > Q_p^N > Q^N > Q^S$$

$$r_Q = 1 \rightarrow c_p^S = c_p^N \quad e_p^S = e_p^N > e^N \quad Q_p^S = Q_p^N > Q^N > Q^S \qquad (7.22)$$

$r_Q < 1 \rightarrow c_p^S < c_p^N < c^N \quad e_p^S > e_p^N > e^N \quad Q_p^N > Q_p^S$

For the bureau's numerical utility function, utility of output is a logarithmic function of output and $r_Q = 1$. From (7.22), it follows that the equilibrium solution for the two settings will be equal and the equilibrium values of the variables are therefore the same as for the Nash–Cournot game. The bureau's utility level will be higher for the piece–rate scheme than for the tranfer system when the sponsor leads. We can not say whether this conclusion holds generally.

Bureau as leader

The sponsor's reaction function is given by its first order condition, (7.6). Differentiation of (7.6) yields:

$$\left[U^1_{QQ}/(1-p) - p\, U^2_{cc}/(1-p) \right] de + \left[e\, U^1_{QQ}/(1-p)^2 - e\, U^2_{cc}/(1-p)^2 \right] dp = 0 \quad (7.23)$$

$$\rightarrow p'(e) = p_e = -\left[U^1_{QQ} - p\, U^2_{cc} \right] (1-p) \,/\, \left[(U^1_{QQ} - U^2_{cc})\, e \right] < 0 \quad (7.24)$$

The sponsor will react to a reduction in effort by increasing the price to counter some of the effect on output. From (7.24) it follows that

$$0 < -p_e\, e/(1-p) = -p_e Q < 1 \qquad (7.25)$$

which implies that $dQ/de > 0$. The increase in price will not be sufficient to compensate for the whole reduction in effort. Output will therefore decrease. This reaction of the sponsor is parallel to what we found for the transfer system.

The bureau will maximize its utility, given the sponsor's reaction function.

$$e_p^S = \operatorname{argmax}_e \; V(p(e),e) = V^1(e/(1-p(e))) - V^2(e) \qquad (7.26)$$

$$\rightarrow V^1_Q \left[1 + e^S p_e/(1-p_p^S) \right] / (1-p_p^S) - V^2_e = 0 \qquad (7.27)$$

p(e) is given by (7.6) and p_e by (7.24).

$$V_Q^1 \left[1 - \left[U_{QQ}^1 - p_p^{\bar{S}} U_{cc}^2 \right] / \left[U_{QQ}^1 - U_{cc}^2 \right] \right] / (1-p_p^{\bar{S}}) - V_e^2 = 0 \qquad (7.28)$$

$$\rightarrow - \left[V_Q^1 \,(1-p_p^{\bar{S}})\, U_{cc}^2 \right] / \left[U_{QQ}^1 - U_{cc}^2 \right] (1-p_p^{\bar{S}}) - V_e^2 = 0 \qquad (7.29)$$

$$\rightarrow V_Q^1 \left[- U_{cc}^2 / (U_{QQ}^1 - U_{cc}^2) \right] - V_e^2 = 0 \qquad (7.30)$$

When (7.5) and (7.30) are compared to (3.17) – (3.18), we see that the equilibrium conditions are exactly equal for the two systems.[6] Therefore, the equilibrium outcome will be the same for the two schemes.

The intuition behind this result is as follows. For a given level of effort, the sponsor is free to choose the level of grants in the price system because the price can take any value between zero and one. For the bureau, it does not matter whether the sponsor sets grants directly, as in the transfer system, or indirectly through the price, as in the piece–rate system. The bureau is concerned about the impact of its strategic move on the final output and this will be independent of the effort level. For a given effort level, the sponsor will prefer one level of output and it will set the parameters of the scheme to achieve this output level independent of the scheme.

Our conclusion does not hold if the scheme a priori restricts the sponsor's choice of grants so that the original Stackelberg solution can not be enforced by the bureau (this point will be illustrated in section 7.3).

The equilibrium outcomes for the two schemes for the numerical utility functions are summarized in table 7.1. The sponsor will unambiguously prefer the piece–rate scheme. Its utility will be higher for all settings except the setting where the bureau leads for which it is indifferent between the two schemes. Equilibrium effort and output level will in each case be higher or equal for the piece–rate system.

The bureau's attitude towards the piece–rate system depends on the setting. It prefers the piece–rate system when the sponsor leads, it is indifferent when itself leads and it prefers the transfer system for the Nash–Cournot game.

This suggests that the reaction of the bureau to proposals of piece–rate schemes will vary according to the strategic relationship between sponsor and bureau. Since schemes where the authorities pay for output have been introduced in the public sector in some countries recently, an empirical study of the institutions' reactions to the new schemes would allow us to make inferences about the actual relationship between authorities and institutions in the public sector.

In chapter 4, we argued that the authorities' lack of incentives to sustain a tight budgetary policy creates a credibility problem that is an obstacle to higher efficiency. In this section, we have seen that – for the piece–rate system – the sponsor will only have minor incentives to deviate ex post from the Stackelberg solution with itself as leader provided r_Q is close to one. This is an argument in favour of the piece–rate system.

Markov perfect equilibria

We now compute a Markov perfect equilibrium for an infinite game where the sponsor sets the piece–rate and the bureau sets effort. In section 4.2, we found a subgame perfect equilibrium for a long finite game where the players move alternately. In this section, we consider an infinite alternating–move game, illustrated in figure 7.1. It turns out that we are able to find a Markov perfect equilibrium for the special case where $\partial V^1(Q)/\partial e$ is independent of p. This is a very restrictive assumption, and we are only aware of one utility function for which the assumption holds, our numerical utility function ln (e/(1–p)). It is straightforward to show that the following dynamic reaction functions constitute a Markov perfect equilibrium:

$$e = e^*$$

$$p = p(e)$$

where e^* is given by

$$V^1_Q \left[1 + p_e\, Q\, \delta\right] / (1-p(e^*)) - V^2_e = 0 \quad (7.31)$$

p(e) is the static reaction function, p_e is the derivative of p(e) with respect to e and δ is the bureau's discount factor.

To check whether these strategies constitute a Markov perfect equilibrium, we consider the effects on the players' discounted sum of one–period utilities of a slight deviation from the proposed equilibrium strategies. For each player, it is sufficient to consider a deviation from the equilibrium strategy in one period (Maskin & Tirole (87)).

Consider first the sponsor. Since the bureau's proposed reaction function is a constant, the sponsor's move does not influence the bureau's future moves. Therefore, the sponsor will maximize its one–period utility, taking the bureau's past and future moves as given. Thus, the dynamic and the static reaction functions are identical.

By assumption, the bureau's incremental utility in period t does not depend on p_{t-1}. Hence, the best response to p_{t-1} in period t is independent of p_{t-1}. Therefore, the dynamic reaction function must be a constant. To find e^*, we compute the incremental change in the bureau's discounted sum of utilities by a small increase in e_t (see figure 7.1). The bureau's move in period t+2 is e^*, causing the deviation in period t to have consequences only for three periods, t, t+1 and t+2. The bureau's utility in period t+3 is independent of its move in period t. The incremental changes in the bureau's utility for the three periods are given below:

Period t: $V^1_Q(p_{t-1},e_t)\,/(1-p_{t-1}) - V^2_e(e_t)$

Period t+1: $\delta\left[V^1_Q(p_{t+1},e_t)\,/(1-p_{t+1}) - V^2_e(e_t)\right] + \delta\, V^1_Q\, p_e\, e_t/(1-p_{t+1})^2$

Period t+2: $\delta^2\, V^1_Q(p_{t+1},e_{t+2})\, p_e\, e_{t+2}/(1-p_{t+1})^2$

e^* is found by adding the incremental utilities of the three periods, setting the sum equal to zero and inserting $e_t = e_{t+2} = e^*$. This operation gives us (7.31).

We see from the first order conditions of the Markov perfect equilibrium solution, the Nash–Cournot solution and the Stackelberg solution with bureau as leader that the two latter outcomes are special cases of the Markov perfect equilibrium. p(e) is equal for all three outcomes. Setting $\delta = 0/1$ in (7.32) gives us the Nash–Cournot solution and the Stackelberg solution with bureau as leader, respectively. The convergence of the Nash–Cournot solution and the Markov perfect equilibrium solution for $\delta = 0$ is parallel to what we found in chapter 4. However, it is a unique feature of this game that the Markov perfect equilibrium solution equals the Stackelberg solution for $\delta = 1$. As in chapter 4, we can therefore conclude that the Markov perfect equilibrium yields an effort level which is between the effort levels of the Nash–Cournot solution and the Stackelberg solution with bureau as leader. A parallel conclusion can not be drawn for grants since the Stackelberg solution with sponsor as leader is identical to the Nash–Cournot solution for our particular utility functions. The equilibrium solutions are:

$$p_p^S = p_p^N < p(e^*) < p_p^{\bar{S}}$$

$$e_p^{\bar{S}} < e^* < e_p^N = e_p^S$$

7.3 IMPLEMENTING A PIECE–RATE SYSTEM

In section 7.2, we assumed that the authorities could not impose any restrictions on p during the constitutional stage. When the bureau leads, this is a a serious disadvantage for the government. In practice, there are several ways the authorities can seek to improve its strategic position before the game of the parliamentary stage.

A transition to a piece–rate system must depart from the present system. The present equilibrium outcome gives the government information which helps it to formulate the rules. We would expect the rules to be more legitimate if they were based on the values of grants and output today, rather than on some mathematically derived incentive scheme. Consider the following rule. After the introduction of the new system, grants shall not exceed today's grants. If the institutions behave as if this rule could not be altered by their behaviour, we would expect the government's position to be strengthened.

In section 7.3, we shall assume that the sponsor is able to impose simple rules of thumb restrictions on the parameters of the scheme and explore how this affects the equilibrium outcomes for alternative settings. We will look at the following two simple rules:

A. The price of the piece–rate system shall equal present grants divided by present output

B. The price of a linear scheme shall equal 20% of present grants divided by present output. 80% of present grants shall be given as unconditional transfers.[7]

Both rules would give a level of grants and effort equal to the present outcome if the bureau does not vary effort. The bureau is therefore guaranteed not to be worse off after the new system is imposed. Therefore, it would be more politically acceptable for the sponsor to carry out the reform. Rule A outlines a piece–rate system where the price is given during the second, parliamentary, stage. Rule B sets up a linear scheme were both parameters are given during the second stage. The budget of the bureau is not immediately affected by the introduction of the new system, but the bureau can increase the budget by increasing effort.

We compute how the equilibrium outcomes of the three basic noncooperative games are affected when the sponsor imposes rules A and B, respectively, for the numerical utility functions. The results are shown in table 7.2.

For the Nash–Cournot game and the game where the sponsor leads, both agents will gain from a transition from the transfer system to a system based on rule A. The bureau prefers to increase effort above the old equilibrium level due to the substitution effect. This increase in effort is favourable to the sponsor.

When the bureau leads, the outcome changes significantly. Since effort is very low in the original equilibrium, the price per unit output will be high. The bureau will increase effort significantly after the new system is imposed and this will cause grants to increase. The result is that the bureau gains from the reform and the sponsor is considerably worse off. The sponsor gains from the increase in effort but this is more than compensated by the increase in grants. Once again, we see that the order of move between the agents is crucial for whether the sponsor will gain from the reform.

When rule B applies, the deviations from the old equilibria are smaller than for rule A because the reform is more modest. The outcome is that grants, effort and output will be raised for every basic game and that both agents are better off after the reform, independent of the initial game. The sponsor will therefore gain from an implementation of rule B for every game during stage two.

From the results of section 7.3, we can conclude that the authorities are able to construct reforms which are based on data from the present system that will improve efficiency and increase the utility of the authorities. The danger with the piece–rate system is that by setting the price too high, the authorities risk a vast budget increase. The revenues of the municipal sector are generally regulated by the federal authorities and they must therefore be careful in introducing reforms which expand their budgets. Any reform along these lines must therefore probably be accompanied by a ceiling on the amount of spending by the institutitons.

Rules A and B restrict the authorities' discretion in the parliamentary stage. The outcomes do not represent a pair of perfect equilibrium strategies if the government can set the price freely. It is hard to imagine a system where the government does not have discretion to change the parameters of the incentive scheme. Due to uncertainty, such as variations in the need for public services, there will generally have to be some adjustments of the schemes' parameters. It will be a problem for the authorities to distinguish between changes that are due to phenomena exogenous to the two agents, and adjustments which are directly caused by an institution's strategic behaviour. When setting the rules during the constitutional stage, the authorities must balance the need for flexibility against the strategic advantage gained through commitment.

7.4 DISCUSSION

This section is divided into two parts. In the first part, we summarize the implications of our analysis for the performance of output–related schemes. In the second part, we discuss the effects of a price system for the health sector.

The main conclusion to be drawn from the analysis of this chapter is that the effects of a piece–rate system on the institutions' efficiency depend on the nature of the game. When the institution moves first, the introduction of an output–related budget has no effect on the institution's effort unless the new scheme is accompanied by measures which decrease the government's utility of granting money. When the the agents move simultaneously, the efficiency of the institution will be increased. When the authorities move first, we can not draw any certain conclusion from our general model. However, for our numerical model, the efficiency will increase. We can therefore conclude that a price–system will probably have a more positive effect, the stronger is the strategic position of the authorities.

The introduction of an output–related scheme may not only change the equilibrium outcome of the game but also the game itself. If the budget reform affects the distribution of power between the agents, the one–period game which describes the interaction may no longer be valid. The order of moves may change.

In chapter 4, we discussed the relevance of the three basic one–period games for the public sector. We provided arguments why the nature of the political decision system will make it difficult for the authorities to undertake long–run commitments. The short–run bias of the political decision system reduces the potential of output–related schemes to improve institutions' efficiency. But so far, we have not considered the existence of uncertainty explicitly. In chapter 8, we shall see that the presence of cost uncertainty will affect the comparison of the two systems.

Introduction of price systems in the health sector

During the seventies and the beginning of the eigthies, worry about soaring costs of the health sector led governments to adjust the cost–based reimbursement system towards a pure grant–system where budget ceilings were imposed on the hospitals (Abel–Smith (84)). Attention was shifted from expansion of health services to containment of costs.

During the second half of the eighties, the attention of the health authorities has gradually focused more on the unfavourable consequences of a pure grant–system. The argument is that when the government sets an upper budget limit which is not tied to the number of patients, hospitals have insufficient incentives to utililize their resources and increase productivity. The prospective payment per patient system has been proposed as a remedy which eliminates both the weaknesses of the cost–based reimbursement system and the pure grant–system. By setting prices for treatment of different categories of patients, the hospitals are encouraged to increase production. Since prices are set according to national standards, hospitals have incentives to make the production as cost–efficient as possible, runs the argument. The most prominent of such per patient price–systems is the DRG–system used by Medicare in the US. The application of similar systems in Western Europe has been proposed by a number of researchers and public commissions.

In the years ahead, we will probably see that many European countries, including Norway and Sweden (Stm. 41 (87–88) and Stockholm lens landsting, rapport 1), introduce payment systems where the hospital budget depends on its output. According to our model, the effect of such reforms depends on how the interaction between authorities and the hospitals takes place. A vital question is whether the introduction of a price–system in itself will change the relative strength of the agents. If it does not, what is the relevant equilibrium concept? Concerning the second question we would expect the strategic position of the authorities to be weaker in the health sector than for other public sectors because the role of asymmetric information is particularly important for health services.

Concerning the first question, we have little experience in Europe with the DRG–system or other price per patient systems. However, there are quite a number of studies from the US which can help to throw light on the issue. The US experience gives little reason to believe that the strategic relationship between the authorities and the hospitals will be significantly changed when a price–system is introduced. The studies reveal that the making of the hospitals' budgets under the new system is characterized by a complex bargaining process which seems to be quite similar to the budget process of Scandinavian municipalities where the grant–system dominates.

One of the reasons why this is so, is that even for the DRG–system, the agents have to negotiate about a number of matters where the behaviour of the authorities can be affected by the hospitals. First, a price–system will not include all patients. Medicare reimburses costs individually when the length–of–stay exceeds a predetermined value or when the treatment is particularly costly (Ellis & McGuire (86), pp. 139). Second, some hospitals carry out national tasks like for instance teaching medical students at university level which require additional resources (Newhouse (83)). Third, case studies of the New Jersey project – where the DRG–system has been applied since 80 (Weiner et al (87) and Hsiao & Dunn (87)) – have shown that the prices tend to be based on the hospitals' historical costs rather than on national standards for the costs of medical services. Fourth, the studies of the New Jersey project showed that prices were adjusted after the introduction of the system following negotiations between state authorities and the hospitals. Fifth, the quality of the capital equipment of hospitals varies. Therefore, the introduction of a price–system must be accompanied by negotiations in order to compensate hospitals which need expensive investments in the years to come.

If it is correct that the introduction of the DRG–system does not significantly affect the strategic relationship between the authorities and the hospitals, we know that the resulting change in efficiency depends on the character of this relationship. Therefore, empirical studies of how grants, efficiency and output are affected by the new system may provide evidence about the relevance of our basic noncooperative games.

ENDNOTES

[1]Some of the contributions in the tradition of the theory of regulation model dynamic games where the sponsor's choice of reward function depends on the outcome of past periods. Freixas et al (85) is an example of a model with hidden information where the incentive–scheme in the second period is affected by the bureau's behaviour in the first period. However, these models still assume that the sponsor is the leader in each single game of the supergame.

[2]The term, "parliamentary stage", is used by writers in the public choice tradition, but – to my knowledge – not by Buchanan himself.

[3]To restrain the policy makers from making shortsighted decisions, Buchanan proposes that the constitution should be amended to make sure that federal budgets are balanced (Buchanan & Wagner (77) and Buchanan et al (78)) and to set an upper limit for the tax level (Brennan & Buchanan (80)). Buchanan (78) is a brief survey and Buchanan (86) a more extensive outline of his political philosophy.

[4]This view is expressed by Levitt & Joyce (87), who writes at pp. 163: "Our examination of a variety of public services suggests that there is much greater scope for the quantification of output and performance in government than has been common hitherto. Genuine conceptual and statistical problems face any attempt to undertake such quantification, but the lack of priority attached to such work in the past is probably the main explanation for the dearth of quantification."

[5]NOU 84:23, pp. 9, discusses dysfunctional consequences of the evaluation of productivity in the public sector.

[6]The equations (3.17) – (3.18) are for the setting with sponsor as leader. However, the equilibrium conditions will be the same when the name of the variables are interchanged for the setting where the bureau leads.

[7]This is close to the system proposed by NOU 87:25 for Norwegian hospitals.

REFERENCES

Abel–Smith, B. 1984: Cost Containment in Health Care, Occasional Paper 73, Bedford Square Press, London.

Besanko, D. & Sappington, D. 1987: Designing Regulatory Policy with Limited Information, Fundamentals of Pure and Applied Economics; vol 20, Harwood Academic Publishers, Chur, Switzerland.

Brennan, G. & Buchanan, J. 1980: The Power to Tax, Analytical Foundations of a Fiscal Constitution, Cambridge University Press, Cambridge.

Buchanan, J. 1978: From Private Preferences to Public Philosophy: The Development of Public Choice, in The Economics of Politics, Institute of Economic Affairs, London.

Buchanan, J. 1986: Liberty, Market and State, New York University Press, New York.

Buchanan, J. & Wagner, R. 1977: Democracy in Deficit, Academic Press, New York.

Buchanan, J., Burton, J. & Wagner, R. 1978: The Consequences of Mr Keynes, Hobart Paper 78, Institute for Economic Affairs, London.

Dixit, A. 1986: Comparative Statics for Oligopoly, International Economic Review 27, 107–122.

Ellis, R. & McGuire, T. 1986: Provider Behaviour under Prospective Reimbursement, Journal of Health Economics 5, 129–151.

Freixas, X., Guesnerie, R. & Tirole, J. 1985: Planning under Incomplete Information and the Ratchet Effect, Review of Economic Studies 52, 173–191.

Hofstede, G. 1981: Management Control of Public and not–for–profit Activities, Accounting, Organizations and Society 6, 193–211.

Hsiao, W. & Dunn, D. 1987: The Impact of DRG Payment on New Jersey Hospitals, Inquiry 24, 212–220.

Levitt, M. & Joyce, M. 1987: The Growth and Efficiency of Public Spending, Cambridge University Press, Cambridge, UK.

Magnussen, J. 1988: Stykkprisfinansiering av sykehus, NIS rapport 23/88, Trondheim.

Newhouse, J. 1983: Two Prospective Difficulties with Prospective Payment of Hospitals, or, It's Better to be a Resident than a Patient with a Complex Problem, Journal of Health Economics 2, 269–274.

Niskanen, W. 1971: Bureaucracy and Representative Government, Aldine–Atherton, Chicago.

NOU 84:23 Produktivitetsfremmende reformer i statens budsjettsystem

NOU 87:25 Sykehustjenester i Norge

Olson, O. 1989: Still Relevant, mimeograph, Norges Handelshøyskole.

Stm. 41 (87–88) Helsepolitikken mot år 2000 Nasjonal Helseplan, Oslo.

Stockholm Lens Landsting, rapport 1, 1990., Stockholm.

Weiner, S., Maxwell, J., Sapolsky, H., Dunn, D. & Hsiao, W. 1987: Economic Incentives and Organization Realities: Managing Hospitals under DRGs, The Milbank Quarterly 65, 463–487.

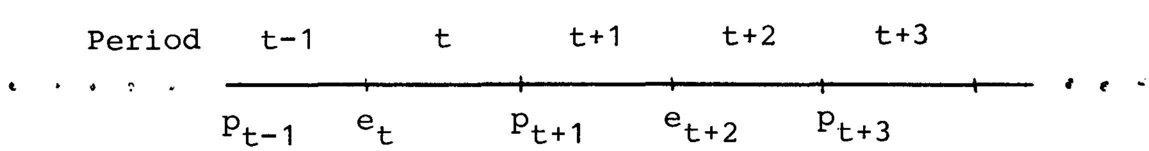

Figure 7.1: Infinite game with alternate moves for the piece-rate system

		c	e	Q	U	V
(Nash) Cournot	Piece-rate system	0.8740	1.4142	2.2882	0.6368	0.3278
	Transfer system	1.0000	1.0000	2.0000	0.4431	0.4431
Sponsor as leader	Piece-rate system	0.8740	1.4142	2.2882	0.6368	0.3278
	Transfer system	0.6781	1.1118	1.7989	0.4691	0.2782
Bureau as leader	Piece-rate system	1.1118	0.6871	1.7989	0.2782	0.4691
	Transfer system	1.1118	0.6871	1.7989	0.2782	0.4691

Table 7.1: Equilibrium outcome for the two schemes for alternative settings

		c	e	Q	U	V
(Nash) Cournot	Transfer system	1.0000	1.0000	2.0000	0.4431	0.4431
	Rule A	1.4142	1.4142	2.8284	0.5397	0.5397
	Rule B	1.0104	1.0670	2.0774	0.4772	0.4465
Sponsor as leader	Transfer system	0.6871	1.1118	1.7989	0.4691	0.2782
	Rule A	0.8741	1.4142	2.2883	0.6368	0.3278
	Rule B	0.6916	1.1658	1.8574	0.4996	0.2794
Bureau as leader	Transfer system	1.1118	0.6871	1.7989	0.2782	0.4691
	Rule A	2.2879	1.4142	3.7021	0.0004	0.8089
	Rule B	1.1612	1.0378	2.1990	0.4509	0.5187

Table 7.2: Equilibrium outcome for transfer system and two different piece-rate system cases (Rule A and Rule B are defined in the text)

			c	e	Q	U	V
(Nash) Cournot	Transfer system	Before cuts	1.0000	1.0000	2.0000	0.4431	0.4431
		After cuts	0.9635	1.0123	1.9758	0.3982	0.4248
	Piece-rate system	Before cuts	0.8740	1.4142	2.2882	0.6368	0.3278
		After cuts	0.8023	1.4142	2.2165	0.5924	0.2959
Sponsor as leader	Transfer system	Before cuts	0.6871	1.1118	1.7989	0.4691	0.2782
		After cuts	0.5921	1.1488	1.7409	0.4347	0.2247
	Piece-rate system	Before cuts	0.8740	1.4142	2.2882	0.6368	0.3282
		After cuts	0.8023	1.4142	2.2165	0.5924	0.2959
Bureau as leader	Transfer system	Before cuts	1.1118	0.6871	1.7989	0.2782	0.4691
		After cuts	1.0634	0.7175	1.7808	0.2387	0.4484
	Piece-rate system	Before cuts	1.1118	0.6871	1.7989	0.2782	0.4691
		After cuts	1.0488	0.6921	1.7409	0.2245	0.4347

Table 7.3: Equilibrium outcome before and after a cut in federal grants to the local authorities equal to 0.1.

CHAPTER 8

INCENTIVE SCHEMES UNDER COST UNCERTAINTY

8.1 INTRODUCTION

In chapter 7, we discussed how a piece–rate scheme performs compared to the pure transfer system when there is no uncertainty. In this chapter, we retain the assumption that output is observable and verifiable and introduce cost uncertainty. The sponsor can not observe effort, nor infer it from grants and output because it does not know the correct production function. The bureau has private information about true costs and effort. It will therefore want to exploit its informational advantage by setting effort low. The sponsor will try to counter its handicap by constructing output dependent incentive schemes which encourage the bureau to raise effort.

The success of the incentive scheme depends on the sponsor's ability to enforce the scheme ex post. For chapter 8, we will assume that the sponsor is the Stackelberg leader for each period. After an incentive scheme is announced for a period, the sponsor can not deviate from the reward prescribed by the scheme. For games where the relationship is repeated for many periods, the sponsor is free to change the scheme for each period.

In chapter 5, we considered a model where the sponsor could observe effort but not output. An important difference between the models of chapters 5 and 8 is that we now assume that output is both observable and verifiable while we assumed that effort was observable but not verifiable in chapter 5. Therefore, in this chapter, the sponsor is able to construct output–contingent schemes while it could not make grants conditional on effort in chapter 5. The asymmetric treatment of the uncertainty in the two chapters is due to the fact that effort is harder to define and verify than output.

The literature distinguishes between two types of asymmetric information which are relevant for our analysis. When the sponsor faces a moral hazard problem, both agents have incomplete information at the time the incentive scheme is formulated. For an adverse selection problem, the bureau knows the production function when the incentive scheme is set.

When one or both types of asymmetric information is present, the sponsor is unable to assess whether low output is due to low effort. The bureau has incentives to set effort low and afterwards claim that low output is the result of high costs or bad luck. When the relationship is repeated, the incentives of the bureau to reduce effort are even stronger due to the so–called ratchet effect. A high output level will tempt the sponsor to reduce grants and this restrains the bureau from setting a high effort level.

In previous chapters, we did not assume that the sponsor had to guarantee the bureau a minimum level of expected utility. However, it is not meaningful to construct optimal schemes when the bureau do not have a reservation utility. In that case, the sponsor can force the bureau to increase effort to an arbitrarily high extent. In order to avoid such counterintuitive implications, we assume that the sponsor's scheme must satisfy a reservation utility restriction. For the public sector, such a restriction can be justified by assuming that a reduction in the bureau's expected utility inflicts political costs on the sponsor (see the discussion in section 2.3).

In section 8.2, we compute the optimal incentive scheme when there is pure moral hazard and relate the result to the general literature on moral hazard. In section 8.3, we reformulate the model to make the sponsor's problem comparable to the principal's problem in adverse selection models and derive the optimal scheme. Section 8.4 extends the model of section 8.3 to multi–period games. The last section, 8.5, discusses the implications of the results for the regulation of public sector institutions.

The output of the bureau is given by the same production function as in chapter 5:

$$Q = c + e + \varphi \qquad (8.1)$$

The error term, φ, is independent of c and e. The sponsor can observe Q and c but not e and φ. The utility functions of the sponsor and the bureau are the same as in the preceding chapters:

$$U(Q,c) = U^1(Q) - U^2(c) \qquad (8.2)$$

$$V(Q,e) = V^1(Q) - V^2(e) \qquad (8.3)$$

For some of the calculations, we will carry out numerical simulations. We will then apply the usual numerical utility functions, (3.2') and (3.3').

In section 8.2, we assume that the stochastic variable is not realized before the bureau sets effort. The sponsor can observe output and grants, and this enables it to infer e + φ, but not effort. The sponsor formulates an incentive scheme which makes grants dependent on e + φ, or – more realistically – on output. In practice, the sponsor will supply funds to the bureau during the budget period, and will make the total amount of grants dependent on the bureau's production. The bureau must set effort without knowledge about φ.

This formulation of the model, makes it parallel to the standard moral hazard model of the agency literature (Holmstrøm (79) or Shavell (79)). However, as discussed in chapter 2, the assumptions underlying the models differ in several respects:

– In the model of Holmstrøm (79), the agent's reward has no ex post influence on the output, only an ex ante influence through the agent's choice of effort. In our model, the bureau's budget is a factor of production which affects output ex post. While our production function is linear and the error term is independent of the other factors of production, Holmstrøm's production function is more general.

– Holmstrøm's principal derives utility from the value of output minus the agent's reward. Our sponsor dislikes granting money and derives utility from total output. Therefore, the utility functions are basically similar although our sponsor's utility function is separable in output and grants.

– Both Holmstrøm's agent and our bureau dislike effort. While Holmstrøm's agent derives utility from its reward, our bureau cares about total output.

As we shall see in section 8.2, these differences in the modeling of the utility functions and the production technology have important implications for the first and second best schemes of the models.

In section 8.3, we change the assumptions concerning the production process. We assume that φ can take one of two values, and that the realization of φ can be observed by the bureau before effort is set. Like in the moral hazard model, the sponsor observes e + φ and makes grants conditional on output. An optimal scheme consists of two pairs of grants and output among which the bureau can choose. The model will now be a parallel to standard adverse selection models (for instance the models of Sappington (83) and Laffont & Tirole (87), section 2).

It is convenient to compare the assumptions of our model and the model of Sappington (83) because Sappington reformulates Holmstrøm's model in a way that is parallel to our reformulation in section 8.3 of the model in section 8.2. Therefore, it follows that the differences are similar to those outlined above in comparing Holmstrøm's model and our section 8.2 model. An additional difference is that Sappington assumes that the principal and the agent are risk neutral in profit while our sponsor and bureau are risk averse in output.

Using the utility functions (3.2') – (3.3'), we run a numerical simulation where we compare the performance of the optimal scheme with two alternative, simplified schemes, the transfer system and the piece–rate system. The two schemes can be viewed as special cases of a linear incentive scheme.

In section 8.4, we extend the numerical model of section 8.3 to a two–period model. We apply the perfect Bayesian equilibrium concept to calculate the outcome for the transfer system and the piece–rate system, respectively.

8.2 A MORAL HAZARD MODEL

Let us define efficiency, E, as:

$$E = e + \varphi \qquad (8.4)$$

The sponsor can observe output and can therefore infer efficiency from (8.1) and (8.4). The bureau must set effort before it knows the realization of φ, but after the incentive scheme is announced by the sponsor. In practice, the incentive scheme is a function of output but it is more convenient to write the incentive scheme as a function of efficiency, c(E). The stochastic term, φ, has probability distribution, $f(\varphi) = f(E-e)$. It follows that:

$$df(E-e)/de = -f'(E-e)$$

$$df(E-e)/dE = f'(E-e)$$

We will not state a priori the exact form of f(E–e). However, we would generally expect f'(E–e) to be positive for low values of φ and negative for high values of φ. An increase in effort will make high efficiency more probable and low efficiency less probable. It follows from the production function that $F_e(E) < 0$, where F(E) is the cumulative probability function of E, conditional on effort. An increase in effort yields a new probability distribution of E which dominates the old by first order stochastic dominance.

The minimum expected utility of the bureau is denoted $\bar{V}$. The Lagrange multipliers of the sponsor's optimization problem are λ and μ.

First best scheme

If effort can be observed, there is no moral hazard problem. The sponsor can induce the bureau to choose the optimal effort level by threatening to set grants very low for other values of effort. However, there will be stochastic shocks which the sponsor must take into account when formulating the incentive scheme. The problems caused by exogenous variations in efficiency are dealt with through a first best scheme, $c_\lambda(E)$, which gives an ex ante Pareto–optimal combination of output and grants as a function of efficiency. Contrary to effort, the budget is set after φ is observed. Therefore, it will be the sponsor who carries the burden of smoothing fluctuations in output. The contribution of the bureau is through the first best choice of effort ex ante. The first best scheme is found by maximization of the sponsor's expected utility, given the condition that the expected utility of the bureau shall exceed $\bar{V}$:

$$\text{Max}_{\ c(E),e} \int \left[U^1(c(E)+E) - U^2(c(E))\right] f(E-e)\, d\varphi \qquad (8.5)$$

$$(\lambda) \quad \int V^1(c(E)+E)\, f(E-e)\, d\varphi - V^2(e) \geq \bar{V} \qquad (8.6)$$

It is straightforward to show that the operator of (8.6) is an equality. Otherwise, the sponsor can increase its expected utility by decreasing grants and compensate with an increase in E to hold output constant. From (8.4), we see that this will decrease the expected utility level of the bureau. Therefore, the sponsor will not want to make the reward function better for the bureau than strictly necessary. Point–wise maximization of (8.5) – (8.6) with respect to c(E) yields:

$$\left[U^1_Q(c_\lambda(E)+E) - U^2_c(c_\lambda(E))\right] / V^1_Q(c_\lambda(E)+E) = \lambda \qquad (8.7)$$

where $c_\lambda(E)$ is the first best scheme. λ is the shadow–price of the sponsor's expected utility with respect to the bureau's expected utility and is therefore negative. An increase in $\bar{V}$ will make the sponsor worse off. Therefore, the parenthesis of (8.7) is negative.

We now introduce the sponsor's static reaction function, $c_*(E)$. $c_*(E)$ is the sponsor's preferred level of grants for a given level of effiency and is given by maximization of (8.5) without constraints, implying that $\lambda = 0$

It follows directly from (8.7) that $c_\lambda(E) > c_*(E)$. The first best scheme implies a grant level above the grant level corresponding to the sponsor's reaction function. This result is due to positive external effects by grants on the bureau's utility.

We now solve for $c_\lambda'(E)$. A total differentiation of (8.7) yields (arguments of the utility functions are omitted):

$$U^1_{QQ}\,(dc + dE) - U^2_{cc}\,dc = \lambda\left[V^1_{QQ}\,(dc + dE)\right] \qquad (8.8)$$

We insert for λ from (8.7) in (8.8):

$$dc/dE = c_\lambda'(E) = -1 - U^2_{cc}/\left[(U^1_{QQ} - U^2_{cc}) - (U^1_Q - U^2_c)V^1_{QQ}/V^1_Q\right] \qquad (8.9)$$

We see from (8.9) that $-1 < c_\lambda'(E) < 0$. The first best incentive scheme can also be expressed as a function of output:

$$c_\lambda'(Q) = 1 - dE/dQ = 1 - 1/(dQ/dE) = (dc/dE)/(1 + dc/dE) < 0 \qquad (8.10)$$

The first best scheme implies that the sponsor increases grants when the efficiency decreases in order to smooth variations in output. However, the increase in grants will not be enough to offset the whole reduction in effort. Therefore, grants will be a negative function of output.

The derivative of $c_*(E)$ is found by a total differentiation of (8.8), setting $\lambda = 0$:

$$c_*'(E) = -1 - U^2_{cc}/\left[(U^1_{QQ} - U^2_{cc})\right] \qquad (8.11)$$

When comparing (8.9) and (8.11), we see that $-1 < c_\lambda'(E) < c_*'(E) < 0$. The extent of output smoothing is higher for the first best scheme due to the external effects of grants.

$c_\lambda'(E)$ depends on the sponsor's risk aversion with respect to output and its preferences concerning variations in the bureau's budget, expressed by U^2_{cc}. When the sponsor has strong preferences for a particular output level, the absolute value of U^1_{QQ} is relatively high and a significant part of the variations in efficiency will be countered by the sponsor. When the sponsor's marginal disutility of granting money increases fast as a function of grants, we arrive at the opposite conclusion.

The first best scheme is also affected by the bureau's preferences concerning variations in output. If the bureau is risk neutral, $c_\lambda'(E) = c_*'(E)$, because the sponsor's risk aversion is the only cause of output smoothing. As the bureau becomes more risk averse ($-V^1_{QQ}/V^1_Q$ increases), the degree of output smoothing increases.

We will briefly state how and why our results differ from those of the moral hazard model of Holmstrøm (79). The first best schemes of the two models are quite different. In Holmstrøm's model, a decrease in the value of output causes the agent's reward to decrease. The principal and the agent share the exogenous risk. The opposite is the case in our model. A decrease in output caused by exogenous factors will make the sponsor increase the bureau's budget. This disparity of the two models is due to the difference between the two production functions. If the bureau's reward is a production factor, the principal has less incentives to reduce the reward when output falls than if output is independent of the reward. If Holmstrøm's model is changed so that output is affected ex post by the agent's reward, the first first best scheme of his model would be more similar to our first best scheme. However, still the two first best schemes would not necessarily be equal because the production function of Holmstrøm is more general than ours.

The form of the first best scheme neatly illustrates a fundamental problem in public budgeting. The authorities dislike fluctuations in output of public services. They will therefore want to compensate with extra grants when an institution faces problems. But by being rewarding when there is low efficiency, the institutions have poor incentives to improve effort.[1]

<u>Optimal scheme under moral hazard</u>

We now compute the optimal incentive scheme, $c_\mu(E)$, given that effort can not be observed. The bureau will set effort to maximize its expected utility. Therefore, we must add an incentive compatibility constraint to (8.5) – (8.6). To simplify the analysis, we will write this constraint as the first order condition of the bureau's maximization problem. This is commonly done in the literature on moral hazard. Grossman & Hart (83) and

Rogerson (85) discuss when this simplification can be carried out for the standard agency problem. In addition, we assume that the maximization problem of the bureau has an interior solution where the second derivative of its utility function with respect to effort is negative. The sponsor's optimal choice of incentive scheme is given by the following maximization problem:

$$\mathrm{Max}_{\,c(E),e} \int \left[U^1(c(E)+E) - U^2_c(c(E))\right] f(E-e)\, d\varphi \qquad (8.12)$$

$$(\lambda) \quad \int V^1(c(E)+E)\, f(E-e)\, d\varphi - V^2(e) \geq \bar{V} \qquad (8.13)$$

$$(\mu) \quad \int - V^1(c(E)+E)\, f'(E-e)\, d\varphi - V^2_e(e) = 0 \qquad (8.14)$$

Point–wise maximization of (8.12) – (8.14) with respect to c(E) yields:

$$\left[U^1_Q(c_\mu(E)+E) - U^2_c(c_\mu(E))\right] / V^1_Q(c_\mu(E)+E) = \lambda - \mu\, f'(E-e)/f(E-e) \qquad (8.15)$$

Setting $\mu = 0$ in (8.15) gives us the first order condition of the first best scheme. The second term on the right hand side captures the incentive effect of the scheme. The first best reward function will be adjusted to provide the bureau with better incentives.

For the moral hazard problem of the classic setting, Holmstrøm (79) provides a proof of the sign of the second Lagrange multiplier, μ. We will use the same technique to prove that $\mu \lneq 0$ provided $(U^1_Q - U^2_c) < 0$, that is, if $c_\mu(E) > c_*(E)$. The proof is given below.

When $\mu < 0$, the second term in (8.15) is positive for $f'(E-e) > 0$ and negative for $f'(E-e) < 0$. As long as $(U^1_Q - U^2_c) < 0$, it is straightforward to show that this implies the following relationship between $c_\mu(E)$ and $c_\lambda(E)$:

$$c_\mu(E) \lessgtr c_\lambda(E) \text{ for } f' \gtrless 0 \qquad (8.16)$$

Expression (8.16) shows that the first best scheme will be modified according to the information signalled by the efficiency variable. When efficiency is high, the bureau will receive a higher budget than for the first best scheme. When efficiency is low, the opposite is the case. Therefore, the second best scheme reflects the trade–off between output smoothing and the need to provide the bureau with favourable incentives. We can not in general say whether the bureau's budget is an increasing or decreasing function of efficiency. That will depend on the sponsor's preferences for output smoothing and how severe the moral hazard problem is. Our conclusion that the second best scheme is a modification of the first best scheme depending on the information content of output, is similar to the results of standard agency models (Holmstrøm (79)).

<u>PROPOSITION 8.1:</u> Assume that $c_{\mu}(E) > c_{*}(E)$. Then $\mu \leq 0$

<u>Proof</u>

We start by assuming that $\mu > 0$ and then show that this assumption leads to a contradiction. The proof requires $(U_Q^1 - U_c^2)$ to be negative, hence $c_{\mu}(E) > c_{*}(E)$. First, we state the first order condition of the sponsor's optimization program, (8.12) – (8.14), with respect to e:

$$\int - U(c_{\mu}(E),E)\, f'(E-e)\, d\varphi \; - \mu \int \left[V(c_{\mu}(E),E)\, f''(E-e) - V_{ee}^2(e)\right] d\varphi \; = 0 \quad (8.17)$$

The second integral of (8.17) is the second derivative the bureau's utility function with respect to effort and is negative, provided the bureau's optimization problem has an interior solution. Since by assumption, $\mu > 0$, the first integral must be negative for the equality to hold. However, we proceed to show that the integral must be positive if $\mu > 0$.

The first step is to show that our assumption concerning μ implies that:

$$c_{\mu}(E) \gtrless c_{\lambda}(E) \;\; \text{for} \;\; f'(E-e) \gtrless 0 \qquad (8.18)$$

(8.18) is valid in general, but it is particularly easy to see that (8.18) is correct if $(U_Q^1 - U_c^2) < 0$ because $\left|(U_Q^1 - U_c^2)/V_Q^1\right|$ is then increasing in c for a given E.

Next, we apply the result that $U(c_{\lambda}(E),E)$ is monotonically increasing in E. This follows from (8.9) since an increase in E will decrease grants and increase output, making the sponsor unambiguously better off. By first order stochastic dominance, it follows that:

$$\int - U(c_{\lambda}(E),E)\, f'(E-e)\, d\varphi > 0 \qquad (8.19)$$

The last step is to show that

$$\int - U(c_\mu(E),E)\, f'(E-e)\, d\varphi > \int - U(c_\lambda(E),E)\, f'(E-e)\, d\varphi. \quad (8.20)$$

When $f'(E-e) < 0$, (8.18) implies that $c_*(E) < c_\mu(E) < c_\lambda(E)$. This result and assumptions A1–A2 yield that $U(c_\mu(E),E) > U(c_\lambda(E),E)$. When $f'(E-e) > 0$, a parallel argument reveals that $U(c_\mu(E),E) < U(c_\lambda(E),E)$. Hence, we have shown that $\left[U(c_\mu(E),E) - U(c_\lambda(E),E)\right]$ $f'(E-e)$ is always < 0, implying (8.20). It follows from (8.19) and (8.20) that

$$\int - U(c_\mu(E),E)\, f'(E-e)\, d\varphi > 0. \quad (8.21)$$

We have shown that (8.17) can not be correct if $\mu > 0$. Thus, we have arrived at a contradiction which implies that $\mu \leq 0$.

Q.E.D

To find $c_\mu'(E)$, we undertake a total differentiation of (8.15):

$$c_\mu'(E) = -\frac{\left[U^2_{cc} - \mu\, V^1_Q\, (f')^2/f + \mu\, V^1_Q\, (f''/f)\right]}{\left[(U^1_{QQ} - U^2_{cc}) - (U^1_Q - U^2_c)V^1_{QQ}/V^1_Q\right]} - 1$$

$$\rightarrow c_\mu'(E) = c_\lambda'(E) + \mu V^1_Q \left[(f')^2/f - f''\right] / \left[(U^1_{QQ} - U^2_{cc}) - (U^1_Q - U^2_c)V^1_{QQ}/V^1_Q\right] f \quad (8.22)$$

For a single peaked, bellshaped probability distribution, f'' is negative for realizations with high probability density. For these realizations of efficiency, the second term of the RHS of (8.22) is positive, hence, $c_\mu'(E) > c_\lambda'(E)$. Therefore, the optimal scheme under moral hazard in general implies less output smoothing than the first best scheme. As output smoothing gives the bureau poor incentives, the degree of output smoothing is restricted compared to what would take place without incentive problems.

We can not draw any precise conclusions for the public sector from the analysis above. The ideal situation, as seen by the authorities, is to be able to command the institutions to set the effort level high and then use grants to smooth variations in output. When effort can not be observed, variation in grants have two purposes, to smooth output and to give the institutions incentives to increase effort. Grants should be increased compared to the full information scheme when output indicates that the effort level has been high.

The literature on moral hazard (Baiman (82) and Hart & Holmstrøm (87) are extensive surveys of this literature) suggest other instruments by which the authorities may improve the institutions' incentives.

First, when there exists several institutions with correlated error terms, the authorities can use information about the performance of all institutions to estimate the effort level of a single institution.

Second, the authorities can design a monitoring system which conveys information about the effort level in addition to the information given by observation of output. Knowledge of the production technology gives the authorities an estimate of the minimum resources required for a given output level. By comparing estimates of minimum costs with historical accounts, the authorities will get an impression of the effort level of the institutions.

The investigation can be made output conditional. The authorities could state that an investigation will be conducted whenever the output/cost ratio drops below a certain limit. Such a scheme, which is proposed by Baiman & Demski (80), would be less expensive than auditing every period and motivates risk averse institutions to increase effort.

Gjesdal (82) discusses how the scheme will depend on the follower's utility function. We have assumed that the bureau's utility function is separable in output and effort. If that is not the case, it can be sensible for the leader to randomize the reward. Risk is imposed on the follower and – under some circumstances – it will react by increasing effort. This will make expected output higher, which can benefit both parties.

As seen by the public institutions, there is much "noise" in the reward function generated by the political decision process. The institutions do not know with certainty the consequences of alternative actions. Political bodies can not generally commit themselves to long term schemes. In chapter 4 we argued that the authorities' ability to commit themselves to a long term policy is important for the effort levels of the institutions. However, the argument of Gjesdal (82) shows that the uncertainty created by the political process can have positive effects on efficiency. If the institutions dislike uncertainty they may try to increase effort in order to avoid fluctuations in output.

The moral hazard problem can be countered by the authorities if the game is repeated for many periods. If the authorities know the probability distribution of E, they are able to compute the average effort level as the number of periods increases. By making grants dependent on past and present effort, the authorities can induce the institutions to set the effort level closer to the outcome of the first best scheme.[2] The relationship between authorities and institutions is repetitive in the public sector. Therefore, we would expect the authorities to be able to counter the pure moral hazard problem in this way.

8.3 AN ADVERSE SELECTION MODEL

We will now assume that the bureau has private information about the true production function, that is, φ is known by the bureau before it sets effort. Neither effort nor the bureau's type is observed by the sponsor. The sponsor's problem is that it does not know whether output is high or low, given the bureau's production potential.

There are two types of bureaus. The production function of the bureau is given by (8.1), where $\varphi = \pm\, \theta$. θ is a parameter which describes the variation in costs among the bureaus. We will assume that $\varphi = \pm\, \theta$ with equal probability.

$$Q = c + e \pm \theta \qquad (8.23)$$

We will name the two types, high cost (H) and low cost (L) bureaus, respectively. The outcome of the game for the optimal scheme is denoted by adding the superscript H or L to the variables. The model is not stochastic in the sense that the bureau knows both its type and its effort level. The production technology of our model is now quite similar to the adverse selection model of Laffont & Tirole (87), section 2, except that they assume that output is given exogenously, and that the principal can observe costs instead of output.

An incentive scheme is a function, c(Q). We consider only deterministic schemes. The optimal scheme maximizes the expected utility of the sponsor given the bureau's IR and IC constraints. The sponsor offers the bureau a menu of combinations among which the bureau can choose. Invoking the revelation principle (Myerson (1979), Dasgupta et al (1979) and Harris & Townsend (1981)), we know that the optimal scheme shall separate the two types of bureaus when the stochastic variable is discrete. We can restrict the analysis to schemes which consist of two pairs, (c^H,Q^H) and (c^L,Q^L). This can be shown by the following argument; Consider an optimal scheme which does not consist of two pairs of outcome.

This scheme will induce the bureau to pick one of two different allocations, depending on the bureau's type. The sponsor can now construct another scheme consisting only of these two pairs of allocations. The new scheme will then yield the same outcome as the old scheme. Hence, it must also be optimal.

As a benchmark, we start by considering the optimal scheme when the sponsor knows the bureau's costs. When the sponsor can observe θ, it can compute effort from the production function since output is observable. The scheme is therefore the combination of grants and output which maximizes the sponsor's utility, provided the bureau's expected utility is equal to or above $\bar{V}$. By applying an argument parallel to that of section 8.2, we know that the sponsor does not want to give the bureau higher expected utility than strictly necessary, implying that the bureau's utility will equal its reservation utility.

Optimal scheme when the sponsor has complete information

When the bureau's costs are known, the sponsor will set the incentive scheme individually, depending on the type of the bureau. The maximization problems can be written as:

High cost bureau:

$$\text{Max}_{c,Q}\ U^1(Q) - U^2(c) \qquad (8.24)$$

$$(\lambda^H)\ \ V^1(Q) - V^2(Q-c+\theta) = \bar{V} \qquad (8.25)$$

Low cost bureau:

$$\text{Max}_{c,Q}\ U^1(Q) - U^2(c) \qquad (8.26)$$

$$(\lambda^L)\ \ V^1(Q) - V^2(Q-c-\theta) = \bar{V} \qquad (8.27)$$

The maximization problems give two pairs, (c^H,Q^H) and (c^L,Q^L), which depend on $\bar{V}$. The first order conditions of the two maximization problems are:

High cost bureau:

$$Q^H:\ U^1_Q(Q^H) + \lambda^H \left[V^1_Q(Q^H) - V^2_e(Q^H - c^H + \theta) \right] = 0 \qquad (8.28)$$

$$c^H:\ - U^2_c(c^H) + \lambda^H \left[V^2_e(Q^H - c^H + \theta) \right] = 0 \qquad (8.29)$$

We eliminate λ^H from the two equations:

$$U^1_Q(Q^H) - U^2_c(c^H) + U^1_Q(c^H)\, V^1_Q(Q^H) \,/\, V^2_e(Q^H - c^H + \theta) = 0 \qquad (8.30)$$

Low cost bureau:

$$Q^L:\ U^1_Q(Q^L) + \lambda^L \left[V^1_Q(Q^L) - V^2_e(Q^L - c^L - \theta) \right] = 0 \qquad (8.31)$$

$$c^L:\ - U^2_c(c^L) + \lambda^L \left[V^2_e(Q^L - c^L - \theta) \right] = 0 \qquad (8.32)$$

We eliminate λ^L from the two equations:

$$U^1_Q(Q^L) - U^2_c(c^L) + U^1_Q(c^L)\, V^1_Q(Q^L) \,/\, V^2_e(Q^L - c^L - \theta) = 0 \qquad (8.33)$$

We can draw (c^H,Q^H) and (c^L,Q^L) as curves in a diagram where each point on the curves corresponds to a value of $\bar{V}$. We denote the curves P' and P'', respectively. P' and P'' characterize the first best or Pareto–optimal combinations of grants and output for the two types of bureau.

The exact shape of the curves will depend on the utility functions. The diagrams of figure 8.1 correspond to the numerical utility functions, (3.2') – (3.3').

For the utility functions (3.2') – (3.3'), the curves are approximately vertical as in figure 8.1. $\bar{V}_j$, j = H, L, are the iso–utility curves for the minimum utility level of the two types. The sponsor prefers points in the diagram which are to the south–east. It will therefore pick the lowest points on the curves for which the bureau's utility is above $\bar{V}$. The high cost bureau will be offered the combination of grants and output at point A, and the low cost bureau the combination at point B. The favourable cost structure of the low cost bureau enables it to produce more output for lower grants.

Optimal scheme when the sponsor has incomplete information

Under certainty, the sponsor is able to capture the whole benefit from the low cost bureau by making individual contracts for each type of bureau. Under uncertainty, the sponsor lets the bureau choose among two pairs of grants/output, (c^H,Q^H) and (c^L,Q^L). The scheme maximizes the sponsor's expected utility, given the incentive compatibility and reservation utility constraints for both types of bureaus. The sponsor's maximization problem is:

$$\text{Max}_{c^H,Q^H,c^L,Q^L}\ 0.5\left[U^1(Q^H) - U^2(c^H) + U^1(Q^L) - U^2(c^L)\right] \qquad (8.34)$$

$$V^1(Q^H) - V^2(Q^H - c^H + \theta) \geq V^1(Q^L) - V^2(Q^L - c^L + \theta) \qquad (8.35)$$

$$V^1(Q^L) - V^2(Q^L - c^L - \theta) \geq V^1(Q^H) - V^2(Q^H - c^H - \theta) \qquad (8.36)$$

$$V^1(Q^H) - V^2(Q^H - c^H + \theta) \geq \bar{V} \qquad (8.37)$$

$$V^1(Q^L) - V^2(Q^L - c^L - \theta) \geq \bar{V} \qquad (8.38)$$

We will now argue that the operators of (8.36) and (8.37) can be written as equalities and that the inequalities, (8.35) and (8.38), are superfluous. We start by proving that (8.38) is superfluous when (8.36) and (8.37) hold.

First, we state that

$$V^1(Q^H) - V^2(Q^H - c^H - \theta) \geq V^1(Q^H) - V^2(Q^H - c^H + \theta). \qquad (8.39)$$

This follows from the fact that V^2 is increasing in its argument. Next, we combine (8.36), (8.37) and (8.39):

$$V^1(Q^L) - V^2(Q^L - c^L - \theta) \geq V^1(Q^H) - V^2(Q^H - c^H - \theta) \geq V^1(Q^H) - V^2(Q^H - c^H + \theta) \geq \bar{V}$$
(8.40)

From (8.40), we see that (8.38) is superfluous.

The argument that (8.36) is an equation follows immediately from the expression for the sponsor's utility function. The sponsor will gain from a lowering of c^L. As (8.38) is superfluous, we do not have to worry about the impact of a lowering of c^L on (8.38). The inequality in (8.35) will continue to hold as c^L is lowered. Therefore, there is no reason why the sponsor should not lower c^L until (8.36) holds as an equality.

The third step is to prove that (8.35) is superfluous. First, we assume that $Q^L \geq Q^H$. Then, the following inequality must hold:

$$Q^L - c^L \geq Q^H - c^H \qquad (8.41)$$

Otherwise, the high cost bureau would get more grants for less output by moving to (c^L, Q^L), implying that (c^H, Q^H) can not be the high cost bureau's best choice. Next, we rewrite (8.36):

$$V^1(Q^L) - V^1(Q^H) = V^2(Q^L - c^L - \theta) - V^2(Q^H - c^H - \theta) \qquad (8.42)$$

We insert (8.42) in (8.35):

$$V^2(Q^L - c^L + \theta) - V^2(Q^L - c^L - \theta) \geq V^2(Q^H - c^H + \theta) - V^2(Q^H - c^H - \theta) \qquad (8.43)$$

(8.43) compares the difference in $V^2(e)$ when we increase the argument with 2θ, from $Q^L - c^L - \theta$ to $Q^L - c^L + \theta$ and from $Q^H - c^H - \theta$ to $Q^H - c^H + \theta$, respectively. Since $V^2(e)$ is convex in its argument, the change in the function will be bigger when the argument is increased from $Q^L - c^L - \theta$ than from $Q^H - c^H - \theta$ because (8.41) states that $Q^L - c^L \geq Q^H - c^H$. Therefore, (8.43) is superfluous, which again implies that (8.35) is superfluous since (8.43) was formed by (8.36) – which is already proved to be an equation – and (8.35).

Second, assume that $Q^H > Q^L$. Then $Q^H - c^H$ must be greater than $Q^L - c^L$ by the same type of argument that implied (8.41). However, in that case, (8.43) can not hold, implying that Q^H can not exceed Q^L.

The last step is to show that (8.37) is an equality. From (8.35), we see that lowering c^H will enable the sponsor to decrease c^L. Both effects are positive as seen by the sponsor. A lowering of c^H until (8.37) can be written as an equality is therefore unambiguously to the advantage of the sponsor.

We can now rewrite the sponsor's maximization problem.

$$\text{Max}_{\,c^H,Q^H,c^L,Q^L}\ 0.5\left[\,U^1(Q^H)-U^2(c^H)+U^1(Q^L)-U^2(c^L)\,\right] \qquad (8.44)$$

$$(\lambda_1)\ V^1(Q^L)-V^2(Q^L-c^L-\theta)=V^1(Q^H)-V^2(Q^H-c^H-\theta) \qquad (8.45)$$

$$(\lambda_2)\ V^1(Q^H)-V^2(Q^H-c^H+\theta)=\bar{V} \qquad (8.46)$$

The first order conditions of the maximization problem are:

$$Q^H\!:\ 0.5\ U^1_Q(Q^H)-\lambda_1\left[\,V^1_Q(Q^H)-V^2_e(e^H-2\theta)\right]+\lambda_2\left[\,V^1_Q(Q^H)-V^2_e(e^H)\right]=0 \qquad (8.47)$$

$$Q^L\!:\ 0.5\ U^1_Q(Q^L)-\lambda_1\left[\,V^1_Q(Q^L)-V^2_e(e^L)\right]=0 \qquad (8.48)$$

$$c^H\!:\ -0.5\ U^2_c(c^H)-\lambda_1V^2_e(e^H-2\theta)+\lambda_2V^2_e(e^H)=0 \qquad (8.49)$$

$$c^L\!:\ -0.5\ U^2_c(c^L)+\lambda_1V^2_e(e^L)=0 \qquad (8.50)$$

The optimal scheme, (Q^H, Q^L, c^H, c^L), is defined by (8.45) – (8.50) and depends on $\bar{V}$. We eliminate λ_1 and λ_2 from (8.47) – (8.50):

$$U^1_Q(Q^H)\ -\ U^2_c(c^H)\ +\ U^1_Q(c^H)\ V^1_Q(Q^H)\ /\ V^2_e(e^H+2\theta)\ +\ \left[V^2_e(e^H)/\ V^2_e(e^H+2\theta)\ -\ 1\right]$$
$$U^2_c(c^L)/\ V^2_e(e^L)=0 \qquad (8.51)$$

$$U^1_Q(Q^L)-U^2_c(c^L)+U^1_Q(c^L)\ V^1_Q(Q^L)\ /\ V^2_e(e^L)\ =0 \qquad (8.52)$$

A comparison of the first order conditions under certainty, (8.30) and (8.33), with (8.51) –

(8.52), reveals that (8.33) and (8.52) are identical. The combination of grants and output chosen by the low cost bureau will therefore be Pareto–optimal which is a standard result in adverse selection models. (c^L,Q^L) will be situated at P'' (figure 8.2).

A comparison of (8.30) and (8.51) shows that the high cost bureau's choice of grants/output is not Pareto–optimal. The combination, (c^H,Q^H), which satisfies (8.30), will make the left hand side of (8.51) negative. This follows from the fact that the second term of (8.51) is smaller than the second term of (8.30) and the third term of (8.51) is negative, independent of c^L and e^L. Hence, the curve which gives the combination of c^H and Q^H, must move to the left compared to the P'. The new combination of c^H and Q^H is drawn as a broken curve in figure 8.2.

The intuition behind (8.51) – (8.52) is illustrated in figure 8.2. V', V'' are iso–utility curves for the low cost bureau. The optimal scheme under certainty is given by points A and B. When uncertainty is introduced, A and B do not constitute the optimal scheme because the low cost bureau prefers A to B. If the sponsor wants to keep point A as part of the scheme, the low cost bureau must be offered a combination of grants and output that is at least as favourable as at A. (c^H,Q^H) will therefore be set at C, which is the point where the curve of the sponsor's preferred combinations of grants and ouput cuts the low cost bureau's iso–utility curve through A, V'.

However, points A and C will not constitute the sponsor's optimal scheme. In order to squeeze the low cost bureau's grants, the sponsor will lower grants and output for the high cost bureau. The low cost bureau's utility can then be decreased to V''. The benefit from being able to reduce the grants to the low cost bureau more than offsets the loss from moving away from the first best combination of grants/output for the high cost bureau. The sponsor will reduce c^H and Q^H down to D where the marginal benefit from a further reduction equals the marginal cost. The low cost bureau will be offered the combination of grants and output given at E. It is indifferent between D and E.

For the utility functions (3.2') – (3.3'), the sponsor's preferred combinations yield curves which are nearly vertical. Moving from C to E will therefore keep output relatively constant while grants are decreased and effort is increased. When moving from A to D, output is reduced. The effort level of the high cost bureau must be reduced to keep the bureau's utility constant. Hence, by going from A and C to D and E, the sponsor sacrifices some of the high cost bureau's effort to increase the effort level of the low cost bureau.

The main result of the model, that the sponsor cuts the production of the high cost bureau to extract rent from the low cost bureau, is well known from the adverse selection literature (Sappington (83)). In both our model and that of Sappington, the combination of output and grants of the low cost bureau will be Pareto–optimal for the second best scheme, while the high cost bureau's preferred choice of grants/output is not Pareto–optimal.

However, the models differ in that the output of the low cost agent of Sappington's model will be the same for the first and second best schemes. In our model, the output of the low cost bureau will in general not be the same for the two schemes because the Pareto–optimal combinations of grants and output are not a vertical curve in the grants/output space as it is in the model of Sappington. This is due to the different specification of the utility functions of the two models. When the two agents maximize expected profit, the optimal production quantity is independent of how the profit is split between the agents. When the utility functions of the public sector agents are given by (8.2) and (8.3), optimal production will vary along the Pareto–optimal set.

Another important difference between the optimal schemes of the two models is the way the low cost bureau extracts rents. In Sappington's model, the low cost agent's rent is a money transfer. In our model, the rent extraction primarily takes the form as a reduction in effort. This is due to the difference between the utility functions of his agent and our bureau. We study non–profit institutions which can only extract rent by creating slack. Since the agents of Sappington's model are risk neutral and derive utility from profit, the production quantity – and therefore the effort level – of the low cost bureau is first best and the rent is extracted as profit. Results similar to our result can be found in models where the agent is profit–oriented but where the principal can observe its true costs (Laffont & Tirole (86)).

Another model, related to ours, is presented in Antle & Eppen (85). They consider a firm where the investors can not observe the true rate–of–return of the firm's different business projects. To reduce the opportunity of the manager to transfer profit to slack, investors will require a higher rate–of–return than the relevant opportunity cost of funds. This causes a reduction in the firm's production and a corresponding reduction in slack. As in our model, investors face a trade–off between allocative efficiency and X–efficiency.

Simulation of alternative incentive schemes

We will now compare the performance of the optimal scheme with the piece–rate system and the transfer system with sponsor as leader by running numerical simulations for alternative values of θ. We apply the numerical utility functions, (3.2') – (3.3').

All three schemes must guarantee the bureau a minimum utility level, $\bar{V}$. We have chosen $\bar{V}$ to be equal to the utility of an average bureau ($\theta = 0$) for the Nash–Cournot solution, hence $\bar{V} = 0.4431$.

For the piece–rate and transfer systems, the sponsor has only one instrument, the value of the price and grants, respectively. The three maximization programs are:

i) Optimal scheme

$$\text{Max}_{c^H, Q^H, c^L, Q^L}\ 0.5\left[\ln(Q^H) - (c^H)^2/4 + \ln(Q^L) - (c^L)^2\right] \qquad (8.53)$$

$$\ln(Q^L) - (e^L)^2/4 \ = \ \ln(Q^H) - (e^H - 2\theta)^2/4 \qquad (8.54)$$

$$\ln(Q^H) - (e^H)^2/4 \ \geq \ 0.4431 \qquad (8.55)$$

$$Q^H = c^H + e^H - \theta \qquad (8.56)$$

$$Q^L = c^L + e^L + \theta \qquad (8.57)$$

ii) Piece–rate scheme

$$\text{Max}_{p}\ 0.5\left[\ln(Q^H) - (c^H)^2/4 + \ln(Q^L) - (c^L)^2/4\right] \qquad (8.58)$$

$$e^H = \text{argmax}_{e}\ \ln(c^H + e - \theta) - e^2/4 \qquad (8.59)$$

$$e^L = \text{argmax}_{e}\ \ln(c^L + e + \theta) - e^2/4 \qquad (8.60)$$

$$Q^H = c^H + e^H - \theta \qquad (8.61)$$

$$Q^L = c^L + e^L + \theta \qquad (8.62)$$

$$c^H = p\, Q^H \qquad (8.63)$$

$c^L = p\,Q^L$ (8.64)

$\ln(c^H + e - \theta) - e^2/4 \geq 0.4431$ (8.65)

iii) Transfer system

$$\text{Max}_c\; 0.5 \left[\ln(c + e^H - \theta) + \ln(c + e^L + \theta) \right] - c^2/4 \qquad (8.66)$$

$$e^H = \text{argmax}_e \ln(c + e - \theta) - e^2/4 \qquad (8.67)$$

$$e^L = \text{argmax}_e \ln(c + e + \theta) - e^2/4 \qquad (8.68)$$

$$\ln(c + e - \theta) - e^2/4 \geq 0.4431 \qquad (8.69)$$

(8.55), (8.65) and (8.69) are the reservation utility constraints for the high cost bureau. The low cost bureau will be better off than the high cost bureau for a given price or a given level of grants, and we therefore do not have to write down its parallel constraint.

The solutions to the maximization programs are given in table 8.1. The expected utility of the sponsor is illustrated in figure 8.3.

Figure 8.3 shows that the piece–rate scheme performs better than the transfer system under certainty and when the uncertainty is small. Under these circumstances, the piece–rate system is a good substitute for the optimal scheme. When the uncertainty is high, the transfer system performs best. In order to ensure a high cost bureau the minimum utility level, the price must be set higher as the uncertainty increases. The low cost bureau will exploit the high price to gain a huge grant. As seen by the sponsor, the transfer system has the disadvantage that effort is low and the advantage that grants can be controlled by the sponsor directly. The advantage of the transfer system grows in importance as uncertainty is increased. Therefore, the transfer system dominates the piece–rate system when there is much uncertainty.

Table 8.1 illustrates that the optimal scheme and the piece–rate system give outcomes that are quite similar for small values of θ. Effort and output are significantly higher than for the transfer system.

When the degree of uncertainty increases, average effort of the optimal scheme falls. In order to reduce the rent extraction by the low cost bureau, the sponsor will reduce the output level of the high cost bureau. To prevent the utility of the high cost bureau from falling, e^H must be decreased. The effort level of the low cost bureau will also decrease as the uncertainty increases because the low cost bureau's gain from its information monopoly is partly due to its ability to decrease effort. Hence, when there is considerable uncertainty concerning the costs of the bureau, effort will be lower than under certainty. Since the bureau's utility must be above its reservation utility, the sponsor is forced to formulate an incentive scheme which implies low effort compared to the full information setting.

When there is much uncertainty, the piece–rate system gives too high effort. The sponsor must set the price high in order to fulfill the utility level guarantee. Since the piece–rate system gives the bureau incentives to set effort high, the combination of high effort and a high price will cause grants and output to increase vastly with increasing uncertainty. We would therefore expect a piece–rate system to perform badly when it is not combined with an upper limit on grants.

The transfer system yields an average effort level which is approximately constant. The sponsor must increase grants when uncertainty increases but it is able to control grants better than for the piece–rate system.

Average output will decrease with increasing uncertainty for the optimal scheme because the sponsor uses cuts in output as a tool to increase the effort of the low cost bureau. This is contrary to the effect of uncertainty on average output for the piece–rate system and the transfer system. These systems do not give the sponsor discretion to construct a reward function which guarantees the high cost bureau a minimum utility level by cutting effort instead of increasing grants and output.

We can conclude that uncertainty is unfavourable for the sponsor when every type of bureau shall have a utility above a minimum level. The sponsor must accept either a decrease in effort or an increase in grants as the gap between low productivity and high productivity bureaus widens. For the optimal scheme, a high degree of uncertainty implies a significant fall in effort and a small increase in grants. For the piece–rate system and the transfer system, uncertainty primarily leads to higher grants.

8.4 EXTENSION OF THE ADVERSE SELECTION MODEL TO A MULTI–PERIOD MODEL

In this section, we study how the extension of the basic model of section 8.3 to a multi–period model affects the equilibrium outcome. Because the computations are mathematically difficult for multi–period games, we will only consider how the piece–rate system and the transfer system perform when we apply the numerical utility functions.

When the relationship between sponsor and bureau is repeated, a new effect will arise, the so called ratchet effect. To understand how the ratchet effect works, consider the choice faced by a low cost bureau in the beginning of a multi–period game. Since it has low costs, it will want to produce relatively much output in a one–period game. However, the low cost bureau knows that by setting output high, it will reveal its true type. After the low cost bureau's type is generally known, the sponsor will want to decrease grants in future periods as it knows that the bureau is of the high productivity type. Hence, the low cost bureau has incentives to hide its true type in the beginning of the game by setting output equal to the output level of the low productivity bureau. This is a new effect compared to the one–period game and causes the low cost bureau to decrease effort. The low cost bureau has therefore two reasons for setting effort low, to extract rent and to hide its true type.

The sponsor can counter the ratchet effect if it is able to commit itself to a long term strategy which rewards high production (Weitzman (76), Holmstrøm (82)). Such a strategy will encourage the low cost bureau to set output high since the sponsor has committed itself not to punish the bureau later in the game. The sponsor's problem is that the optimal reward scheme is not incentive compatible in the last periods. The sponsor will have incentives to deviate from the scheme in order to reduce grants once the low cost bureau has revealed its true type.

An important question is whether the sponsor is able to commit itself for many periods. For public authorities, the answer is generally no. The parliament or the city council can not make legally binding decisions concerning future budgets. And even if the authorities were able to write legally binding contracts with institutions, the contract will have to leave some scope for discretion due to the existence of exogenous uncertainty. The government can therefore argue that a deviation from the contract is due to external factors and does not represent any attempt to squeeze the institutions.

We will start by modeling a two–period game where the setting in each period is that of the preceeding game. To simplify the analysis we will only consider games where the sponsor applies the piece–rate system and the transfer system, respectively. The sponsor can observe the output of the first period before it sets the parameter of the scheme of the second period. It can not commit itself not to use the information provided by the bureau's move in the first period when setting the scheme of the second period. We will use the perfect Bayesian equilibrium concept. The sponsor updates its probability belief of the bureau's type according to Bayes' law. Both agents maximize their expected utility during both periods. Hence, none of the agents act myopically. The structure of our model is quite similar to the models in three seminal papers on asymmetric information in multi–period games without commitment, Freixas et al (85) and Laffont & Tirole (87,88).

Let:

c_t , $t = 1,2$ – grants in period t

e_t^H , $t = 1,2$ – effort level of a high cost bureau in period t

e_t^L , $t = 1,2$ – effort level of a low cost bureau in period t

$Q_t^H = c_t + e_t - \theta$, $t = 1,2$ (8.70)

$Q_t^L = c_t + e_t + \theta$, $t = 1,2$ (8.71)

p_t – the price per unit output for period t for the piece–rate system

$U_t(Q_t,c_t) = \ln(Q_t) - c_t^2/4$, $t = 1,2$ (8.72)

$V_t(Q_t,e_t) = \ln(Q_t) - e_t^2/4$, $t = 1,2$ (8.73)

π_t , $t = 1,2$ – the sponsor's probability belief that the bureau has high costs

$\pi_1 = 0.5$ (8.74)

$\mathbf{V} = 0.4431$ – the minimum utility level of the bureau for both periods

For the piece–rate system, we demand that:

$c_t = p_t\, Q_t$, $t = 1,2$ (8.75)

We define the bureau's optimal choice for a one–period game:

e_*^H – the optimal choice of effort of the high cost bureau if the game lasts for one period

e_*^L – the optimal choice of effort of the low cost bureau if the game lasts for one period

Q_*^H, Q_*^L – the corresponding output levels

e_*^H, e_*^L, Q_*^H and Q_*^L depend on the payment scheme. Since the game ends at the second period, the outcome in the last period will be (e_*^H,Q_*^H) and (e_*^L,Q_*^L). The bureau has not incentives to hide its true type in the second period.

We will now prove that the output in period 1 will be either Q_*^H or Q_*^L when the bureau's reservation utility, $\overline{V}$, equals 0.4431. We have set the reservation utility level of the bureau higher than the high cost bureau's utility for the basic one–period Stackelberg game with sponsor as leader with common knowledge about the bureau's costs. This assumption ensures that the sponsor will not want to give the high cost bureau more than its minimum utility level in the second period provided its type is known. Therefore, the high cost bureau has no incentives to signal its type in the first period. Hence:

<u>PROPOSITION 8.2:</u> In the first period, a high cost bureau will always set $e_1 = e_*^H$ so that $Q_1 = Q_*^H$. The low cost bureau will either set $e_1 = e_*^L$ so that $Q_1 = Q_*^L$ or set effort to make $Q_1 = Q_*^H$.

<u>Proof:</u>

The proof follows the arguments of the proofs of Lemmas 1–2 of Freixas et al (85). Our choice of $\overline{V}$ ensures that the sponsor will want to keep the high cost bureau at its minimum utility level in period 2. Nor will the sponsor want to set the high–cost bureau's utility level above $\overline{V}$ in period 1. The only reason to give the high cost bureau a higher utility level in period 1 is that it will be easier to separate the two bureaus. But raising the high cost bureau's utility level will make it more tempting for the low cost bureau to hide its true type in period 1.

It follows from the argument above that the high cost bureau will not get higher utility than $\bar{V}$ in either of the periods. Therefore, it has no incentives to deviate from its short run optimal strategy in the first period and will set $e_1 = e_*^H$ and $Q_1 = Q_*^H$.

The last step is to show that the low cost bureau will want to set $Q_1 = Q_*^H$ or Q_*^L. If the low cost bureau prefers to hide its true type in the first period, it must set $Q_1 = Q_*^H$. Otherwise, the sponsor will spot the bureau's true type. If the low cost bureau prefers to reveal its true type in period 1, it might just as well maximize its one–period utility by setting $e_1 = e_*^L$ and $Q_1 = Q_*^L$. The low cost bureau will therefore set $Q_1 = Q_*^H$ or Q_*^L.

Q.E.D.

In the model of Laffont & Tirole (87), the authors have to consider the possibility that the high cost bureau (agent) prefers to set $Q_1 = Q_*^L$ in the first period because it can exit the game before period 2. Hence, it will not be punished in the second period if it signals that it is a low cost bureau. This effect occurs when the sponsor applies an optimal scheme. In this section, we apply simplified schemes which both can be viewed as special cases of a linear scheme. It follows directly from (8.59) – (8.60) and (8.67) – (8.68) that the optimal one–period choices of output differ for the two bureaus. Therefore, we do not have to impose "an upwards incentive constraint on the high cost bureau" (see the observation in Freixas et al (85), at the bottom of pp. 189).

The equilibrium can be one of three types depending on the low cost bureau's preferences.

– The low cost bureau can choose to hide its type by setting $Q_1 = Q_*^H$, in which case we have a pooling equilibrium in the first period.

– If the low cost bureau prefers to reveal its type, it sets $Q_1 = Q_*^L$ and the equilibrium is separating.

– If the low cost bureau is indifferent between Q_*^H and Q_*^L in the first period and randomizes, we have a semi–separating equilibrium (the terminology is that of Freixas et al (85)).

We will now outline the general procedure for finding the sponsor's optimal choice of parameters of the two schemes. We will then carry out the numerical simulations for the piece–rate system and the transfer system, respectively. To describe the behaviour of the low cost bureau, we introduce two concepts:

LOSS – the low cost bureau's utility loss in the first period by pooling

GAIN – the low cost bureau's utility gain in the second period by pooling in the first period

GAIN depends on the sponsor's a posterori probability beliefs, π_2, which is a sufficient statistics for the information carried by the sponsor prior to the second period. GAIN is not discounted. Both LOSS and GAIN depend on the sponsor's choice of incentive scheme. The condition for the feasible equilibria are:

$$
\begin{aligned}
&\text{LOSS} < \delta\,\text{GAIN} \rightarrow \text{the equilibrium is pooling}\\
&\text{LOSS} = \delta\,\text{GAIN} \rightarrow \text{the equilibrium is semi–separating} \qquad (8.76)\\
&\text{LOSS} > \delta\,\text{GAIN} \rightarrow \text{the equilibrium is separating}
\end{aligned}
$$

When the bureau is of the low cost type, the sponsor's a posteriori probability belief that the bureau is of the high–cost type, π_2, depends on the category of equilibrium. If the equilibrium is pooling, π_2 will equal 0.5 since the sponsor does not get any new information by the bureau's first move. For a separating equilibrium, $\pi_2 = 0$. If the equilibrium is semi–separating, $0.5 \leq \pi_2 \leq 1.0$ for $Q_1 = Q_*^H$ and $\pi_2 = 0$ if $Q_1 = Q_*^L$. GAIN is nondecreasing in π_2 since the sponsor is inclined to offer a better deal to a high cost bureau than a low cost bureau. This is because a high cost bureau will set output lower than the low cost bureau in the second period.

The relationship between the category of equilibrium, the LOSS and GAIN functions and π_2 for the game between the sponsor and a low cost bureau is illustrated in figure 10.4.[3] The LOSS function is a horizontal curve since it does not depend on π_2.

When the LOSS function is given by LOSS1, it will never pay to pool, the low cost bureau will reveal its true type, and π_2 equals 1.0. Therefore, for a LOSS function which is above A, the equilibrium will be separating.

By using a similar argument, we show that the equilibrium will be pooling if the LOSS function is below point C, as LOSS3. It will never pay to separate

For LOSS = LOSS2, the equilibrium must be semi–separating with $\pi_2 = \pi_2'$ and LOSS will equal GAIN at B. The equilibrium can not be separating or pooling. For a separating equilibrium, the low cost bureau will prefer to deviate from its strategy and set $Q_1 = Q_*^H$. The sponsor will then believe that the bureau has high costs and the gain from a deviation exceeds the loss. For a pooling strategy, the gain is given as the ordinate of point C since $\pi_2 = 0.5$ for a pooling equilibrium. The gain will therefore be lower than the loss. Once again, the bureau prefers to deviate from a pure strategy. Finally, we can rule out any other equilibrium than the equilibrium at point B. Otherwise, GAIN would not equal LOSS and the bureau would therefore not be indifferent between Q_*^H and Q_*^L.

We are now ready to state the procedure for finding the perfect Bayesian equilibrium for the piece–rate and transfer system when the bureau has high and low costs, respectively. For each system, the procedure is in four steps:

1. We compute the best move of the two types of bureau in the second period as a function of the parameter of the second period scheme and θ.

2. We compute the sponsor's choice of parameter for the second period as a function of π_2 and θ.

3. We compute the LOSS and GAIN functions for the low cost bureau as functions of π_2, θ and the sponsor's optimal choice of parameter of the second period. We find the low cost bureau's optimal choice of effort in the first period as a function of the parameter of the first period scheme.

4. We compute the sponsor's optimal choice of parameter of the scheme in the first period.

<u>Equilibrium for the piece–rate system</u>

We define:

c_2^H – second period grant to a high cost bureau

c_2^L – second period grant to a low cost bureau

i) Step 1

The bureau maximizes its second period utility, (8.73), given the price of output in the second period, p_2, and the technological constraints given by (8.70) – (8.71):

$$e_*^H = \text{argmax}_{e_2} \ln(Q_2^H) - (e_2)^2/4 \quad (8.76)$$

$$e_*^L = \text{argmax}_{e_2} \ln(Q_2^L) - (e_2)^2/4 \quad (8.77)$$

$$Q_2^H = (e_2-\theta)/(1-p_2) \quad (8.78)$$

$$Q_2^L = (e_2+\theta)/(1-p_2) \quad (8.79)$$

The solution to the bureau's maximization problem is:

$$e_*^H = 0.5\left[\text{sqrt}(\theta^2+8) + \theta\right] \quad (8.80)$$

$$e_*^L = 0.5\left[\text{sqrt}(\theta^2+8) - \theta\right] \quad (8.81)$$

From (8.80) – (8.81), we see that effort is independent of p_2. e_*^H and e_*^L will also be independent of p_1 in period 1. We write the solution to the bureau's maximization problems as $e_*^H(\theta)$ and $e_*^L(\theta)$.

ii) Step 2

The sponsor's maximization problem in period 2 is:

$$\text{Max}_{p_2}\ \pi_2 \left[\ln(Q_*^H(\theta)) - (c_2^H)^2/4\right] + (1-\pi_2)\left[\ln(Q_*^L(\theta)) - (c_2^L)^2/4\right] \quad (8.82)$$

$$c_2^H = p_2\, Q_*^H \quad (8.83)$$

$$c_2^L = p_2\, Q_*^L \quad (8.84)$$

$$Q_*^H = c_2^H + e_*^H(\theta) - \theta \qquad (8.85)$$

$$Q_*^L = c_2^L + e_*^L(\theta) + \theta \qquad (8.86)$$

$$\ln(Q_*^H(\theta)) - (e_*^H(\theta))^2/4 \geq 0.4431 \text{ if } \pi_2 > 0 \qquad (8.87)$$

$$\ln(Q_*^L(\theta)) - (e_*^L(\theta))^2/4 \geq 0.4431 \text{ if } \pi_2 = 0 \qquad (8.88)$$

The maximization problem gives p_2 as a function of θ and π_2. It turns out that p_2 is independent of π_2 for $\pi_2 > 0$. The sponsor will always want to make the high cost bureau's reservation utility constraint, (8.87), binding. Since e_*^H is independent of p_2, it follows that p_2 is independent of π_2 for $\pi_2 > 0$. When $\pi_2 = 0$, p_2 will be lower since the sponsor no longer has to worry about the minimum utility level of the high cost bureau. We will therefore write the two different prices as $p_2(1)$ and $p_2(0)$ for $\pi_2 > 0$ and $\pi_2 = 0$, respectively.

This implication of our model's assumptions seems a bit unrealistic. In real life, we would not expect p_2 to jump abruptly as π_2 varies from zero to an infinitely small number.

iii) Step 3

Since p_2 is independent of π_2 as long as π_2 is not zero, it follows that the GAIN function must be independent of π_2. GAIN is therefore a horizontal curve in figure 3. We will either have a pooling or a separating equilibrium in the first period. We now compute whether the low cost bureau prefers a pooling or a separating equilibrium.

First, we state that the effort level of the high cost bureau in period 1 is given by (8.80). The effort level of a low cost bureau which reveals its true type is given by (8.81). Since the price does not influence the effort level, the effort levels of a separating equilibrium in the first period will equal the effort levels of the second period.

Next, we define:

e_{**}^L – the effort level which makes $Q_1^L = Q_*^H$

$Q_1^L = (e_{**}^L+\theta)/(1-p_1) = Q_*^H = (e_*^H-\theta)/(1-p_1)$ (8.89)

$\rightarrow e_{**}^L = 0.5\left[\text{sqrt}(\theta^2+8)-3\theta\right]$ (8.90)

(8.90) is found by inserting e_*^H from (8.80) in (8.89). We can now compute the loss and gain functions:

$\text{LOSS} = \ln\left[(e_*^L(\theta)+\theta)/(1-p_1)\right] - (e_*^L)^2/4 - \ln\left[(e_{**}^L(\theta)+\theta)/(1-p_1)\right] + (e_{**}^L)^2/4$ (8.91)

$\text{GAIN} = \ln\left[(e_*^L(\theta)+\theta)/(1-p_2(1))\right] - (e_*^L(\theta))^2/4 - \ln\left[(e_*^L(\theta)+\theta)/(1-p_2(0))\right] + (e_*^L(\theta))^2/4$
(8.92)

To compute the low cost bureau's optimal choice of strategy in period 1, we must carry out a numerical simulation where LOSS and δ GAIN is compared. The price of the second period is found from step 2. It turns out that LOSS is not sensitive to variations in p_1 and that δ GAIN will exceed LOSS for those values of θ for which we have run a simulation ($\theta \leq 0.5$), provided $\delta \geq 0.2$. For a realistic length of the budget period, we can therefore conclude that the low cost bureau will prefer to pool. The second period gain from not being detected will exceed the first period loss.

iiii) Step 4

The sponsor knows that the first period equilibrium will be a pooling equilibrium. Therefore, the sponsor does not have to consider the effect on the second period equilibrium when it sets the price in the second period. If the low cost bureau's strategy depends on the first period price, the sponsor will have incentives to set the price low in order to force the low cost bureau to reveal its true type. As the sponsor does not have this option, it sets the price to maximize the first period utility:

$\text{Max}_{p_1} \ln(Q_*^H) - c_1^2/4$ (8.93)

$Q_*^H = (e_*^H(\theta)-\theta)/(1-p_1)$ (8.94)

$c_1 = p_1 Q_*^H$ (8.95)

$$\ln(Q_*^H) - (e_*^H)^2/4 \geq 0.4431 \quad (8.96)$$

We do not have to write down the low cost bureau's rationality constraint as it will set output equal to the high cost bureau's output and its effort level will be lower.

The equilibrium outcome for period 2 will equal the solution to the one–period game of section 8.3 since the bureau's type is not revealed in the first period. The equilibrium outcome for period 1 as a function of θ is given in table 8.2. We see that average effort will be lower than for period 2 due to the ratchet effect. The low cost bureau will reduce effort to hide its true type in period 1. The higher is uncertainty, the lower is the average effort level.

By comparing tables 8.1–8.2, we see that the sponsor will <u>gain</u> from the ratchet effect for the piece–rate system! This is due to the fact that average output and grants are reduced. From the analysis in section 8.3, we remember that the major disadvantage of the piece–rate system is that the sponsor is not able to control total grants. The ratchet effect will make the bureau decrease output on average and this mitigates the sponsor's control problem.

<u>Equilibrium for the transfer system</u>

The equilibrium solution for the transfer system is quite similar to that of the piece–rate system and we will therefore not go through the same four steps. Second period grants will not depend on the probability beliefs, provided $\pi_2 > 0$. The low cost bureau will always prefer to pool in the first period. The equilibrium outcome of the second period is equal to the outcome of the one–period game in section 8.3. The equilibrium outcome of the second period is given by table 8.2.

Contrary to what we found for the piece–rate system,. the sponsor will loose from the ratchet effect. The major disadvantage of the transfer system is that effort is low and the ratchet effect will exacerbate the sponsor's problem. As seen by table 10.2, the effort level of the low cost bureau will be very low in period 1.

A general result in our model is that the low cost bureau has strong incentives to pool in the first period. We would expect this tendency to be more accentuated in our model than in the model of Freixas et al (85). They allow the sponsor (principal) to apply linear schemes. A linear scheme has two parameters while in our case the sponsor has only one policy instrument. We would expect the sponsor's ability to separate the two types to improve as the scheme becomes more sophisticated.

The long run equilibrium

We will now argue that the equilibrium of period 1 will be the long run equilibrium of a multi–period game. The high cost bureau will always have its utility set at the minimum level and it will therefore set effort equal to e_*^H for every period of the game. The low cost bureau prefers to hide its true type for a two–period game and the arguments for pooling will be strengthened as the game becomes longer. The low cost bureau will pool until the last period of the game. Therefore, the long run equilibrium outcome will be the same as the outcome for the first period of the two–period game.

It follows from the analysis that the ratchet effect will cause effort to be low in a multi–period relationship. The low cost institutions have strong incentives to hide their true production potential and will therefore reduce effort considerably compared to the preferred one–shot effort level. However, only for the transfer system is the ratchet effect a disadvantage for the sponsor.

The negative effect on the low cost bureau's effort level is caused by the sponsor's guarantee to the high cost bureau. To keep the high cost bureau's utility above the minimum level, the sponsor can not pursue an aggressive strategy in order to mitigate the ratchet effect. Therefore, as long as public authorities guarantee the existence of all public institutions, we would expect the institutions' information monopoly to be hard to overcome.

A comparison of the sponsor's expected utility (table 8.2) shows that the piece–rate system is preferred to the transfer system, except for $\theta = 0.5$. When we compare with the outcome of the one–period game, we find that the ratchet effect provides an argument in favour of the piece–rate system compared to the transfer system.

8.5 DISCUSSION

We start by summarizing the major results of this chapter. Then we discuss the relevance of asymmetric information models in studies of public sector efficiency. Last, we relate our results to the budget process in the public sector.

We first considered a model where the sponsor faces a moral hazard problem. The sponsor can observe output but not infer effort. The true production function is not known by the bureau when it sets effort. The first best scheme implies that the sponsor uses grants to smooth output. However, this scheme gives the bureau strong incentives to set effort low. Therefore, the second best scheme modifies the first best scheme to reward the bureau when output signals that effort is high.

When the sponsor faces an adverse selection problem, both types of bureau have incentives to claim that costs are high. In the optimal scheme, the sponsor imposes tight budgets on all bureaus to force low cost bureaus to raise their effort level. In both models, the sponsor faces a trade–off between allocative and cost efficiency. A simulation of the effects of the transfer system and the piece–rate system showed that the piece–rate system performs almost as well as the optimal scheme when the uncertainty is small. When the true costs of the bureaus vary substantially, the piece–rate system performs badly because of the sponsor's lack of control of grants.

When the adverse selection model is repeated, the low cost bureau has strong incentives to hide its true preferences to benefit from high grants during the game. The ratchet effect induces the bureau to set effort low for both the transfer system and the piece–rate system. However, the ratchet–effect makes the sponsor better off for the piece–rate system because expected grants is reduced compared to the one–period game

When the analysis in this chapter is compared to the results in chapter 5, we see that cost uncertainty is probably a bigger problem for the sponsor than output uncertainty. In chapter 5, we found that the effort level is generally very close to the effort level under no uncertainty. When the bureau moves first and has private information about the true output level, effort increases compared to the full information game. The conclusions in this chapter are considerably more pessimistic as seen by the sponsor. When effort can not be observed, it is hard to counter the bureau's information monopoly. The effort level will in general be lower than when there is no uncertainty.

We now discuss some studies which throw light on the role of asymmetric information in the public sector. A considerable number of studies have been conducted of the budget process of Norwegian and Swedish municipalities the last twenty years. These give the impression that the distribution of information between the agents plays a crucial role in the budgeting process. Brunsson & Rombach (82), chapters 3 and 7, interpret the budget process as a struggle between many and well informed advocates who protect their part of the budget and few guardians who try to find ways to reduce the total amount of expenditures. The advocates use their information advantage to point out negative consequences from cuts. The guardians favour small cuts across the board while the advocates want the guardians to elaborate on out how the activity is to be reduced if grants are cut.

The point that advocates seek to "visualize" the consequences of budget reductions is elaborated by Jønsson (82) in his study of Gøteborg. When the Executive Committee of the municipality asked the offices (the different departments of the administration) to suggest how cuts could be carried out, many offices set forth proposals which were obviously strategic ploys because they hurt politically sensitive activities. By refusing to help the guardians cut waste, the advocates retain their information monopoly. The guardians are forced to make general cuts, and they will therefore be more careful in enforcing reductions than if they could identify and remove superflous spending.

Two major Norwegian studies have shown that the findings of the Swedish studies have relevance for Norway (the Oslo–study (Cowart & Brofoss (79), Hansen (85)) and the Bergen–project (Høgheim (89), Høgheim et al (89))). The budget process of Norwegian municipalities is a game between different parts of the municipal hierarchy where the supply of information is an important part of the agents' negotiation strategies.

It is difficult to give a general description of what the institutions know that the authorities do not. However, the studies seem to indicate that the key question of dispute is whether the institutions can increase or sustain the present level of production with lower grants. Hence, the authorities and the institutions do not agree on the true minimum costs of production. It is therefore reasonable to conclude that the model of this chapter captures important elements of the kind of asymmetric information that really exists in the public sector.

Our models have illustrated two major challenges facing the authorities when promoting the efficiency of public bureaus. First, the authorities must accept that some bureaus have a low output (the adverse selection model), and that not all fluctuations in a bureau's output are countered by the authorities (the moral hazard model). A corollary of the last statement is that the authorities should not cover the whole deficit when institutions run deficits (provided the financial result is caused by high or low efficiency), and not withdraw the whole surplus of institutions going well, but rather make sure that the surplus leads to higher production. If the authorities take the responsibility for preventing output from falling for every institution, the low cost institutions have strong incentives to engage in lobbying and information processing to convince the authorities that its potential for rationalization is low. If the authorities carry the whole responsibility for smoothing variations in output, the institutions will not have incentives to undertake measures to stabilize output themselves.

The second major problem facing the authorities, is the ratchet–mechanism. In order to induce the institutions to reveal their true productivity, the institutions must belive that a better performance is not punished in forthcoming budget periods. Therefore, the authorities must refrain from letting next year's budget reward this year's bad performers by transferring resources from the institutions who performed well.

The two challenges are related to each other. The authorities have to resist short–run pressure for higher grants in order to stop output from falling. If they are not able to say no, there will be no resources left to reward high effort. A consistent, long–run policy implies making hard decisions in the short–run in order to obtain efficiency gains in the long–run.

This brings us to the vital question of whether the assumption that the authorities lead is relevant for our purpose. In this chapter, we have assumed that the authorities are able to commit themselves to incentive schemes before the budget period. In chapter 4, we discussed the relevance of the different one–period games for the public sector and concluded that there are strong arguments why the outcome of a political decision process will have a short–run bias. The individuals or groups which take part in the decision process have insufficient incentives to make short–run sacrifices in order to secure long–run gains.

This effect is pointed out by Wildavsky (88), pp. 179–198, in his analysis of why the US budget deficit is so persistent. Everyone in Congress agrees that the deficit should be cut, but there is no stable majority for any of the major realistic alternative strategies for obtaining a balanced budget. Wildavsky claims that the deterioration in public finances has exacerbated the tendency towards short–run behaviour in the budget process (pp. 226–233). Since the attention of the Law makers is concentrated on the impact of decisions on the total amount of expenditures, the content of the programs get little attention.

The main result provided by section 8.2 is that the sponsor will be more reluctant to punish inefficient bureaus in our model than in the standard moral hazard model, because cuts in the transfer to the bureau will reduce output. Similarly, the authorities will find it hard to reward increases in efficiency as the money is needed to stop the output of inefficient institutions from falling. This moral hazard problem was stated by Wildavsky (64) in his first book on the budgeting process of the US Congress in the fifties. Wildavsky writes that public agencies should avoid running surpluses because surpluses are generally followed by cuts in its grants. Wildavsky's claim was supported empirically by Warren (75).

We would expect the moral hazard problem to be graver, the more short–run is the policy horizon of the authorities. In his second book, Wildavsky (88) writes that the incentive problem created by the budget process has grown worse. Since there is a desperate need in Congress to find areas where cuts will not hurt, any improvements or savings will be followed by reductions in grants. According to Wildavsky, the crises has led to a change in the attitude of bureaus towards each other. Thirty years ago, it was anathema for a bureau to comment on the budget base of other bureaus. Today, such practice is common and makes the bureaus careful not to undertake any measure which weakens their negotiation position.

The impression that the authorities do not follow the optimal scheme prescribed by our moral hazard model is confirmed by Norwegian studies. Empirical studies of the budgets of Norwegian hospitals (Jørgensen et al (87) and Pettersen (87)) have shown that there is no correlation between the extra grants appropriated during the budget year / the deficit of an hospital and the deviation between planned and actual output of the hospital. Grants in excess of the budget are therefore not a reward for high productivity but rather an instrument to close the gap between actual and expected performance of the hospital.

The Bergen–project (Høgheim (89) and Høgheim et al (89)) and the Habberstad–study of Oslo (Habberstad (89)) showed that deficits have become a common part of the budget process in Norwegian municipalities. For Bergen, financial statements show that the growth per year of actual expenditures in the period 83–88 was approximately twice as large as stated in the period's budgets. When deficits are so common, it is difficult to pursue a policy which rewards surpluses and punishes deficits. Either all institutions are punished, and that would lead to an unacceptable reduction in output, or only some institutions are punished, and that would be regarded as unfair.

Even though the first best scheme under moral hazard gives the institutions poor incentives, one should be careful not to conclude from our model that non–profit institutions in general are less efficient than profit institutions. The non–profit institution cares more about output than the profit institution. For a given budget, the agent of standard moral hazard models will want to set effort equal to zero, while the non–profit bureau of our model will set effort to equalize the marginal benefit of output and the marginal disutility of effort.

The main conclusion of section 8.3 is that uncertainty about the bureaus' productivity will reduce the effort of both types of bureaus and the output level of the high cost bureau compared to the full information scheme. The authorities should accept the reduction in output and effort of the high cost bureau in order to reduce the grants and increase the effort level of the low cost bureau. By setting the budgets tight, the authorities force institutions with slack to increase their productivity. Thus, our model gives an explanation for the widespread use of general across the board cuts (Tarschys (85)). Since the authorities do not have sufficient information to identify slack, they impose tight budgets on all institutions and hope that most of the institutions have sufficient slack to avoid cuts in output.

The difficult point in the optimal scheme for the authorities is that they have to accept that high cost institutions reduce their output substantially or even close. The political bodies will be under heavy pressure to reverse their budget decisions when it becomes clear that some institutions are about to reduce their activity levels. The empirical studies we have referred to from Norway and Sweden show that it is indeed rare that a substantial reduction in output actually takes place. However, as the financial situation of the public sector has deteriorated, the number of actual reductions in output has increased.

If the bureaus suspect that the authorities do not intend to stand firm on their budget proposals, low cost bureaus have incentives to carry out output reductions in order to increase the pressure on the politicians. Since the authorities can not distinguish between low cost and high cost bureaus, decisions to increase the total budget limits will necessarily allow some low cost bureaus to refrain from reducing slack. The authorities' problem gets worse when the budget process is repeated. The low cost bureaus will be even more reluctant to increase effort once they realize that their budgets may be cut for many periods to come as a result. This "ratchet–effect" is described verbally by Wildavsky (64), pp. 64, where he states that agencies working to increase their budgets should be careful not to boast about their results. Too good results are interpreted by Congress as signals indicating that past budgets have been too generous.

From the analysis in section 8.4, we know that the higher the agents' discount rates, the more serious is the "ratchet–problem" for the authorities. The tendency of the public sector budget process towards moving emphasis from future to present considerations will therefore make the "ratchet–problem" more difficult to handle. When budgets are reset many times during the year, the policy of the bureaus will be directed away from long–run considerations of efficiency towards strategic considerations concerning its effects on the magnitude of the present budget.

Within the health sector, there is a growing tendency that the authorities make part of the hospitals' budgets dependent on the number of patients treated. However, the proposed schemes are much simpler than the optimal schemes we have computed. The DRG–system for hospitals can be regarded as a modification of the piece–rate system dealt with in section 8.4. As we have showed, a piece–rate system can be a bad substitute for the optimal scheme when there is much uncertainty concerning the hospital's production technology **although the ratchet effect might actually mitigate this.**

ENDNOTES

[1]This problem is pointed out by Enthoven (85) in his study of the British health system: "A standard problem in bureaucratic budgeting systems is that one strengthens one's case for more resources by doing a poor job with what one has, and weakens one's case by doing the job with less."

[2]Multi–period models of moral hazard are dealt with by Radner (81,85,86), Lambert (83) and Rubinstein & Yaari (83).

[3]To simplify the figure, we have set the discount factor equal to one.

REFERENCES

Baiman, S. 1982: Agency Research in Managerial Accounting: A Survey, Journal of Accounting Literature 1, 154–213.

Baiman, S. & Demski, J. 1980: Economically Optimal Performance Evalution and Control Systems, Journal of Accounting Research 18, 184–220.

Brunsson, N. & Rombach, B. 1982: Går det att spara, Doxa, Lund.

Cowart, A. & Brofoss, K. 1979: Decisions, Politics and Change. A Study of Norwegian Urban Budgeting, Universitetsforlaget, Oslo.

Dasgupta, P., Hammond, P. & Maskin, E. 1979: The Implementation of Social Choice Rules: Some General Results on Incentive Compatibility, Review of Economic Studies 46, 185–216.

Enthoven, A. 1985: Reflections on the Management of the National Health Service, Occasional Papers 5, Nuffield Provincial Hospitals Trust, London.

Fevolden, T. & Sørensen, R. 1987: Norway, in Page, E. & Goldsmith, M. (ed): Central and Local Government Relations, SAGE Publications.

Freixas, X., Guesnerie, R. & Tirole, J. 1985: Planning under Incomplete Information and the Ratchet Effect, Review of Economic Studies 52, 173–191.

Gjesdal, F. 1982: Information and Incentives: The Agency Information Problem, Review of Economic Studies 49, 373–390.

Grossman, S. & Hart, O. 1983: An Analysis of the Principal–Agent Problem, Econometrica 51, 1–45.

Habberstad (89): Oslo kommunes finansielle situasjon, Habberstad–rapport, Høvik.

Hansen, T. (ed) 1985: Offentlige budsjettprosesser, Universitetsforlaget, Oslo.

Harris, M. & Townsend, R. 1981: Resource Allocation under Asymmetric Information, Econometrica 49, 33–64.

Hart, O. & Holmstrøm, B. 1987: The Theory of Contracts, in Bewley, T. (ed): Advances in Economic Theory, Cambridge, Boston.

Holmstrøm, B. 1979: Moral Hazard and Observability, Bell Journal of Economics 10, 74–91.

Holmstrøm, B. 1982: Design of Incentive Schemes and the New Soviet Incentive Model, European Economic Review 21, 127–148.

Høgheim, S. 1989: Rekneskapen i bruk, Mimeograph, NHH, Bergen.

Høgheim, S., Monsen, N., Olsen, R. & Olson, O. 1989: Action Research in Accounting – Experiences in Redesigning an Annual Report, Mimeograph, NHH, Bergen.

Jønsson, S. 1982: Budgetary Behaviour in Local Government – a Case Study over 3 Years, Accounting, Organizations and Society 7, 287–304.

Jørgensen, S., Kindseth, P., Magnussen, J., Pettersen, I., Slåttebræk, O. 1987: Sykehussektorens økonomi, NIS rapport 33/87, Trondheim.

Laffont, J. & Tirole, J. 1986: Using Cost Observation to Regulate Firms, Journal of Political Economy 94, 614–641.

Laffont, J. & Tirole, J. 1987: Comparative Statics of the Optimal Dynamic Incentive Contract, European Economic Review 31, 901–926.

Laffont, J. & Tirole, J. 1988: The Dynamics of Incentive Contracts, Econometrica 56, 1153–1175.

Lambert, R. 1983: Long–Term Contracts and Moral Hazard, Bell Journal of Economics 14, 441–452.

Myerson, R. 1979: Incentive Compatibility and the Bargaining Problem, Econometrica 47, 61–73.

Pettersen, I. 1987: Hospital Budgets – Strategic Documents or Ritual Acts? Mimeograph, NIS, Trondheim.

Radner, R. 1981: Monitoring Cooperative Agreements in a Repeated Principal–Agent Relationship, Econometrica 49, 1127–1148.

Radner, R. 1985: Repeated Principal–Agent Games with Discounting, Econometrica 53, 1173–1198.

Radner, R. 1986: Repeated Moral Hazard with Low Discount Rates, in Heller, W. (ed): Information, Incentives and Economic Mechanisms, University of Minnesota Press.

Rogerson, W. 1985: The First–Order Approach to Principal–Agent Problems, Econometrica 53, 1357–1367.

Rubinstein, A. & Yaari, M. 1983: Repeated Insurance Contracts and Moral Hazard, Journal of Economic Theory 30, 74–97.

Sappington, D. 1983: Limited Liability Contracts between Principal and Agent, Journal of Economic Theory 29, 1–21.

Shavell, S. 1979: Risk Sharing and Incentives in the Principal and Agent Relationship, Bell Journal of Economics 10. 55–73.

Sørensen, R. 1985: Offentlig budsjettering, in Hansen, T. (ed): Offentlige budsjettprosesser, Universitetsforlaget, Oslo.

Tarschys, D. 1985: Curbing Public Expenditures: Current Trends, Journal of Public Policy 5, 23–67.

Warren, R. 1975: Bureaucratic Performance and Budgetary Reward, Public Choice 24, 51–57.

Weitzman, M. 1976: The New Soviet Incentive Model, Bell Journal of Economics 7, 251–257.

Wildavsky, A. 1964: The Politics of the Budgegary Process, Little, Brown & Co.

Wildavsky, A. 1988: The New Politics of the Budgetary Process, Scott, Foresman & Co.

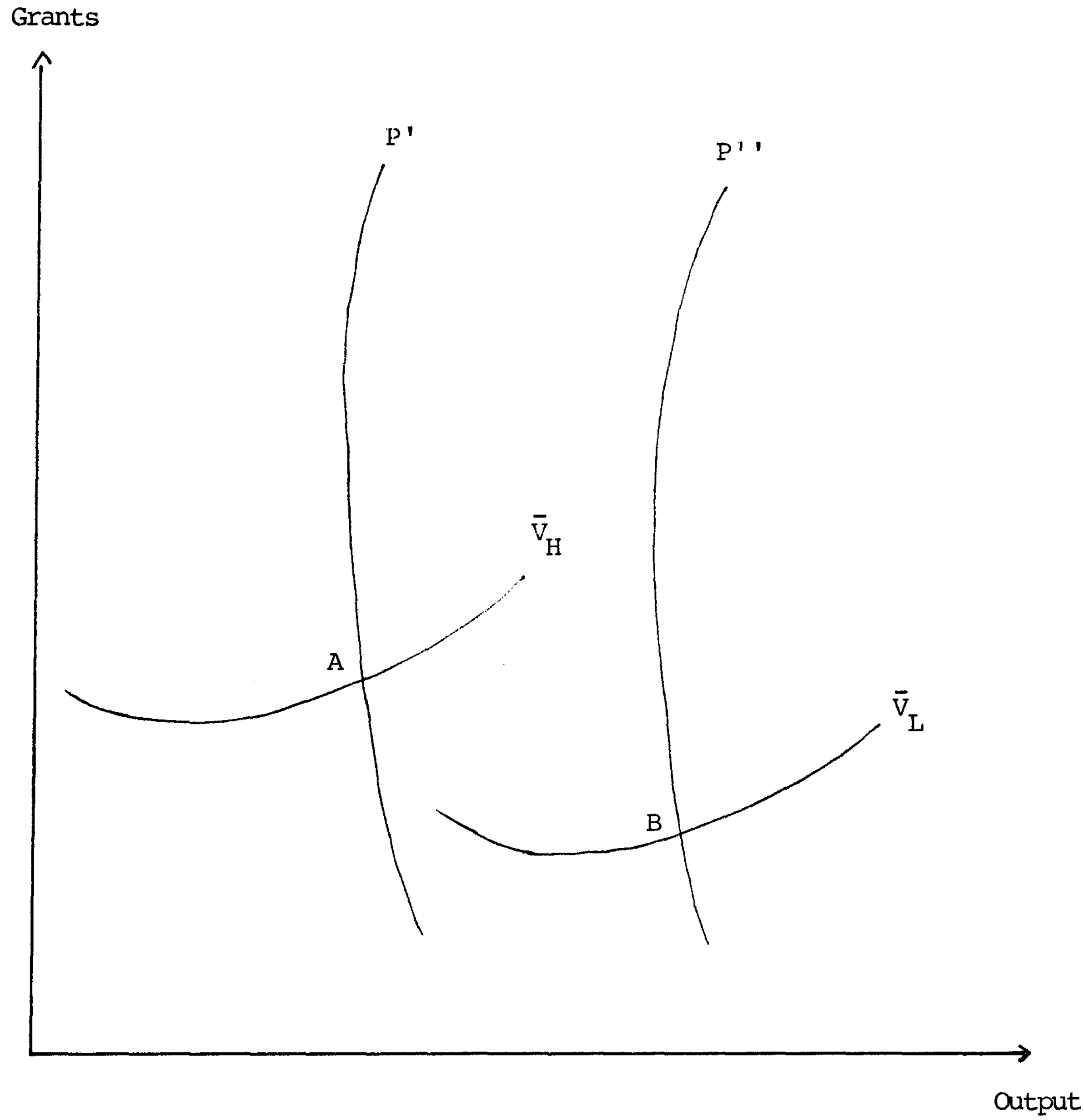

Figure 8.1: Optimal scheme under full information

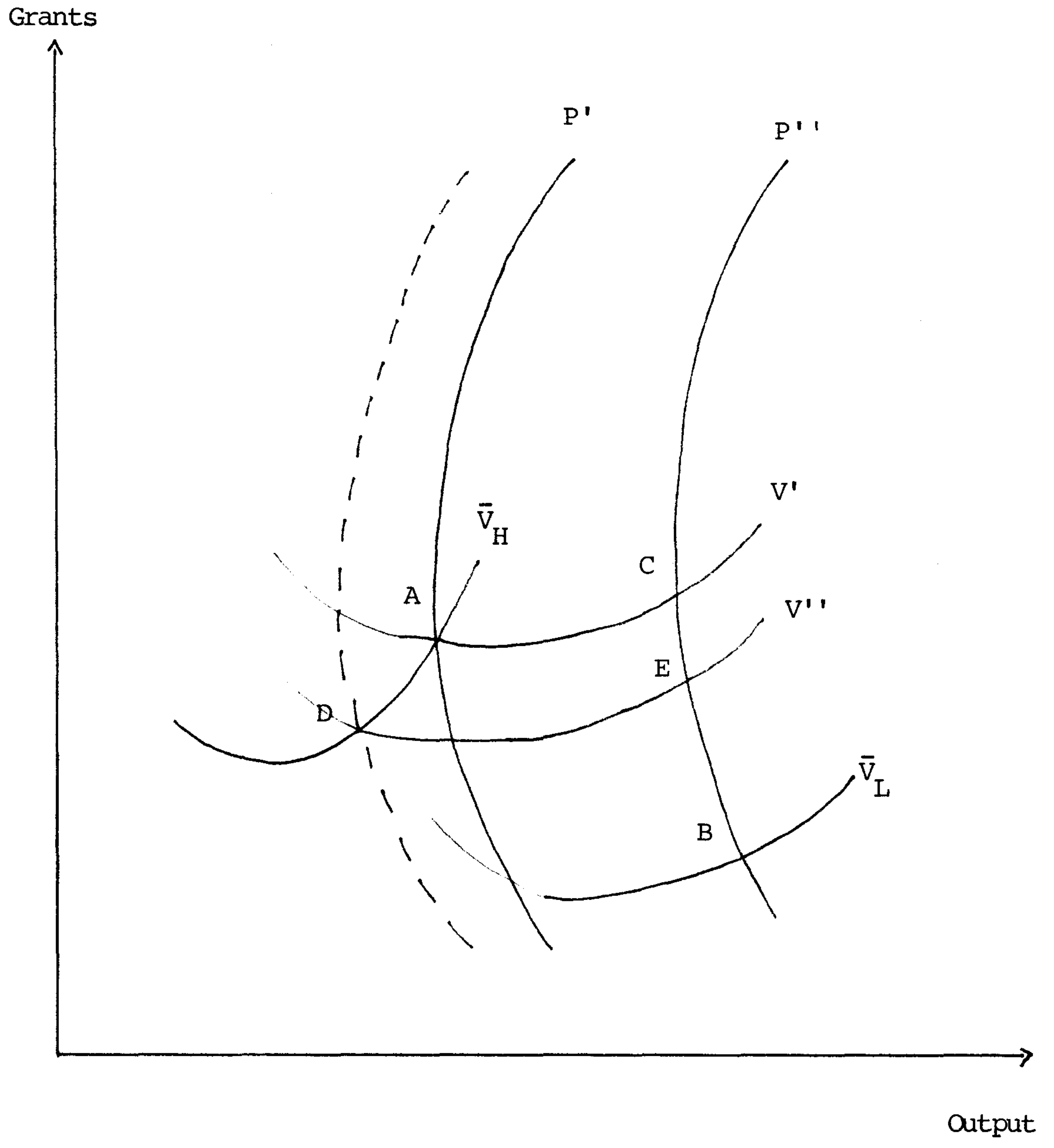

Figure 8.2: Optimal scheme under incomplete information

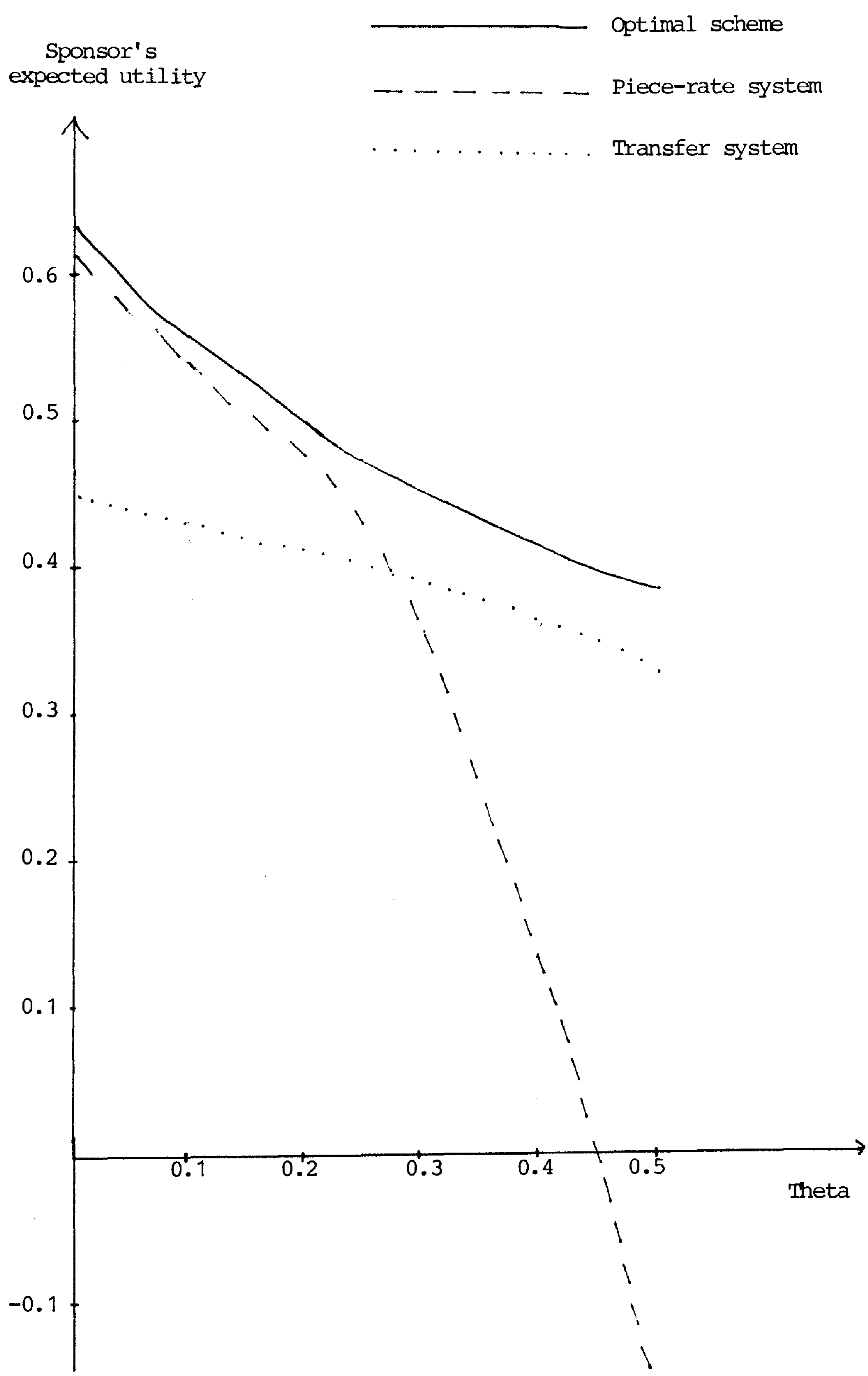

Figure 8.3: Sponsor's expected utility for different schemes as a function of the degree of uncertainty

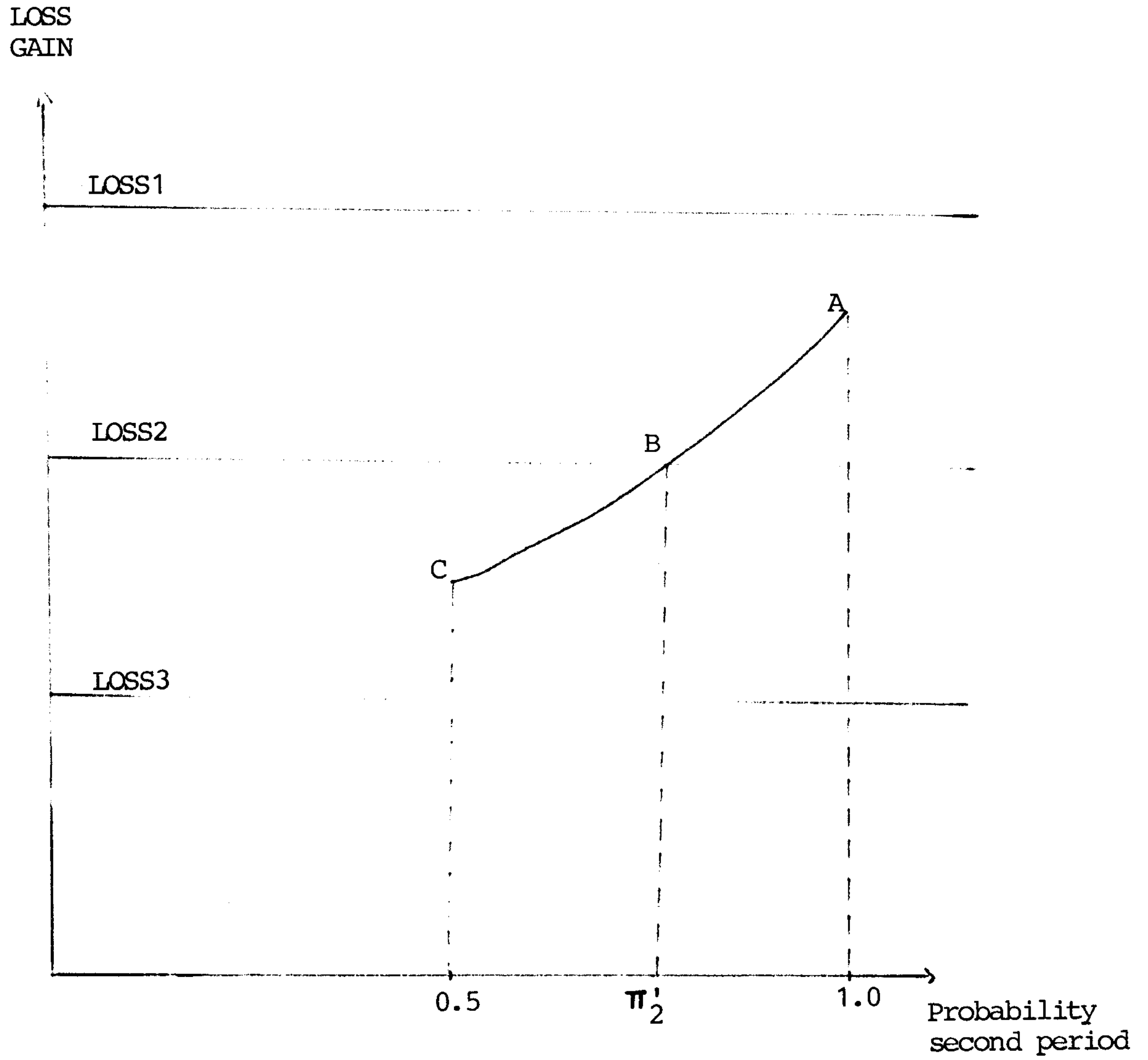

Figure 8.4: The low cost bureau's choice of strategy as a function of the LOSS and GAIN functions

Theta	System	E(c)	e^H	e^L	E(e)	E(Q)	E(U)
0.0	Optimal	1.2902	1.5502	1.5502	1.5502	2.8404	0.6278
	Piece-rate	1.1538	1.4142	1.4142	1.4142	2.5681	0.6103
	Transfer	1.0000	1.0000	1.0000	1.0000	2.0000	0.4431
0.1	Optimal	1.3519	1.4727	1.3976	1.4270	2.7789	0.5640
	Piece-rate	1.3464	1.4651	1.3651	1.4151	2.7615	0.5614
	Transfer	1.1010	1.0359	0.9359	0.9859	2.0869	0.4324
0.2	Optimal	1.3914	1.3605	1.2687	1.3146	2.7060	0.5063
	Piece-rate	1.5631	1.5177	1.3177	1.4177	2.9808	0.4759
	Transfer	1.2046	1.0767	0.8767	0.9767	2.1813	0.4161
0.3	Optimal	1.4019	1.2189	1.2289	1.2239	2.6258	0.4632
	Piece-rate	1.8080	1.5721	1.2721	1.4221	3.2301	0.3406
	Transfer	1.3117	1.1218	0.8218	0.9718	2.2835	0.3934
0.4	Optimal	1.3971	1.0920	1.2517	1.1718	2.5689	0.4384
	Piece-rate	2.0859	1.6283	1.2283	1.4283	3.5146	0.1378
	Transfer	1.4235	1.1709	0.7709	0.9709	2.3944	0.3631
0.5	Optimal	1.3912	1.0152	1.3074	1.1613	2.5525	0.4276
	Piece-rate	2.4011	1.6861	1.1861	1.4361	3.8372	-0.1550
	Transfer	1.5411	1.2235	0.7235	0.9735	2.5145	0.3234

Table 8.1: Numerical simulation of three different schemes for different degrees of uncertainty when there is adverse selection

Theta	System	c	e^H	e^L	E(e)	E(Q)	E(U)
0.0	Piece-rate	1.1538	1.4142	1.4142	1.4142	2.5680	0.6103
	Transfer	1.0000	1.0000	1.0000	1.0000	2.0000	0.4431
0.1	Piece-rate	1.2985	1.4651	1.2651	1.3651	2.6636	0.5582
	Transfer	1.1000	1.0000	0.8362	0.9181	2.0681	0.3996
0.2	Piece-rate	1.4571	1.5177	1.1177	1.3177	2.7706	0.4914
	Transfer	1.2000	1.0000	0.6798	0.8399	2.0390	0.3523
0.3	Piece-rate	1.6171	1.5721	0.9721	1.2721	2.8892	0.4072
	Transfer	1.3000	1.0000	0.5248	0.7624	2.0624	0.3009
0.4	Piece-rate	1.7941	1.6283	0.8262	1.2262	3.0224	0.3014
	Transfer	1.4000	1.0000	0.3763	0.6882	2.0882	0.2454
0.5	Piece-rate	1.9844	1.6861	0.6861	1.1861	3.1705	0.1694
	Transfer	1.5000	1.0000	0.2321	0.6161	2.1161	0.1855

Table 8.2: Equilibrium outcome for period 1 for a two-period game with adverse selection

CHAPTER 9

ONE SPONSOR AND MANY BUREAUS

9.1 INTRODUCTION

In this chapter, we consider how the basic noncooperative games are affected by the introduction of many bureaus. We retain the assumption that the sponsor and the bureaus have full information. The policy variables are as in chapters 3–6. The sponsor sets the bureaus' budgets and the bureaus set their effort levels.

When the sponsor moves first or all agents move simultaneously, the analysis do not contain results that are basically different from the corresponding single–bureau games. The sponsor will distribute funds according to its preferences for the bureaus' production. When it moves first, it reduces grants to each bureau compared to the equilibrium of the Nash–Cournot game to force the bureaus to increase effort.

The nature of the game changes drastically as we move to the game where the bureaus move first. For this order of moves, the equilibrium outcome crucially depends on the number of bureaus. It turns out that an increase in the number of bureaus generally leads to a decrease in the bureaus' effort level.

This result has important implications for the effects of various public reform proposals. In chapter 4, we argued that the Stackelberg game with the bureau as leader has relevance as a description of the interaction process in the public sector due to the short–run bias of the political decision process and the fact that grants normally can be adjusted faster than effort. If this claim is correct, containment of total public expenditures causes a reduction in the output of public bureaus but does not enhance their efficiency provided the budget of each bureau is small compared to the authorities' total revenues. However, the model provides a strong argument for earmarking, e.g. tying public revenues to specific activities. Such earmarking will reduce the discretion of the authorities to redistribute grants between bureaus and reduce the incentives of the bureaus to cut their effort levels strategically.

In section 9.2, we carry out the computations and compare the model to related models within the public choice tradition. In section 9.3 we discuss the implications of our model for various reform proposals aimed at improving the performance of public bureaus.

9.2 THE MODEL

There are one sponsor and n bureaus. The sponsor sets the bureaus' budgets while each bureau decide on its effort level. Let:

Q_j – output of bureau j, j = 1,n

c_j – grants from the sponsor to bureau j, j = 1,n

c – total grants from the sponsor to the bureaus, $c = \sum_{j=1}^{n} c_j$

e_j – effort of bureau j, j = 1,n

The basic model consists of the the bureaus' production functions, the sponsor's utility function and the bureaus' utility functions.

$$Q_j = c_j + e_j \quad j = 1,n \qquad (9.1)$$

$$U = \sum_{j=1}^{n} U^{1j}(Q_j) - U^2(c) \qquad (9.2)$$

$$V^j = V^{1j}(Q_j) - V^{2j}(e_j) \;, j = 1,n \qquad (9.3)$$

The assumptions of this chapter's model are:

9.A1: $U_Q^{1j}(Q_j) > 0 \quad U_{QQ}^{1j}(Q_j) < 0 \quad , j = 1,n$

9.A2: $U_c^2(c) > 0 \quad U_{cc}^2(c) > 0$

9.A3: $V_Q^{1j}(Q_j) > 0 \quad V_{QQ}^{1j}(Q_j) < 0 \quad , j = 1,n$

9.A4: $V_e^{2j}(e_j) > 0 \quad V_{ee}^{2j}(e_j) > 0 \quad , j = 1,n$

The sponsor's total utility of the bureaus' production is the sum of utilities of each bureau's output. An alternative formulation would be to make the sponsor's utility of output a function of the sum of the output levels of all bureaus, $U^1(\Sigma\, Q_j)$. However, that would imply that the bureaus' outputs are perfect substitutes, which is unreasonable for the public sector. You can not compensate a cut in the number of schools by building more hospitals.

The bureaus move simultaneously. Each bureau sets the effort level while taking the other bureaus' effort levels as given. The sponsor reacts to the bureaus' moves by allocating grants to each bureau.

From (9.2), it follows that the sponsor's allocation of grants will be a function of all effort levels. Hence, from the sponsor's utility function, we can compute the derivatives of the n × n reaction functions, of the form dc_i/de_j, which all depend on the effort level of every bureau. Fortunately, to find the equilibrium outcome, we only need to compute the dependence between an effort level and the corresponding grant. This is due to the fact that the first order conditions of the bureaus only contain the derivatives of the direct reaction functions, dc_j/de_j.

To simplify the computations, we assume that the utility functions of the bureaus are equal and that the sponsor's utility function is symmetric. We solve for a symmetric equilibrium solution where output, grants and effort are equal for all bureaus.

The first order conditions of the sponsor are:

$$U_Q^{11}(Q_1) - U_c^2\left(\sum_{j=1}^{n} c_j\right) = 0$$

$$U_Q^{12}(Q_2) - U_c^2\left(\sum_{j=1}^{n} c_j\right) = 0 \qquad (9.4)$$

$$\vdots$$

$$U_Q^{1n}(Q_n) - U_c^2\left(\sum_{j=1}^{n} c_j\right) = 0$$

We undertake a total differentiation of (9.4) to find the sponsor's reaction functions. Since we solve for a symmetric equilibrium solution, we omit the arguments and simplify the superscripts of the utility functions.

$$\begin{bmatrix} U^1_{QQ}-U^2_{cc} & -U^2_{cc} & \cdot & \cdot & -U^2_{cc} \\ -U^2_{cc} & U^1_{QQ}-U^2_{cc} & \cdot & \cdot & -U^2_{cc} \\ \cdot & \cdot & \cdot & \cdot & \cdot \\ -U^2_{cc} & \cdot & \cdot & U^1_{QQ}-U^2_{cc} & -U^2_{cc} \\ -U^2_{cc} & \cdot & \cdot & -U^2_{cc} & U^1_{QQ}-U^2_{cc} \end{bmatrix} \begin{bmatrix} dc_1 \\ dc_2 \\ \cdot \\ dc_{n-1} \\ dc_n \end{bmatrix} = \begin{bmatrix} -U^1_{QQ}de_1 \\ -U^1_{QQ}de_2 \\ \cdot \\ -U^1_{QQ}de_{n-1} \\ -U^1_{QQ}de_n \end{bmatrix} \tag{9.5}$$

We define DET_n to be the following (n x n) determinant:

$$DET_n = \begin{vmatrix} U^1_{QQ}-U^2_{cc} & -U^2_{cc} & \cdot & -U^2_{cc} \\ -U^2_{cc} & U^1_{QQ}-U^2_{cc} & \cdot & -U^2_{cc} \\ \vdots & \vdots & \vdots & \vdots \\ -U^2_{cc} & -U^2_{cc} & \cdot & U^1_{QQ}-U^2_{cc} \end{vmatrix} \tag{9.6}$$

From (9.5), we find the expression for the direct reaction functions:

$$dc_j/de_j = (-U^1_{QQ})\, DET_{n-1}/\, DET_n \quad , j = 1,n \tag{9.7}$$

To find DET_{n-1} and DET_n, we successively double the number of matrices by splitting each row into

$$\begin{bmatrix} 0 & . & 0 & 0 & U^1_{QQ} & 0 & 0 & . & 0 \end{bmatrix} + \begin{bmatrix} -U^2_{cc} & -U^2_{cc} & \cdots & -U^2_{cc} \end{bmatrix}$$

and use the property that the determinant of a matrix is the sum of the determinants of the new matrices. The procedure is shown below and leads to the following formulas:

$$DET_{n-1} = (U^1_{QQ})^{n-1} - (n-1)\, U^2_{cc}\, (U^1_{QQ})^{n-2} \qquad (9.8)$$

$$DET_n = (U^1_{QQ})^n - n\, U^2_{cc}\, (U^1_{QQ})^{n-1} \qquad (9.9)$$

We insert (9.8) – (9.9) in (9.7):

$$dc_j/de_j = - \left[U^1_{QQ} - (n-1)\, U^2_{cc} \right] / \left[U^1_{QQ} - n\, U^2_{cc} \right] \;, j = 1,n \qquad (9.10)$$

By assumptions 9.A1 – 9.A2:

$$-1 < dc_j/de_j < 0$$

Cuts in effort will partly be compensated by the sponsor. This conclusion is not affected by a binding upper limit on total grants provided there is more than one bureau. If $n = 1$, making U^2_{cc} equal to infinity (which means that the upper limit on grants is binding) drives dc/de down to zero. When $n \geq 2$, a reduction in effort releases a redistribution of funds between the bureaus.

<u>Derivation of (9.8) and (9.9)</u>

$$\begin{vmatrix} U^1_{QQ}-U^2_{cc} & -U^2_{cc} & \cdot & -U^2_{cc} \\ -U^2_{cc} & U^1_{QQ}-U^2_{cc} & \cdot & -U^2_{cc} \\ \cdot & \cdot & \cdot & \cdot \\ -U^2_{cc} & \cdot & U^1_{QQ}-U^2_{cc} & -U^2_{cc} \\ -U^2_{cc} & \cdot & -U^2_{cc} & U^1_{QQ}-U^2_{cc} \end{vmatrix} =$$

$$\begin{vmatrix} U^1_{QQ} & 0 & \cdot & 0 \\ -U^2_{cc} & U^1_{QQ}-U^2_{cc} & \cdot & -U^2_{cc} \\ \cdot & \cdot & \cdot & \cdot \\ -U^2_{cc} & \cdot & U^1_{QQ}-U^2_{cc} & -U^2_{cc} \\ -U^2_{cc} & \cdot & -U^2_{cc} & U^1_{QQ}-U^2_{cc} \end{vmatrix} + \begin{vmatrix} -U^2_{cc} & -U^2_{cc} & \cdot & -U^2_{cc} \\ -U^2_{cc} & U^1_{QQ}-U^2_{cc} & \cdot & -U^2_{cc} \\ \cdot & \cdot & \cdot & \cdot \\ -U^2_{cc} & \cdot & U^1_{QQ}-U^2_{cc} & -U^2_{cc} \\ -U^2_{cc} & \cdot & -U^2_{cc} & U^1_{QQ}-U^2_{cc} \end{vmatrix}$$

(9.11)

We name the two determinants, $[1]_n$ and $[2]_n$, respectively.

$$[1]_n = U^1_{QQ}\,\mathrm{DET}_{n-1} \qquad (9.12)$$

$$[2]_n = \begin{vmatrix} -U^2_{cc} & -U^2_{cc} & \cdot & -U^2_{cc} \\ 0 & U^1_{QQ} & 0 & 0 \\ \cdot & \cdot & \cdot & \cdot \\ -U^2_{cc} & \cdot & U^1_{QQ}-U^2_{cc} & -U^2_{cc} \\ -U^2_{cc} & \cdot & -U^2_{cc} & U^1_{QQ}-U^2_{cc} \end{vmatrix} +$$

$$\begin{vmatrix} -U^2_{cc} & -U^2_{cc} & \cdot & -U^2_{cc} \\ -U^2_{cc} & -U^2_{cc} & \cdot & -U^2_{cc} \\ \cdot & \cdot & \cdot & \cdot \\ -U^2_{cc} & \cdot & U^1_{QQ}-U^2_{cc} & -U^2_{cc} \\ -U^2_{cc} & \cdot & -U^2_{cc} & U^1_{QQ}-U^2_{cc} \end{vmatrix} \qquad (9.13)$$

The second determinant of $[2]_n$ is zero. The first determinant is U^1_{QQ} times $[2]_{n-1}$.

Hence, we can successively reduce $\left[2\right]_n$ to $(U^1_{QQ})^{n-1}\, U^2_{cc}$. From (9.12) and (9.13), it follows that:

$$\mathrm{DET}_n = U^1_{QQ}\, \mathrm{DET}_{n-1} - (U^1_{QQ})^{n-1}\, U^2_{cc} = (U^1_{QQ})^2\, \mathrm{DET}_{n-2}$$

$$-\,2\,(U^1_{QQ})^{n-1}\, U^2_{cc} = \ldots = (U^1_{QQ})^n - n\,(U^1_{QQ})^{n-1}\, U^2_{cc} \qquad (9.14)$$

We can not in general state how the reaction functions will be affected by incorporation of one more bureau. This will depend on how we adjust the sponsor's utility function as more bureaus are added. If $(n\ U^2_{cc})$ increase monotonically in n and faster than U^1_{QQ}, the asymptotic limit of the slope of the reaction functions approach minus one:

$$\lim_{n\to\infty} dc_j/de_j = \lim_{n\to\infty} - \left[\, U^1_{QQ}/n - U^2_{cc}\,(n-1)/n \right] \,/\, \left[\, U^1_{QQ}/n - U^2_{cc} \right] = -1 \qquad (9.15)$$

Hence, we have obtained the astonishing result that as the number of bureaus grows, the part of the reduction in effort which will be compensated, moves towards unity. In the limit, the sponsor will compensate all cuts by increased grants. This result follows from our assumption concerning the first term in the sponsor's utility function. The sponsor's utility function is concave in each output level, which implies that the marginal cost of decreases in output increases as the cuts in output get bigger. Imagine a situation where the sponsor has maximized its utility, given the effort level of the bureaus. The budget is allocated so that the marginal benefit of one extra unit of grant is equal for all bureaus. Then one of the bureaus cuts the effort level. The marginal benefit of grants to that bureau will now exceed the marginal benefit of grants to the other bureaus, and the sponsor will react by transferring funds to the bureau which has cut its effort level. The redistribution of grants will continue until the marginal benefit of grants is equalized among the bureaus. If the number of bureaus is large, the n–1 bureaus are marginally affected by the redistribution. Therefore, the new level of marginal benefit of grants is only slightly higher than before the cut. This implies that the bureau which cuts the effort level, will be almost 100% compensated.

Our result has implications for the equilibrium effort levels of games where the number of bureaus is large. Since almost all cuts in effort will be compensated by the sponsor, the bureaus have strong incentives to cut effort. Cuts will partly be countered by reducing the grants to other bureaus and partly by raising the total budget. When there is only one bureau, cuts can only be compensated by increasing total grants. The sponsor is therefore more sensitive to cuts in effort in the multi–bureau setting.

We state the first order conditions for the identical bureaus when we have interior solutions:

$$V^1_Q(Q_j)\,(1 + dc_j/de_j) - V^2_e(e_j) = 0\ ,\ j = 1,n \qquad (9.16)$$

For symmetric utility functions, the equilibrium effort level will be equal for all agents. As dc_j/de_j decreases towards minus unity, the sum in the parenthesis will go towards zero and the equilibrium effort level will approach minus infinity or its lower value.

We have found that the efficiency of public institutions will fall as the number of institutions increases. This result differs from the conclusion of the regulation literature concerning how the number of institutions affects the authorities' ability to promote a high level of efficiency in the public sector. Typically, regulation models assume that the effort level or the true costs of a public firm can not be monitored or inferred. When the production functions of the firms are stochastically dependent, information from some of the firms will help the authorities to infer effort or costs of other firms. Therefore, the authorities will be better off by making the reward of one firm dependent on observable performance measures of other firms. In general, the authorities gain from an increase in the number of firms because each firm can be given more powerful incentives when the idiosyncratic risk that each firm carries can be decreased.[1] The general conclusion to be drawn from the regulation literature is consequently the opposite of what we have found. This is basically due to the difference concerning the order of move of the players.

Before we discuss various reform proposals in section 9.3, we briefly compare our model to related strands of the public choice literature.

Our model complements the theories of lobbying and rent–seeking.[2] These theories state that public institutions will use resources in order to capture part of the authorities' total budget. As for our model, the public institutions will act strategically to affect the behaviour of the authorities. But instead of spending money directly to affect the political process, they cut effort (and therefore output) to exert pressure on the authorities. In practice, public institutions use both tools. To increase their budgets, they apply a variety of instruments; propaganda through local news media, verbal and written arguments directed at the policy makers and cuts in output. The purpose of these actions is to influence the administration and the political bodies which decide their budget. Wickstrøm (89) explores how the waste of resources depends on the number of contestants in a rent–seeking game. He finds that if the agents are of equal strength (as defined by the relationship between input and output of their rent–seeking activity), waste will increase as the number of contestants increases. This outcome is an interesting parallel to our result that effort will decrease as the number of bureaus increases. If the contestants have unequal strength, the impact of the number of contestants on the waste of resources is ambiguous. We have been unable to show a similar result analytically in our model.

Another related strand of literature is the theory of collective action set forward by Mancur Olson (65,82). His basic view is that coalitions and interest groups reduce society's growth rate by actions which intend to affect the government's redistribution of income. As coalitions grow stronger, their incentives to produce diminishes, and their incentives to obtain a larger share of what is produced increases. Hence, the production capacity of society will erode over time.

Finally, our approach should be compared to the contractual–constitutional theory of public institutions, which in particular has been advanced by Geofrey Brennan and James Buchanan (Brennan & Buchanan, 77, 78, 80, 85). Brennan & Buchanan do not explicitly analyze the interaction between the authorities and bureaus. Instead, they assume that the budget decisions are dominated by powerful, budget–maximizing bureaucrats. Hence, at the constitutional level, a voter prefers a tax–system which restricts the ability of the bureaucrats to raise revenues and which forces the bureaucrats to spend the revenues on services which benefit the general public rather than themselves. This approach to the post–constitutional stage is clearly inspired by the bureaucracy model of Niskanen (71), while our model is based on works by Niskanen's successors. In the next section, we will see that our approach lead to somewhat different conclusions about the appropriate reforms at the constitutional level than the Brennan & Buchnanan approach.

9.3 DISCUSSION

In this section, we offer a discussion of various public sector reform proposals based on the model of section 9.2.

a) Measures which seek to contain public expenditures

During the seventies and eighties, a large number of reforms have been implemented or proposed with the intention of reducing the growth in public expenditures. Such measures include constitutional limits on deficits, setting ceilings on public expenditures, setting upper limits on tax rates and giving the Ministry of Finance more to say in the cabinet.[3]

Brennan & Buchanan (77,80) discuss the implication of the Niskanen–model of bureaucracy for tax–reforms. Their conclusion is that the voters should make the tax–base noncomprehensive or place limits on the discretion of the bureaucrats to set the tax–rate structure in order to limit the resources available for the bureaucracy.

Reforms which aim at curbing public expenditures, work in two different ways. First, reforms seek an 'optimal' size of the public sector by countering the bias towards excessive spending of the political decision process. Second, by tying the hands of the authorities, reforms will make public bureaus redirect their efforts from affecting government decisions towards production of services. The reforms intend to enhance the credibility of the authorities' commitment to a tough budget policy.

We will not comment on the first objective. Concerning the second objective, we can draw clear conclusions from our model about the desirability of these kinds of reforms. When the number of public bureaus is small compared to the size of the total budget, our model predicts that the reforms may serve to increase the efficiency of public bureaus. Curbing total expenditures will reduce the bureaus' incentives to cut effort strategically.

However, when the number of bureaus is large, the total amount of revenues available for the authorities do <u>not</u> have a significant impact on the effort level of the bureaus. The sponsor's compensation to a bureau when it cuts effort will then almost completely be financed by withdrawing grants from other bureaus. Hence, limiting the total pool of funds available for the sponsor will not mitigate the poor incentives of the bureaus. <u>Reducing public expenditures will lead to lower output but not higher effort.</u>

During the last part of the seventies and during the eighties, federal governments in several countries have put constraints on the fiscal freedom of the local sector (Brunsson & Rombach (82), Lane & Magnusson (87) and Schou (87)). These measures have succeeded in reducing the growth rate of the local sector, but have not necessarily made the local sector more efficient.

<u>b) Earmarking of grants and fees</u>

Brennan & Buchanan (78) argue that each public good should be financed by a special tax whose tax–base is highly complementary with the benefits of the good. The point of such earmarking is to prevent the bureaucrats from spending revenues on slack since that would reduce total revenues. Hence, roads should be financed by road tolls and defence by revenues from capital taxes.

Our results support the conclusions of Brennan & Buchanan, but we provide a more general argument in favour of earmarking. According to our model, any earmarking of revenues would enhance the productivity of public bureaus. Earmarking should not be limited to the assignment of tax–bases to complementary goods. The mechanism which generates inefficiency in our model, is the sponsor's discretion to redistribute grants between the bureaus. If the sponsor's revenues are earmarked to certain activities, the sponsor's discretion to redistribute funds would be considerably limited. Thus, there is a strong case for tying revenues to expenditures in order to stop the bureaus from acting strategically to obtain a higher share of the sponsor's total revenues.

Furthermore, our results indicate that the federal government should not fund the municipalities by giving general grants which can be spent at the discretion of the grantee. The grant should be 'selective', designed for a narrow purpose. Earmarking of the municipalities' revenues reduces the power of the municipal council and reduces the scope for rent–seeking by municipal bureaus. Interestingly, the development in the Western World seems to go in the opposite direction, away from selective grants towards general grants.

c) Introduction of price–systems in the public sector

In the last decade, a number of schemes have been set forth which intend to make bureaus' grants dependent on the bureaus' production. Perhaps the best example of such a scheme is the DRG–system for financing of hospitals. Prospective prices are set for treatment of different categories of patients. The DRG–system has been implemented by Medicare in the US, and several European countries are currently discussing how price–systems can be implemented in their national health services (Culyer (90)).

In chapter 7, we studied a game between one sponsor and one bureau under certainty and found that the introduction of a price system will not affect the equilibrium outcome when the bureau moves first. This conclusion also holds for the model of this chapter. If the sponsor is completely free to adjust the individual prices during a budget period, it is straightforward to show that introducing a price system does not affect the equilibrium outcome. The bureaus set effort before the sponsor makes the final adjustment of the piece–rates. It does not matter for the bureaus whether they receive their revenues as lump–sum transfers or as payment per unit of output. In any system where the rates can be costlessly changed, the sponsor will adjust the rates of the payment system to maximize its utility, taking the effort levels of the bureaus as given. Hence, as seen by the bureaus, the sponsor's reaction functions are the same. Therefore, the bureaus' choices of effort levels are independent of the payment system.

In practice, the sponsor has limited discretion to adjust the rates of any payment system during the budget period. The crucial question is therefore whether a price–system has more inertia than the pure lump–sum transfers. The rates of a price–system will normally be based on national standards or scientific cost comparisons. Thus, the sponsor can argue that it would be unfair to deviate from the national norm. On the other hand, the bureaus will maintain that a price–system is not able to capture all dimensions of the their production, making individual treatment of each bureau warrented. US studies of the DRG–system confirm that the system has not done away with bilateral bargaining between the authorities and the hospitals. There are plenty of unresolved issues which must be handled individually (Weiner et al (87), Hsiao & Dunn, (87)).

On balance, it seems reasonable to conclude that formal price–systems have a potential for reducing strategically induced slack but that the effects of the system are uncertain because we know very little about how price–systems affect the distribution of power between the budget participants.

Conclusion

We have computed the equilibrium outcome of a game where many bureaus move simultaneously and the sponsor reacts to their moves by distributing grants between the bureaus. The sponsor's utility function is additive and concave in each bureau's output. These assumptions lead to the conclusion that the sponsor will respond to a strategic increase in slack by a bureau by redistributing public grants to the bureau from other bureaus. This mechanism gives the bureaus strong incentives to decrease their effort levels.

If our model gives a realistic picture of the interaction between political decision makers and public institutions, public reform proposals should be judged by their impacts on the policy makers ability to redistribute funds between institutions. Our analysis provides arguments in favour of reforms which reduce the authorities' short–run discretion.

ENDNOTES

[1]Holmstrøm (82), Nalebuff & Stiglitz (83), Mookerjee (84), Shleifer (85).

[2]A theory of lobbying is developed by Becker (83,85). The theory of rent–seeking is comprehensive. The tradition which is closest to the spirit of our model, departs from Tullock(80) where he constructs a one–shot Nash–equilibrium of a game between players who compete for resources. The probability of being allocated funds depends on the resources invested by each player. Depending on the technology of the players' rent–seeking activity, the outcome may be that more or less of the total pool of funds is wasted during the rent–seeking process. Recent research has extended Tullock's analysis to compute how the dissipation of resources depends on the setting of the game (Concoran & Karels (85), Higgins et al (85), Hillman & Samat (87), Allard (88) and Hirshleifer (89)). Faith (80) relates the theory of rent–seeking to bureaucracies.

[3]Tarschys (85) is a comprehensive survey of efforts to curb the growth in public expenditures.

REFERENCES

Allard, R. 1988: Rent–Seeking with Non–Identical Players, Public Choice 57, 3–14.

Becker, G. 1983: A Theory of Competition among Pressure Groups for Political Influence, Quarterly Journal of Economics 93, 371–400.

Becker, G. 1985: Public Policies, Pressure Groups and Dead Weight Costs, Journal of Public Economics 28, 329–347.

Brennan, G. & Buchanan, J. 1977: Towards a Tax Constitution for Leviathan, Journal of Public Economics 8, 255–273.

Brennan, G. & Buchanan, J. 1978: Tax Instruments as Constraints on the Disposition of Public Revenues, Journal of Public Economics 9, 301–318.

Brennan, G. & Buchanan, J. 1980: The Power to Tax: Analytical Foundations of a Fiscal Constitution, Cambridge University Press.

Brennan, G. & Buchanan, J. 1985: The Reason of Rules, Cambridge University Press.

Brunsson, N. & Rombach, B. 1982: Går det att spara? (in Swedish), Doxa.

Corcoran, W. & Karels, G. 1985: Rent–Seeking Behaviour in the Long–Run, Public Choice 46, 227–246.

Culyer, A. 1990: Cost Containment in Europe, in Health Care Systems in Transition, Social Policy Studies No. 8, OECD.

Faith, R. 1980: Rent–Seeking Aspects of Bureaucratic Competition, in Buchanan, J., Tullock, G. & Tollison, R. (ed): Toward a theory of the Rent–Seeking Society, Texas University Press.

Higgins, W., Shughart, W. & Tollison, R. 1985: Free Entry and Efficient Rent–Seeking, Public Choice 46, 247–258.

Hillman, A. & Samet, D. 1987: Dissipation of Rents and Revenues in Small Numbers Contests, Public Choice 54, 63–82.

Hirschleifer, J. 1989: Conflict and Rent–Seeking Success Functions: Ratio vs. Difference

Models of Relative Success, Public Choice 63, 101–112.

Holmstrøm, B. 1982: Moral Hazard in Teams, Bell Journal of Economics 13, 324–340.

Hsiao, W. & Dunn, D. 1987: The Impact of DRG Payment on New Jersey Hospitals, Inquiry 24, 212–220.

Lane, J. & Magnusson, T. 1987: Sweden, in Page, E. & Goldsmith, M. (ed): Central and Local Government Relations, SAGE Publications.

Mookerjee, D. 1984: Optimal Incentive Schemes with Many Agents, Review of Economic Studies 51, 433–466.

Nalebuff, B. & Stiglitz, J. 1983: Prizes and Incentives, Bell Journal of Economics 14, 21–43.

Niskanen, W. 1971: Bureaucracy and Representative Government, Aldine–Atherton.

Olson, M. 1965: The Logic of Collective Action, Harvard University Press.

Olson, M. 1982: The Rise and Decline of Nations, Yale University Press.

Scou, B. 1987: Frihet under ansvar (in Danish), mimeograph, Center for Public Organization and Management, Copenhagen.

Shleifer, A. 1985: A Theory of Yardstick Competition, Rand Journal of Economics 16, 319–327.

Tarschys, D. 1985: Curbing Public Expenditures: Current Trends, Journal of Public Policy 5, 23–67.

Tullock, G. 1980: Efficient Rent–Seeking, in Buchanan, J., Tullock, G. & Tollison, R. (ed): Toward a Theory of the Rent–Seeking Society, Texas University Press.

Weiner, S., Maxwell, J., Sapolsky, H., Dunn, D. & Hsiao, W. 1987: Economic Incentives and Organization Realities: Managing Hospitals under DRGs, The Milbank Quarterly 65, 463–487.

Wickstrøm, B. A. 1989: Decentralization and Pressure–Group Activities, Arbeidspapier Nr. 8906, University of Linz.

CHAPTER 10

THE ROLE OF INVESTMENT

10.1 INTRODUCTION

The rate of investment of Norwegian municipalities has been very high in recent years. For example, in the city of Trondheim city and in Sør–Trøndelag County, investments in new projects have amounted to as much as 20–30% of net revenues. Investments have mainly been financed with loans causing a rapid accumulation of debt in the local sector.

The purpose of chapter 10 is to discuss the causes of the local sector's investment policy and how this policy affects the efficiency of public institutions. Section 10.2 presents a simple extension of the basic model of chapter 3 which incorporates capital as a factor of production. In section 10.3, we discuss alternative explanations for the rate of investment in the municipal sector.

There is no general agreement among theorists regarding the ratio of labour and capital in the public sector. One view, presented by de Alessi (69), is that the bureaus will set the discount rate low in order to attract new projects and a high total budget. This will cause the production of public services to be overly capital intensive as a low discount rate favours capital input to other input factors.

An alternative view is expressed by Orzechowski (77), who argues that the bureaus seek a "quiet life" and therefore prefer to increase the staff, hence causing the labour–capital ratio to be high.

The empirical evidence from the public sector is mixed. Borcherding et al (82), pp. 140 state that there is no indication that the capital–labour ratio of the public sector differs systematically from that of the private sector. Neither is there an unambiguous connection between the capital–labour ratio and the efficiency of public institutions. Orzechowski's point is that excessive staff will make a low effort level possible. However, the opposite can also be true, that a low investment ratio decreases the quality of buildings and equipment and forces the staff to work harder.

A weakness of both theories is that they are based on the preferences of the bureau alone. It would be more satisfactory to model the investment policy as the outcome of a game between the sponsor and the bureau, where the sponsor has the legal right to decide on the bureaus' capital budget. In section 10.2, we model the investment decision as an integrated part of the interaction between sponsor and bureau.

10.2 THE MODEL

The production function (3.1) does not include the capital of the bureau. We will rewrite the production function in a more general form. At time t, the production function is:

$$Q_t = Q_t(K_t, c_t + e_t) \qquad (10.1)$$

$$K_t = K_{t-1} + I_t \qquad (10.2)$$

K_t – the capital of the bureau at time t

I_t – grants for capital expenditures at time t

c_t – grants for current expenditures at time t

The function (10.1) states that the output is a function of the capital of the bureau, the grants for current expenditure and the effort level. Effort is assumed to have no effect on the amount of capital. Effort affects the productivity of current expenditures. Since current expenditures primarily include wage expenses, effort characterizes the efficiency of the labour force. We have set capital to be independent of effort because the bureaus' staff usually does not take part in the construction of buildings or equipment.

Equation (10.2) states that investments are the difference between the capital of two periods. To simplify the analysis, we have omitted depreciation. We do not distinguish between gross and net investments.

We will compute one–shot equilibria. We assume that investments have an instant impact on capital. For the purpose of our analysis, we can therefore omit K_{t-1} and the subscripts of (10.1) – (10.2).

The utility functions are as (3.2) – (3.3) except that the disutility of grants depends on the total grants, both for investments and current expenditures. The one–period model is therefore:

$$Q = Q\ (I, c+e) \qquad (10.3)$$

$$U(Q,I+c) = U^1(Q) - U^2(I+c) \qquad (10.4)$$

$$V(Q,e) = V^1(Q) - V^2(e) \qquad (10.5)$$

The properties of the utility functions are as for chapter 3. U^1 and V^1 are concave in output, U^2 is convex in total expenditures and V^2 is convex in effort.

(10.3) – (10.5) state that the sponsor provides two production factors and that output is not necessarily linear in the two factors. The production factor of the bureau augments one of the sponsor's production factors.

The properties of the output function are perhaps less obvious than those of the utility functions. The first derivatives with respect to I and c+e are certainly positive. For a given level of grants and effort, output will increase as capital increases. Similarly, for a given capital base, output increases with grants and effort.

The sign of the direct second derivatives are set to be negative. The marginal productivity of output with respect to investments decreases as investments increase for a given level of grants / effort. The same is the case for the second derivative with respect to grants and effort.

A crucial question is the sign of the cross derivatives of the output function, that is, whether capital and current expenditures are complementary input factors. We assume that the output function is continuous and twice differentiable, therefore $Q_{cI} = Q_{eI} = Q_{Ic} = Q_{Ie}$. If the cross derivatives are positive, increases in investment raise the marginal productivity of grants and effort.

In the long run, we would expect the cross derivatives to be positive. When current expenditures and effort are raised, the bureau will sooner or later reach the point where capital is the limiting factor. For instance, when the number of employees is doubled, the capital generally has to be augmented.

In the short run, the effect of investment on the marginal productivity of effort and grants depends on several factors, including the quality of the capital equipment and whether the capital is fully utilized. The effect of quality on the cross derivatives is ambiguous. Inferior capital equipment can make a high level of current expenditures and effort necessary to avoid a severe cut back of production. But new and better equipment can also trigger a more efficient organization of the work. When the production is close to full capacity utilization, the effect of investment on productivity will be higher than when there is idle capital.

Overall, it seems reasonable that the sign of the second derivatives is positive. We will therefore assume that the production factors are complementary. The assumptions of the model can be summarized as follows:

A11: $Q_c = Q_e > 0 \quad Q_{cc} = Q_{ee} < 0$

A12: $Q_I > 0 \quad Q_{II} < 0$

A13: $Q_{Ic} > 0$

The lower subscript denotes the partial derivative of output with respect to the variable. We now compute and compare the solutions of two games, the Nash–Cournot game and the Stackelberg game with sponsor as leader.

The Nash–Cournot game

Q^N, I^N, c^N, e^N – the Nash–Cournot solution

FOC:

$$\text{I:} \quad U_Q^1(Q^N)\, Q_I(I^N, c^N + e^N) - U_I^2(I^N + c^N) = 0 \qquad (10.6)$$

$$\text{c:} \quad U_Q^1(Q^N)\, Q_c(I^N, c^N + e^N) - U_I^2(I^N + c^N) = 0 \qquad (10.7)$$

$$\text{e:} \quad V_Q^1(Q^N)\, Q_c(I^N, c^N + e^N) - V_e^2(e^N) = 0 \qquad (10.8)$$

Sponsor as leader

The reaction function of the follower, the bureau, describes how effort varies as a function of grants and investment. The first order condition of the bureau's maximization problem is:

$$V^1_Q(Q)\ Q_c(I,c+e) - V^2_e(e) = 0 \qquad (10.9)$$

From (10.9) we can find the derivatives of the reaction function. A total differentiation of (10.9) yields:

$$de = -\left[(V^1_{QQ}\ Q_c + V^1_Q\ Q_{cc}) \,/\, (V^1_{QQ}\ Q_c + V^1_Q\ Q_{cc} - V^2_{ee})\right] dc -$$

$$\left[(V^1_{QQ}\ Q_I + V^1_Q\ Q_{Ic}) \,/\, (V^1_{QQ}\ Q_c + V^1_Q\ Q_{cc} - V^2_{ee})\right] dI \qquad (10.10)$$

$$\partial e/\partial c = e_c = -(V^1_{QQ}\ Q_c + V^1_Q\ Q_{cc}) \,/\, (V^1_{QQ}\ Q_c + V^1_Q\ Q_{cc} - V^2_{ee}) < 0 \qquad (10.11)$$

$$\partial e/\partial I = e_I = -(V^1_{QQ}\ Q_I + V^1_Q\ Q_{Ic}) \,/\, (V^1_{QQ}\ Q_c + V^1_Q\ Q_{cc} - V^2_{ee}) \qquad (10.12)$$

The derivative of the reaction function with respect to grants, e_c, will unambiguously be negative and its absolute value will be between zero and one. Like in the basic model, a cut in grants will lead to increased effort for a given level of investments, but the increase in effort will not be sufficient to compensate for the cuts.

The sign of e_I is ambiguous. The denominator of (10.12) is negative. The first addend of the numerator is negative and reflects the indirect effect from investment on effort through output. An increase in investment will increase output and reduce the marginal utility of effort. The second addend of the nominator is positive and is due to the direct effect of investments on effort. The overall effect of investment on effort is ambiguous.

We now move to the leader's maximization problem:

Q^S, I^S, c^S, e^S – the equilibrium solution when the sponsor leads

$$I^S = \operatorname{argmax}_I\ U^1(Q(I,c^S+e(I,c^S))) - U^2(I+c^S) \qquad (10.13)$$

$$c^S = \operatorname{argmax}_c\ U^1(Q(I^S,c+e(I^S,c))) - U^2(I^S+c) \qquad (10.14)$$

(10.13) – (10.14) yield the first order conditions:

$$U_I = U_Q^1(Q^S)\left[Q_I(I^S,c^S+e^S) + Q_c(I^S,c^S+e^S)\, e_I\right] - U^2(I^S+c^S) = 0 \qquad (10.15)$$

$$U_c = U_Q^1(Q^S)\left[Q_c(I^S,c^S+e^S)\,(1 + e_c)\right] - U^2(I^S+c^S) = 0 \qquad (10.16)$$

(10.9), (10.15) and (10.16) constitute the Stackelberg – equilibrium when we set $Q = Q^S$, $I = I^S$, $c = c^S$ and $e = e^S$ in (10.9). Once again, we are not guaranteed that we can have an interior and stable solution due to the positive external effects between investments and grants / effort. For the same reason, we can not compare the equilibrium outcome of the two settings without a total differentiation of the first order conditions. The resulting expressions contain a great number of derivatives of second and third order, and for many of them, we can not make sensible a priori assumptions about their sign or magnitude. We will therefore carry out the analysis in a simpler way, by inserting the Nash–equilibrium solution in the first order conditions of the Stackelberg setting. We insert Q^N, I^N, c^N and e^N in (10.15) – (10.16) and use (10.6) – (10.7) to simplify the resulting expressions:

$$\text{I:}\ \ U_I = U_Q^1\, Q_c\, e_I \qquad (10.17)$$

$$\text{c:}\ \ U_c = U_Q^1\, Q_c\, e_c < 0 \qquad (10.18)$$

From (10.18), it follows that the sponsor will want to cut grants when the variables are set at the grant value of the Nash–Cournot solution. The marginal utility of investments depends on the sign of e_I. When $e_I < 0$, the sponsor will want to reduce investments to force the bureau to increase effort. When $e_I > 0$, the sponsor wants to increase investments. We will point out that we have only computed how the sponsor will react, when starting from the Nash–Cournot solution. The resulting equilibrium can give different conclusions due to the positive external effects of the production function.

The main conclusion we can draw from the model, is that the sponsor can use investments strategically to increase effort. Whether strategic considerations will lead the sponsor to increase or decrease investments from the Nash–equilibrium, depends on the form of the production function and the utility functions.

The implication for the public sector is that the authorities might want to press for high investments and at the same time cut current expenditures of the institutions. Both measures can be interpreted as an attempt to make the institutions raise their effort level. and is one possible explanation why Norwegian municipalities and counties have high investments ratios. Schou (87), pp. 15, reports that during the years of a tight fiscal policy in Denmark in the eighties, the federal government tried to make the municipalities reduce current expenditures rather than capital expenditures.

Since the character of public services differs, it could be that the authorities want to press ahead with investments in some areas while holding back capital expenditures for other purposes. The expansion will take place for activities where the authorities expect that a high capital ratio will induce the institutions to produce services more efficiently. The ambiguity of the government with respect to capital expenditures could explain the empirical findings of Borcherding et al (82).

10.3 DISCUSSION

In section 10.2 we presented a theory that the high investment rate in Norwegian municipalities and counties is a tool to increase the efficiency of the institutions. This conclusion would probably be strengthened if we introduce uncertainty in the production function. When the authorities face a moral hazard problem, they will choose a combination of input factors that reduce the bureaus' opportunity to set a low effort level. One could argue that moral hazard is generally a smaller problem when the capital–labour ratio is high than when the ratio is low because the moral hazard problem is due to actions taken by the labour force. The less important is the staff, the less severe are the consequences of a low effort level. If this is the view of the municipalities, they would want to push ahead with investments.

The assumption that labour productivity depends on investments, is a variant of the learning–by–doing phenomenon which have been observed in some industries. The productivity of firms increases with output due to the accumulation of knowledge of the production process. Within the theory of industrial organization, learning–by–doing arguments have been used to explaining the persistence of monopolies (Tirole (88), pp. 72). If the municipalities believe that the productivity of institutions is a positive function of the output, they will want to drive up output through increases in current and capital expenditures.

A less subtle explanation for the high investment ratio is simply that investing is the only way for the municipalities to be able to run a deficit. Since Norwegian law prohibits the local authorities from running a deficit on the current account, they may want to overinvest compared to a situation where both current and capital expenditures are unconstrained. A finding which supports this theory is that many municipalities appear to try to figure out ways to define current expenditures as investments in the historical accounts.[1]

A third theory of the high investment rates is that it is due to the political process of the county/municipality. Local politicians are expected to fight for their constituency. An investment project faces the elected representatives with yes/no decisions. Campaigns for investment projects are therefore well suited to convey a positive impression to the constituency. The decision by a political body to grant an operating budget to an existing institution is more difficult for the electorate to evaluate than the decision to accept or reject a new project.[2]

A fourth explanation for the investment policy of public authorities focuses on the lack of allocation of capital costs in the public sector (NOU 89:5, pp. 172–175). Public institutions pay no interest on their capital. This will lead them to press for higher investments. They do not have incentives to extend the life time of their present buildings and equipment. Spending on maintenance will decrease the pressure directed on the authorities to appropriate new investment projects. Once the investment has taken place, it is "free" for the institutions. Therefore, they will exploit their information monopoly to affect the policy makers to increase investments. They have incentives to hold back information which would have helped the authorities to make a balanced assessment of the need for current and capital expenditures, respectively.

ENDNOTES

[1]Municipalities in Nord–Trøndelag "hide" wage expenses in the following way: When a municipality invests, it applies for a loan from the bank which includes wage expenses of an external contractor. Then, the municipality lets its own employees do part of the job. In that way, the municipality's wage expenses are financed by loans, which is not legal according to federal rules.

Bergen municipality frequently postpone parts of an investment project after the project's loan is received. The extra funds are used to finance current operations (Mellemvik (89), pp. 145).

[2]Savas (87) argues that the neglect of maintenance in the public sector is due to this effect. New buildings are more visible to the electorate than expenditures on maintenance on existing buildings.

REFERENCES

Borcherding, T., Pommerehne, W. & Schneider, F. 1982: Comparing the Efficiency of Private and Public Production: The Evidence from Five Countries, Zeitschrift fur Nationaløkonomie, suppl. 2, 127–156.

De Alessi, L. 1969: Some Implications of Property Rights for Government Investment Choices, American Economic Review 59, 16–23.

Mellemvik, F. 1989: Kommuneregnskapets rikdom, Ph.D. thesis, NHH, Bergen.

NOU 89:5 En bedre organisert stat

Orzechowski, W. 1977: Economic Models of Bureaucracy. Survey, Extensions and Evidence, in Borcherding, T. (ed): Budgets and Bureaucrats, Duke University Press, Durham, 229–259.

Savas, E. 1987: Privatization, Chatham House, N.J.

Schou, B. 1988: Frihed under ansvar, COS forskningsrapport 2/88, Center for offentlig organisation og styring, Handelshøyskolen i København, København.

Tirole, J. 1988: The Theory of Industrial Organization, MIT Press, Cambridge, Boston.

CHAPTER 11

CONCLUSION

In this chapter, we summarize and compare some of the results of the former chapters.

We started out by formulating a standard bureaucracy model in the Niskanen–tradition. There are one sponsor and one bureau. The bureau produces services while the sponsor supplies funds to the bureau. The basic one–period model consists of one production function and two utility functions:

$$Q = c + e \qquad (11.1)$$

Sponsor: $U(Q,c) = U^1(Q) - U^2(c) \qquad (11.2)$

$U^1_Q > 0 \quad U^1_{QQ} < 0 \quad U^2_c > 0 \quad U^2_{cc} > 0$

Bureau: $V(Q,e) = V^1(Q) - V^2(e) \qquad (11.3)$

$V^1_Q > 0 \quad V^1_{QQ} < 0 \quad V^2_e > 0 \quad V^2_{ee} > 0$

Q – the bureau's output

c – grants from the sponsor to the bureau

e – the bureau's effort

Both agents derive positive utility from output but they disagree on how output should be provided. The sponsor wants output to be produced with as small grants as possible, which implies that effort is high. The bureau wants higher output to be the result of higher grants. The sponsor sets the budget and the bureau sets effort. Except for chapter 8, we assume that the sponsor does not have to guarantee the bureau a minimum level of expected utility. We justify this assumption by reference to the fact that public bureaus seldom can choose whether to produce or not.

In chapter 3, we compute the equilibrium outcomes of three basic noncooperative games, the Nash–Cournot game, where the agents move simultaneously, the Stackelberg game with sponsor as leader and the Stackelberg game with bureau as leader. Both players gain from being the leader. When the sponsor leads, it forces the bureau to increase effort by cutting grants below the grant level of the Nash–Cournot game. A Stackelberg game with bureau as leader yields lower effort and higher grants than the Nash–Cournot game. The form of the utility functions ensures that output is lower for the two Stackelberg solutions than for the Nash–Cournot solution. All three noncooperative games give output levels which are lower than the output levels corresponding to the points on the Pareto–optimal locus. This is due to the positive external effects attached to the two policy variables.

It is common to let the sponsor set the budget in the bureaucracy literature. However, I am not aware of any paper in this tradition where the bureau sets effort. In chapters 2–3, we survey some models with alternative assumptions concerning the bureau's policy variable and relate the models' equilibrium outcomes to the outcomes of our three basic games.

If the bureau sets output instead of effort, the Stackelberg solution with sponsor as leader remains the same. The outcome for the two other noncooperative games is changed considerably. Under reasonable assumptions, zero output will be the Nash–Cournot solution when the bureau sets output. When the bureau moves first, effort will equal its maximum value. Hence, the bureau's advantage from moving first disappears when its policy variable is changed from effort to output.

Next, let the bureau set effort as a percentage of output (e/Q) instead of effort. Again, the Stackelberg solution with sponsor as leader stays unchanged. The Nash–Cournot solution will be affected but its basic characteristics are roughly the same as before. It is feasible that the bureau will raise e/Q compared to the Nash–Cournot solution when it moves first. Whether the Stackelberg solution with bureau as leader gives higher or lower effort than the Nash–Cournot solution depends on the sponsor's preferences. This ambiguity does not exist in our basic model.

From the discussion in chapters 2–3, we can conclude that moving first gives the player an advantage in our basic model, but that this conclusion is sensitive to the choice of policy variable for the bureau.

In chapter 7, we consider an alternative policy variable for the sponsor, price per unit output (c/Q). For the Nash–Cournot game, the change of policy variable yields higher utility for the sponsor and lower utility for the bureau. Grants will be lower, and effort and output higher compared to basic model. Whether the sponsor will cut the price when it moves first, depends on the elasticity of the bureau's marginal utility. A price change has both an income and a substitution effect. When the income effect dominates, the sponsor will reduce the price in order to make the bureau increase effort. When the substitution effect dominates, a price increase leads to higher effort. The sponsor gains from being a leader, and effort will be higher than for the Nash–Cournot game in both cases. However, contrary to what we found for our basic game, we can not rule out the possibility that grants are higher when the sponsor leads. When the bureau leads, the equilibrium outcome will be the same as for our basic model. Hence, effort is lower than in both Nash–Cournot games.

In chapter 4, we discuss how the equilibrium outcomes of our basic games will be affected when the interaction between the two agents is repeated. When the basic game is repeated a finite number of times, the one–shot Nash–equilibrium is the only subgame perfect equilibrium outcome for every period as long as this equilibrium is unique. For our model, this result implies that the outcome of the finite multi–period game is exactly the same for each period as in the basic one–period model. When the number of periods of the supergame is infinite and the players move simultaneously, the sustainable equilibrium outcomes depend on the discount factors of the players. The higher the discount factors, the better are the sustainable equilibrium outcomes. When the players do not discount the future payoffs, any outcome is sustainable.

When the players move alternately in an infinite game, a Markov perfect equilibrium consists of a pair of subgame perfect strategies that are restricted to depend solely on the last move of the opponent. The Markov perfect equilibrium concept neatly reflects the dual nature of the players' motives in a dynamic game. Both agents partly accomodate to the opponent's last move and partly act strategically to affect the opponent's future moves. We compute numerically a subgame perfect equilibrium of a long finite game which can be interpreted as a finite game counterpart to a Markov perfect equilibrium. This equilibrium yields grant and effort levels which are below the corresponding grant and effort levels of the one–period Nash–Cournot game. It can be shown that the gap between the subgame perfect equilibrium solution and the Nash–Cournot solution widens as the players become more patient. High discount factors induce the players to put more emphasis on acting strategically and less emphasis on accomodation. The conclusion that both players loose from being more patient is the opposite of what we found for the infinite supergame with simultaneous moves. Each player will gain by becoming more patient if the opponent's discount factor stays constant. Since a player's discount factor depends on its trade–off between short– and long–run benefits, we would expect its discount factor to be related to the player's willingness and ability to undertake commitments. If this assumption is correct, the main conclusion of the multi–period alternating–move game is the same as for the basic one–period model. Both players gain from being able to make long–run commitments.

Uncertainty is dealt with in chapters 5, 6 and 8. We distinguish between three types of uncertainty. Output uncertainty is present when effort is observable but output is not. If output is observable but effort is private information for the bureau, the sponsor faces cost uncertainty. The last type of uncertainty is preference uncertainty which is relevant when one or both of the agents have private information about their true preferences.

In chapter 5, there is output uncertainty. Because the true demand for a bureau's services varies or because the bureau's output is multi–dimensional and therefore difficult to measure, we include a random element in the production function. Hence, there is uncertainty concerning the true marginal utility of output. We compute the equilibrium outcomes for the three basic games for two alternative information structures. In case A, both players must set their policy variables before the true production function is revealed. In case B, the bureau has private information about the production function when it sets effort. It turns out that the equilibrium outcome is very close to the equilibrium solution under certainty for five of the six games we study. For the Stackelberg game with bureau as leader, case B, the introduction of uncertainty has a profound influence on the outcome. Since the bureau sets effort with private information, our model is a signalling game. We find a perfect Bayesian equilibrium which satisfies the intuitive criterion. A low effort level is perceived by the sponsor as indicating that the the marginal utility of output is low. Therefore, the bureau's strategic position is weaker compared to the game where the production function is invariant. As a result, the effort level will be higher and grants will be lower when there is uncertainty about the true production function. The conclusion of chapter 5 is therefore that output uncertainty does not represent an obstacle to efficiency in a one–perod model.

In chapter 6, we introduce uncertainty concerning an agent's true preferences. We consider two different models. In both models, the agents move simultaneously. First, we assume that the sponsor has private information about its true utility function while the bureau's preferences are common knowledge. We compute a perfect Bayesian equilibrium of a multi–period game where the bureau acts myopically. The sponsor will want to manipulate the bureau's probability beliefs during the first part of the game in order to build a reputation as having strong preferences for low grants. We show that the sponsor can sustain an equilibrium outcome which it prefers to the one–shot Nash–equilibrium. This outcome gives lower grants and higher effort than the one–shot Nash–equilibrium. Therefore, preference uncertainty will move the equilibrium outcome in the direction of the one–period Stackelberg solution with sponsor as leader. Thus, the sponsor's private information about its preferences produces a similar effect as if it were the leader in the relationship.

In the next model of chapter 6, we assume that both agents maximize their discounted sum of expected utilities and both have private information about their utility functions. In order to find a perfect Bayesian equilibrium, we let the players move continuously in an infinite game. We are only able to find an equilibrium with mixed strategies. It turns out that the equilibrium outcome will be quite different to the outcome of the first model. The probability that a players chooses a low value for its policy variable depends on the player's discount factor and the opportunity losses of the feasible moves. When both players are patient and put much emphasis on forcing the opponent to reveal its true type, an equilibrium outcome with low grants and low effort can be sustained for a long time. From the sponsor's point of view, this equilibrium outcome is very undesirable.

The conclusion of chapter six is that preference uncertainty has a significant impact on the game between the sponsor and the bureau. Moreover, the equilibrium outcome is very sensitive to how we model the information structure and whether the bureau acts strategically to affect the sponsor's future moves. The sponsor's ability to exploit uncertainty about its true utility function depends on the bureau's planning horizon and the sponsor's knowledge about the bureau's preferences.

In chapter 8, we introduce cost uncertainty. The production function is modeled as in chapter 5. We can interpret the model as describing a situation where the true costs of the bureaus vary between bureaus and over time. The bureau has private information about effort. The sponsor can observe output but is not able to infer effort from output because it does not know the true production function. We allow the sponsor to construct output–dependent schemes and compare the performance of optimal schemes to the piece–rate system and the pure transfer system. In chapter 8, we assume that the bureau must be guaranteed a minimum level of expected utility. We start by finding the sponsor's optimal scheme for a one–period game for two different information structures.

When the bureau must set effort without information about the true production function, the sponsor faces a moral hazard problem. The optimal scheme represents a trade–off between two objectives. On one hand, the sponsor wants to smooth output since the marginal utility of output is highest when costs are high. On the other hand, rewarding bureaus with low output gives poor incentives for the bureaus to increase output by setting effort high. The first best scheme implies that the sponsor supplies more grants to bureaus with low output than to bureaus with high output. The second best scheme modifies the first best scheme by granting more to bureaus when the output level signals that effort is high.

When the bureau sets effort with information about the true costs, the sponsor faces an adverse selection problem. There are two types of bureaus, high–cost and low–cost bureaus. As for the moral hazard problem, the optimal scheme represents a trade–off between allocative and cost efficiency. The optimal scheme implies tight budgets to all bureaus. The point of this policy is to force low–cost bureaus to raise their effort levels. To avoid low–cost bureaus from pooling with high–cost bureaus, the output of high–cost bureaus must be reduced. Hence, the sponsor moves the high–cost bureaus away from the Pareto–optimal locus in order to extract grants from low–cost bureaus.

We also compare numerically the optimal scheme with the piece–rate system and the grant system for the adverse selection model. When the variance of the random term in the production function is low, the piece–rate system performs almost as well as the optimal scheme while the transfer system performs considerably worse. This conclusion changes as the variance increases. A piece–rate system gives the sponsor poor control over total grants when the two types of bureaus differ very much. The transfer system is preferable to the piece–rate system in this case, but it is clearly inferior to the optimal scheme.

When the adverse selection game is repeated, it becomes harder for the sponsor to separate the two types of bureaus. We assume that the sponsor is not able to commit itself to a particular policy for more than one period. This creates a ratchet–effect. The high–cost bureau will be reluctant to reveal its true type for fear of being punished in later periods. For our choice of numerical utility functions and reasonable discount factors, it is too costly for the sponsor to separate the bureaus. The sponsor prefers to let the low–cost bureau mimic the high–cost bureau by producing the same output with lower effort. We compute numerically the perfect Bayesian equilibrium of multi–period games for the piece–rate system and the transfer system, respectively. The ratchet–effect leads to lower expected effort than for the one–period game. However, for the piece–rate system, the ratchet effect is an advantage for the sponsor. The main problem of the piece–rate system, that the low–cost bureau exploits its low costs to expand its revenues, is mitigated by the ratchet–effect. For the transfer system, the sponsor is worse off in the multi–period game.

The conclusion of the chapter is that cost uncertainty is a serious obstacle to higher efficiency. The bureaus extract rents from their private information in the form of low effort. Since the sponsor's utility function is concave in output, the marginal utility of grants is higher when costs are high than when costs are low. The sponsor's inclination to smooth output restraints it from constructing incentives schemes which counter its informational disadvantage.

In chapter 9, we consider an extension of the basic one–period model where there are one sponsor and many bureaus. When the sponsor moves first and when all players move simultaneously, the equilibrium outcomes are not fundamentally different from those of the basic model. However, when the bureaus move first and the sponsor reacts to their moves, the outcome is drastically changed. As in chapter 8, the sponsor wants to smooth the output levels between the bureaus. Therefore, it will assign more grants to a bureau with low effort than to a high–effort bureau. When the number of bureaus grows, the sponsor's incentives to redistribute grants to low–effort bureaus increases. As the number of bureaus approaches infinity, the whole reduction in a bureau's effort will be compensated by the sponsor and the bureaus will therefore want to reduce effort towards its lower limit. The conclusion of chapter 9 is that the divergence between the outcome of the three basic games increases with the number of bureaus.

In chapter 10, we consider a variation of the basic game where the sponsor simultaneously sets current expenditures and investments. If the productivity of effort increases with investments, the sponsor may want to set investments higher in a Stackelberg game with itself as leader compared to the investment level of the Nash–Cournot game.

We have extended the basic bureaucracy model in a number of ways to explore how the equilibrium outcome, in particular the bureau's effort level, depends on the assumptions of the game. We have found that the order of move of the game is particularly important to the outcome. An agent will in general gain from moving first, although there are exceptions to this rule. Therefore, we would expect that the ability of the different public sector agents to commit themselves to long–run schemes is very important for the efficiency of public sector institutions. We have also found that uncertainty may have profound effects on the outcome of the interaction and that the bureau's effort level is sensitive to how we model the information structure of the game. It seems as though private information about the bureau's true preferences and costs is difficult to counter by the sponsor and generally leads to low levels of effort. The order of move of the game and the distribution of information between the agents is crucial for the success of public sector reforms which make bureaus' grants dependent on output.