

The Maximization of Discretionary Budget:
an Explanation for the Pattern of Computer Investments
in the Federal Government/

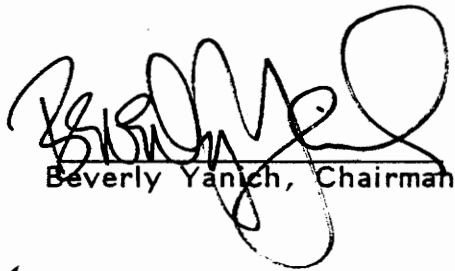
by

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Chapter I

INTRODUCTION

Yossarian saw it clearly in all its spinning reasonableness. There was an elliptical precision about its perfect pairs of parts that was graceful and shocking, like good modern art, and at times Yossarian wasn't quite sure that he saw it at all, just the way he was never quite sure about good modern art or about the flies Orr saw in Appleby's eyes.¹

Are the activities and performance of the United States federal bureaucracy systematically predictable? Examinations of bureaucracy have ranged from the iconic model of Joseph Heller's Yossarian, who saw the bureaucracy as an incomprehensible and maddening maze, to the analytical models of Tullock, Buchanan, Niskanen and other public choice economists, who see the bureaucracy as mammoth and complex - but quite comprehensible and predictable. This thesis is a study of bureaucratic behavior from the perspective of a particular federal government operations process - the management and delivery of computing services to the federal agencies. It supports the idea that federal bureaucrats are utility maximizers. The emphasis, however, is upon examining the computing services process for an indication as to what it is that bureaucrats value - what is the incentive force that drives the federal bureaucracy?

¹ Joseph Heller, Catch 22, (New York: Simon and Schuster, 1955), p. 46.

1.1 THE RATIONALE

Information processing in the United States is a critically important industrial sector of our economy and a significant resource in the provision of government services. Computer user spending in the United States today equals 5% of the Gross National Product; in 1985 it will exceed 8%.² Ten billion dollars of the federal budget in 1975-76 was for providing information processing services to the various government agencies.³ That expenditure was about 4% of the total federal budget. Poor utilization of computer systems affects the federal agencies' ability to provide effective, efficient government services. For instance, improved cashflow, reduced inventories, better customer service, and productivity improvements have been traditional objectives of information processing systems. Today, those objectives are being met with new computer and telecommunications facilities functioning as word processing and office systems, process control systems, and fully integrated communications networks.⁴ Federal bureaus' effectiveness and efficiency are becoming dependent upon the degree to which modern computer systems are integrated into their organizational processes.

² American Federation of Information Processing Societies, Information Processing Processing in the United States - A Quantitative Summary, (March, 1978), p. 6.

³ Committee on Government Operations, Administration of Public Law 89-306, Procurement of ADP Resources by the Federal Government, (Washington: U. S. Government Printing Office, 1976), p. 1.

⁴ For more on this, see James Martin's book Telematic Society, (Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1981), pp. 1-244.

1.1.1 Federal Computer Systems

Prior to the 1960's, the federal government was a world leader in the development of state-of-the-art computer systems.⁵ However, since the 1960's, there has been a significant deterioration in the efficiency and effectiveness of the federal government's computer systems. For instance, the Honorable Jack Brooks, Chairman of the House Government Operations Committee, has stated that the deterioration "has grown to such massive proportions that virtually every agency is in danger of having its operations hampered by outdated and obsolete information systems."⁶ Are the federal operations policies at fault? According to the Honorable Charles G. Rose, III, Chairman of the House Computer Operations Subcommittee, the 1965 Brooks Act, which governs computer management policies, was a message from Congress to the Executive Branch that automatic data processing resources had been mismanaged.⁷ From his perspective, the Brooks Act was intended to eliminate the management problems. However, through the advocacy of the Honorable Sam Steiger of the Committee on Government Operations, the federal agencies have protested the excessive cost and time involved in the federal government's computer procurement process.⁸ Steiger implies

⁵ Robert V. Herd, "Seeking a Path through the Paperwork Jungle," Infosystems, (April, 1981), p. 54.

⁶ Jack Brooks, "Paper Reduction Act of 1980" in a speech at the Federal DP Exposition (Washington, D. C., April 14, 1981).

⁷ U. S. Dept. of Commerce, Proceedings of the Interagency, p. 71.

⁸ Committee on Government Operations, Administration of Public Law 89-306, p. 17.

that the excessive time and cost are related to policies leading from the implementation of the Brooks Act. Arnold Keller, editorial director of Infosystems, in explaining growing concerns about the effectiveness of federal computer systems, stated that "the best of good intentions can be buried in a bureaucratic maze and that's exactly what happened to the Brooks Bill."⁹ "Buried in a bureaucratic maze" is certainly not a very precise explanation of what has happened to the federal computer systems. It is, however, indicative of the confusion and lack of understanding of the "massive" failure in the computer acquisition process.

1.1.2 Perspective: The Bureaucratic Maze

Several ideas have influenced the search for a reasonable explanation of bureaucratic behavior in the investment process.¹⁰ First has been the notion that the federal government has not efficiently managed its computer investments and that this inefficient investment has contributed to the development of ineffective and inefficient computer systems. Another bias has been the idea that, given the policies established for federal computer acquisitions with the implementation of the Brooks Act, the sub-optimal development of the computer inventory has

⁹ Arnold Keller, "A Case of Mismanagement - Part I," Infosystems, Nov. 1977, p. 36.

¹⁰ Interest in the topic evolved while I was employed as a federal administrator involved in the computer acquisition process; that experience explains the initial perspective from within the federal bureaucracy.

been inevitable.¹¹ A perplexing contradiction to the assumption that the Brooks Act policies contributed to the problems in the computer acquisition process has been the understanding that those policies were intended to insure the economic and efficient management of computing. If federal computer acquisitions are inefficient, what is the failure in the acquisition process? Further, if the Brooks Act was directed towards economic and efficient acquisitions, why isn't it resulting in optimal investments? Government operations policies are the laws and regulations that define the instructions to the bureaucracy for the provision of government services. The search for an explanation of any failure in government operations begins with an examination of those instructions, but must include an understanding of how those instructions are processed. Instruction processing is governed by the structure of motivating forces at work within the bureaucratic organization. In other words, government output is shaped through our federal laws and regulations - which define to the federal bureaucrat a system of constraints and opportunities. The degree of effectiveness and efficiency in producing that output is limited by the federal bureaucrat's objectives in the discretionary interpretation of our laws and regulations.

¹¹ An example of those policies includes the requirement that conversion cost be excluded from consideration in the requirements specification of a proposed new computer system. See the "Administration of Public Law 89-306, Procurement of ADP Resources by the Federal Government", Thirty-eighth Report by the Committee on Government Operations together with Additional Views, (Washington: U. S. Government Printing Office, 1976), p. 6.

What motivates administrative decisions in the operation of our government? An understanding of motivating forces at work in government operations may be a critical prerequisite to the control, or instruction, of that government. Skillfulness of instruction may lead to a government's classification as good or bad, effective or ineffective, "smart or stupid."

Achilles: Do they have a special name?

Crab: Yes; they are called "smart-stupids", since they are so flexible, and have the potential to be either smart or stupid, depending on how skillfully they are instructed.¹²

Like Hofstadter's smart-stupids, the institutional decision-units that form the federal bureaucracy quite possibly respond exactly as they are instructed. The "instructions" are the structural incentives and disincentives for efficiency inherent in federal government operations. Effective instruction of the bureaucracy, then, requires an understanding of what motivates the decision-unit.

1.2 THE PROBLEM STATEMENT

The utilization of computer systems by the United States Government has been the subject of intensive, and controversial, study for over twenty years. The studies have been generated both within the execu-

¹² Douglas R. Hofstadter, Godel, Escher, Bach: An Eternal Golden Braid, (New York: Vintage Books, 1979), p. 721.

¹³ An example is a report by the U. S. Department of Commerce, Proceedings Of The Interagency Automated Data Processing Planning Conference, February 22 Through 24, 1976, (Springfield, Va.: Na-

tive branch¹³ and by the Congress.¹⁴ The general perception is that this important facet of government operations is being mismanaged, resulting, for instance, in an aging inventory of computer systems.¹⁵ However, the complaints have tended to be of a general, non-quantifiable nature. (Using the aging inventory example, age was not shown to indicate obsolescence - obsolescence was not shown to reveal ineffectiveness and inefficiency.) More significantly, explanations for the perceived deficiencies in computer acquisitions have either not been offered, or when offered not supported by empirical evidence.

This thesis examines the federal computer services process and the inherent investment decisions of federal administrators for consistency with either of two conflicting theories of bureaucratic behavior. The first of the two theories considered in this thesis is based upon William Niskanen's hypothesis that the primary objective of the government bureaucrat is to maximize the bureau's budget through the maximization of output.¹⁶ In other words, for an authorized level of output a bureau is

tional Technical Information Service, May, 1976).

¹⁴ An example is a report by the Committee on Government Operations, Administration Of Public Law 89-306, Procurement Of ADP Resources By The Federal Government, (Washington: U. S. Government Printing Office, 1976), pp. 1-19.

¹⁵ Office of the Controller General, Continued Use of Costly, Outmoded Computers in Federal Agencies Can Be Avoided, (Washington: United States General Accounting Office, December 15, 1980), pp. 1-61.

¹⁶ This theory was first developed by William A. - Niskanen in his book, Bureaucracy and Representative Government (Chicago: Aldine-Atherton, 1971).

given a set budget. Therefore, the utility-maximizing bureaucrat will attempt to have total output increased to some amount constrained only by the demand for the bureau's output.

The second theory is based upon Jean-Luc Migue's and Gerald Belanger's hypothesis that the objective of bureaucrats is to maximize "discretionary budget" - the difference between the bureau's total budget and the cost of producing the bureau's authorized output.¹⁷ For example, federal administrators, according to this theory, would be thought to allocate resources to activities not related to the production of the bureau's expected output.

An understanding of the objectives of the federal administrators may explain what is happening in the computer acquisition process. Is that bureaucrat intent upon maximizing efficiency in the delivery of computing services and upon improving organizational effectiveness? Is the decision-maker an "empire builder" intent upon the maximization of the bureau's budget? Or is the maximization of some other objective revealed by the investment decision? This thesis contends that the maximization of discretionary budget is the maximand of the federal bureaucrat evaluating the computer investment decision.

¹⁷ This second theory was first proposed by Jean-Luc Migue and Gerald Belanger in the 1974 Public Choice article, "Toward a General Theory of Managerial Discretion," Spring, 1974, pp. 27-43.

1.3 THE HYPOTHESIS

As will be seen in Chapter IV, a model of the federal computer services utility based (first) upon Niskanen's theory of bureaucratic behavior and (then) upon Migue-Belanger's theory will yield significantly different predictions concerning federal computer investments. For instance, high efficiency (low operating cost/unit of compute power) in the delivery of compute power and high compute capacity (relative to total acquisition expenditure) will be shown to be consistent with investment decisions maximizing total output/budget. In contrast, low efficiency (high operating cost/unit of compute power) and low compute capacity (relative to total acquisition expenditures) will be shown to be consistent with investment decisions maximizing discretionary budget. A model of the computer services process, which maximizes a bureau's discretionary budget, will predict a highly inefficient, obsolete federal government computer inventory. In other words, the application of the model will support the hypothesis that inefficient computer investments are a function of discretionary budget maximizing behavior of federal bureaucrats. It will contradict the hypothesis based upon total budget maximizing behavior.

1.4 THE METHODOLOGY

This thesis examines two conflicting maximands: first, that bureaucrats maximize total budget through the maximization of output; second, that bureaucrats maximize discretionary budget.

In order to evaluate the hypothesis that computer investment decisions are a function of Niskanen's output maximization theory, the relationship between a computer's residual value index (the ratio of salvage value, or used-market value, to capital expenditure) and its compute potential is defined. A model reflecting the relevant variables in the computer services process (such as the maximum compute potential of the current technology and the cost of upgrading to a newer technology) is used to predict the expected state of the federal computer inventory - given the assumption of output maximization and as indicated by the residual value index. The model reflects the life cycle of one computer system in the institutional setting typical of the federal computer services process. From that model, the residual value index is derived as an appropriate key feedback indicator on which an investment decision can be based. The state of the federal computer inventory, as indicated by the residual value index computed from a significant sample of the inventory, is then compared to the state consistent with Niskanen's theory of output maximization and predicted by the model.

The same model of the computer services process is used to evaluate the hypothesis that computer investments are a function of the Migue-Belanger discretionary budget maximand. The bureaucratic structure

involved in the production of computing services is viewed as concerned with one basic decision - the investment decision for new computer technology. The discretionary budget maximand is used to predict the point at which an obsolete computer will be replaced with one which reflects the state-of-the-art technology. The predicted state of the computer inventory, consistent with the Migue-Belanger theory, is then compared for consistency with the actual current state of the federal computer inventory.

1.5 ORGANIZATION

This thesis is organized into four additional chapters. Chapter II is a more thorough analysis of the Niskanen and Migue-Belanger theories of bureaucratic behavior. It also serves as a review of the literature on economic theories of bureaucracy. Chapter III reviews current federal policies applicable to its computer services utilities and outlines key economic considerations unique to computer technology. It also defines the model of the federal computer services utility. Chapter IV defines the methodology used to support the thesis. It further defines the computer investment decision model in which the two alternative bureaucratic maximands are used to predict the point at which an obsolete computer will be replaced with one which reflects the state-of-the-art technology. Chapter V reviews the observations which reveal the current state of the federal computer inventory and compares that state to the state predicted by the investment decision model. Data obtained

from the General Services Administration and from the General Accounting Office is used to ascertain the current state of the federal computer inventory. The observations are then analyzed for consistency with the two hypotheses. The arguments that support the conclusion that suboptimal utilization of computer technologies is a function of the maximization of discretionary budget are then reviewed.

Chapter II

ECONOMIC THEORIES OF BUREAUCRATIC BEHAVIOR

Most things have a price at which they may be obtained, and adjustments in behavior are made according to the price (benefit) that is charged (received).¹⁸

To what degree are the instructions (policies and ideas) to an administrative government bureaucracy, by its people and its legislative sponsors, translated into the appropriate actions by the administering bureaucracy. Where the process between instruction and action is dysfunctional, why is it? Bureaucratic efficiency and effectiveness is certainly influenced by organizational structures and processes. But underlying the dominant paradigms of public administration are critical assumptions about the motives governing the decision-makers. One popular assumption is that the public interest dominates the behavior of public administrators. Another is that personal preferences rule. But an important premise of this thesis is that the premier force in government operations decisions is the resolution of personal preferences with the system of incentives - the motivational structure. In other words, bureaucrats are motivated by personal preferences, but within the region of what is possible, given institutional constraints. That premise is consistent with the utilization of an economic theory of bureaucratic behavior.

¹⁸ Richard B. McKenzie and Gordon Tullock, The New World of Economics, (Homewood, Illinois: Richard D. Irwin, Inc., 1981), p. 25.

2.1 PUBLIC INTEREST THEORIES

Both the alternative theories considered in this thesis share the premise that federal bureaucrats are maximizing some aspect of personal economic utility. Not considered (in this thesis) is the antithesis of the utility maximizing premise which is that bureaucrats are motivated to act in the public interest. Some policy analysts support theories based upon the public interest premise.¹⁹ Hopefully the public interest takes precedence as a motivating force in issues most critical to the nation's well-being. Those expecting high efficiency in government operations may use, as a measure of that efficiency, a level of output consistent with production of goods in the public interest. However, in certain situations, the public interest may not overcome the perceived tendency for key administrators to respond to other motivations during the decision-making process.²⁰

Are computer investment decisions (especially) susceptible to considerations not consistent with the public interest? The answer requires an understanding of the special nature of the computer services utility within the federal government. For instance, sometimes a set of

¹⁹ For instance, Chris Argyris in "Some Limits of Rational Man Organizational Theory" (in Public Administration Review, May/June 1973) refers to the potential for "humane" organizations and to a social science universe which "...can be what we make it to be..." (p. 264). And Robert A. Dahl in Modern Political Analysis (Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1964) suggests that political man might "...attempt to obtain advantages for larger strata with which he identifies - his neighborhood, region, class, religion, ethnic group, race, nation" (p. 66).

²⁰ Gordon Tullock, The Politics of Bureaucracy, (Washington: Public Affairs Press, 1965), p. 21.

executive-legislative policies do not directly relate to a specific public good, or national goal, but to some aspect of the administration of an operations process (i. e. an activity). In a private sector organization, these activities might come under the heading "Administrative Support" or "Auxiliary Operations." Examples of policies of these activities include government purchasing and the management of computer services.

Decisions (not motivated by the public interest) may be characteristic of policies related to these government activities for three reasons.

First, since these policies are not related to some specific national goal or product, these policies may fall into the "less critical - less visible" category. For instance, data processing policy has only recently begun to receive attention with such news releases as those revealing the national defense alerts caused by failures in obsolete, unreliable computer systems.²¹

Second, because these government operations activities do not directly relate to an end-product, the legislative branch may not have the information requisite to its oversight.²² For example, oversight of policies for effective utilization of data processing requires the quantification of the product of data processing. It is not clear, however, what the product of computers is. This leads to a problem in the valuation of benefits.

²¹ For example, see "Senate Discloses Two More False Norad Alerts" by Jake Kirchner in Computerworld, 10 Nov. 1980, p. 19.

²² Niskanen, Bureaucracy, p. 20.

Third, from the bureau's perspective, auxiliary government operations may be considered its concern, rather than the concern of either the public or the Congress as the public's representative, because it relates to its own internal efficiency and not to a specific national goal, or policy.

An underlying interest of this thesis is the evaluation of the efficiency of federal computer systems. The efficiency interest demands an analysis based upon economic considerations in the decision process. An "efficient acquisition" is defined, for this study, as one which results in a computer system which is purchased and is operated at minimum cost relative to state-of-the-art technology. An efficient acquisition is also viewed as implying the supply of optimum quantities of compute power. The observations of this study, outlined in Chapter V, are inconsistent with the idea that efficiency, and therefore the public interest, is a significant incentive in the investment decision process. As is explained in this chapter, inefficiency - not efficiency - is characteristic of bureaus operating according to the Migue-Belanger maximand. And efficiency is a characteristic - an externality - but not a driving objective of bureaus operating under the Niskanen maximand. The investment decision criterion is defined more precisely in the presentation of the model of the federal computer utility in Chapter III.

2.2 NISKANEN: BUDGET MAXIMIZATION

William A. Niskanen, in Bureaucracy and Representative Government, applies the techniques and assumptions of economics to the analysis of the bureaucratic machinery of government.²³ His is a theory of the supply of services by the bureaucracy. The critical difference between his model of government bureaucracy and previous models is his emphasis on the institutional setting of the bureau and on the behavior of bureaucrats. According to Niskanen, a bureau's institutional setting defines its relationship with its sponsor. Also, he states that the behavior of the government bureaucrat is due to the structure of personal preferences and institutional incentives. The three critical elements in his analysis of bureaucracy, then, are the bureau, the sponsor, and the maximand of the bureaucrat.

2.2.1 The Bureau

Niskanen defines a bureau as a non-profit organization which receives its revenue as a lump sum appropriation in exchange for a promised level of output.²⁴

Bureaus specialize in providing those goods and services that some people prefer be supplied in larger amounts than would be supplied by their sale at a per-unit rate.²⁵

²³ Niskanen, Bureaucracy, p. 5.

²⁴ Niskanen, Bureaucracy, p. 15.

²⁵ Niskanen, Bureaucracy, p. 18.

In other words, when the public demands goods beyond those supplied by the market economy, those goods will quite possibly be supplied by a government bureau. Other important characteristics of bureaus identified by Niskanen are their tendency to grow - to become large and complex organizations - and their administration by individuals with salaries not directly related to the effectiveness and efficiency of the organization. Relative to this last point, the employees of bureaus, according to Niskanen output maximand, will not convert potential bureau profit²⁶ into compensation for services performed.

2.2.2 The Sponsor

In the federal government, the bureau is often an agency within the executive branch and the sponsor is the Congress. Niskanen reasons that the separation of the legislative and executive functions has left the bureaus with a virtual monopoly power in the provision of specified services. Niskanen argues that a critical advantage of the bureaus is their ability to propose new programs and expanded activities based on constituent information not available to reviewing sponsors.²⁷ Also, as noted above, a bureau receives a budget from a sponsor in exchange for an expected level of output.²⁸ An important distinction is the indi-

²⁶ For this paper a bureau's profit (i. e. discretionary budget) is defined as equal to total budget less the total cost of producing its expected output.

²⁷ Niskanen, Bureaucracy, p. 40.

²⁸ Niskanen, Bureaucracy, p. 25.

visible nature of the exchange: the bureau receives a total budget in return for a minimum total amount of output. The lack of a per-unit price gives the bureau

... the same type of bargaining power ...

in the trade as that characteristic of an all-or-nothing offer.²⁹ In effect, the bureau offers to the sponsor a total amount of output in exchange for its total budget.³⁰ Therefore, according to this theory of bureaucratic behavior, the sponsor is at a distinct disadvantage in negotiating with the bureaus.

2.2.3 The Maximand

The basic motivational assumption in Niskanen's model is that bureaucrats maximize personal utility. How is personal utility maximized? Corresponding to personal utility are variables such as

... salary, perquisites of office, public reputation, power, patronage, output of the bureau, ease of making changes, and ease of managing the bureau.³¹

²⁹ Niskanen, Bureaucracy, p. 25.

³⁰ Perhaps the current debate on the MX missile system is a good example. The argument will probably be decided with "an all-or-nothing" decision as to whether the system will be developed. If the decision is to build system, it is unlikely that there will be much discussion on its scale. The Defense Department analysis as to the appropriate size of the MX complex will probably not be an issue.

³¹ William A. Niskanen, Bureaucracy: Servant or Master?, (Great Britain: The Institute of Economic Affairs, 1971) p. 22.

Niskanen notes that all but the last two variables are a positive function of the bureau's total budget.³² He emphasizes that the budget maximization assumption is not a

... cynical interpretation of the personal motivations of bureaucrats.³³

Even the most dedicated bureaucrats might

... describe their objective as maximizing the budget for the particular services for which they are responsible.³⁴

Budget maximization, then, is consistent with the assumption of rational behavior by bureaucrats.

2.2.4 The Niskanen Model of Bureaucracy

Niskanen's model of the bureau is best summarized through a description of the budget-output function.³⁵ The following budget-output function

$$B(\text{or } TR) = aQ - bQ^2$$

represents budget as a function of quantity. Total budget is designated by "B"; to the bureau, total budget can also be viewed as its total revenue (traditionally represented in economics by "TR"). Quantity of

³² Niskanen, Bureaucracy: Servant, p. 22.

³³ Niskanen, Bureaucracy, p. 39.

³⁴ Niskanen, Bureaucracy, p. 39.

³⁵ The mathematical derivation that follows parallels Niskanen's explanation of the differences between the Migue-Belanger model and his own model. The discussion was in "Bureaucrats and Politicians" (published in the December, 1975 issue of Journal of Law and Economics).

output is designated by "Q." The function was chosen by Niskanen because it has the following two properties:

1. The first derivative is positive over the range corresponding to that in which the sponsor is willing to increase the per unit budget in return for increased output.
2. The second derivative is negative over the range corresponding to that in which the sponsor is willing to increase the per unit budget for a smaller output.

Therefore, the definition of the budget-output function is in terms of quantity of output produced (the preferred limit defined by the sponsor) and of the total budget (the incentive to the bureau).

The following cost-output function

$$C = cQ + dQ^2$$

defines cost as a function of quantity. It represents the minimum cost to the bureau to produce the desired level of output.³⁶ Total cost of producing the output is represented by "C." Again, "Q" represents the quantity of output produced.

The following equation

$$P = B - C$$

represents the bureau's profit function. It defines the relationship between budget and cost in the institutional structure of incentives and preferences. Using the previous definition of "profit," this last func-

³⁶ Niskanen, Bureaucracy, p. 45.

tion reveals a bureau's Profit ("P") as equal its total budget ("B") less the total cost of output produced ("C"). Both Niskanen and, as will be shown, Migue-Bellanger propose that bureaucrats are utility maximizers. However, Niskanen proposes that the quantity produced will be maximized thus maximizing the budget (total revenue) received from the sponsor.³⁷ Since quantity of output produced is the maximand, that quantity will be produced at optimal (i. e. least) cost to the sponsor. In other words, the total budget will be used by the bureau to produce the maximum quantity of output and "profit" will equal zero.

Figure 1 takes the Niskanen argument a step further. Substituting for "B" and "C" in the profit function, the Niskanen budget function is defined in terms of the bureau's profit potential. But for Niskanen's maximand, profit will equal zero. Therefore, solving for quantity ("Q") where profit ("P") equals zero, the amount of output the bureau will produce is defined. That point is identified in Figure 1 as

$$\frac{(a-c)}{(b+d)}$$

At this point, the output that can be produced for the total budget provided by the sponsor is maximized.

Figure 2 graphically illustrates the Niskanen budget-output function. In Figure 2, the curve represents both the budget constraint faced by the bureau and the marginal rate of substitution for additional

³⁷ Niskanen, Bureaucracy, p. 42.

$$P = (B - C) = (aQ - bQ^2) - (cQ + dQ^2)$$

$$P = 0 = aQ - bQ^2 - cQ - dQ^2$$

$$bQ^2 + dQ^2 = aQ - cQ$$

$$(b+d)Q^2 = (a-c)Q$$

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

Figure 1: THE NISKANEN MAXIMAND

output from the perspective of the sponsor. We can see that the output produced at the Niskanen maximand is twice the optimal level, but is produced quite efficiently at the minimum per unit cost to the sponsor. In other words, the marginal rate of substitution increases, then decreases. And by the traditional definition of optimal production, the optimal amount of output is achieved at the maximum point of marginal substitution.

Niskanen concludes that budget maximization coincides with output maximization.³⁸ Therefore, the only constraint to increasing the budget will be the requirement to supply the level of output expected by the sponsor. Niskanen's model leads him to hypothesize that bureaus will over-produce, but produce that output at minimum costs.³⁹ With respect to Niskanen's theory and this thesis, decisions by federal computer utilities should result in two detectable characteristics. First, relative to the state of technology, investment decisions should result in computer systems with maximum compute capability at minimum operating costs. For instance, the Niskanen bureaucrat will not invest in obsolete technology - i. e. in computers which are no longer economically viable. Second, compute capacity, according to the Niskanen criterion, should exceed the demand anticipated at the equilibrium point for marginal cost.

³⁸ Niskanen, Bureaucracy, p. 42.

³⁹ Niskanen, Bureaucracy, p. 64.

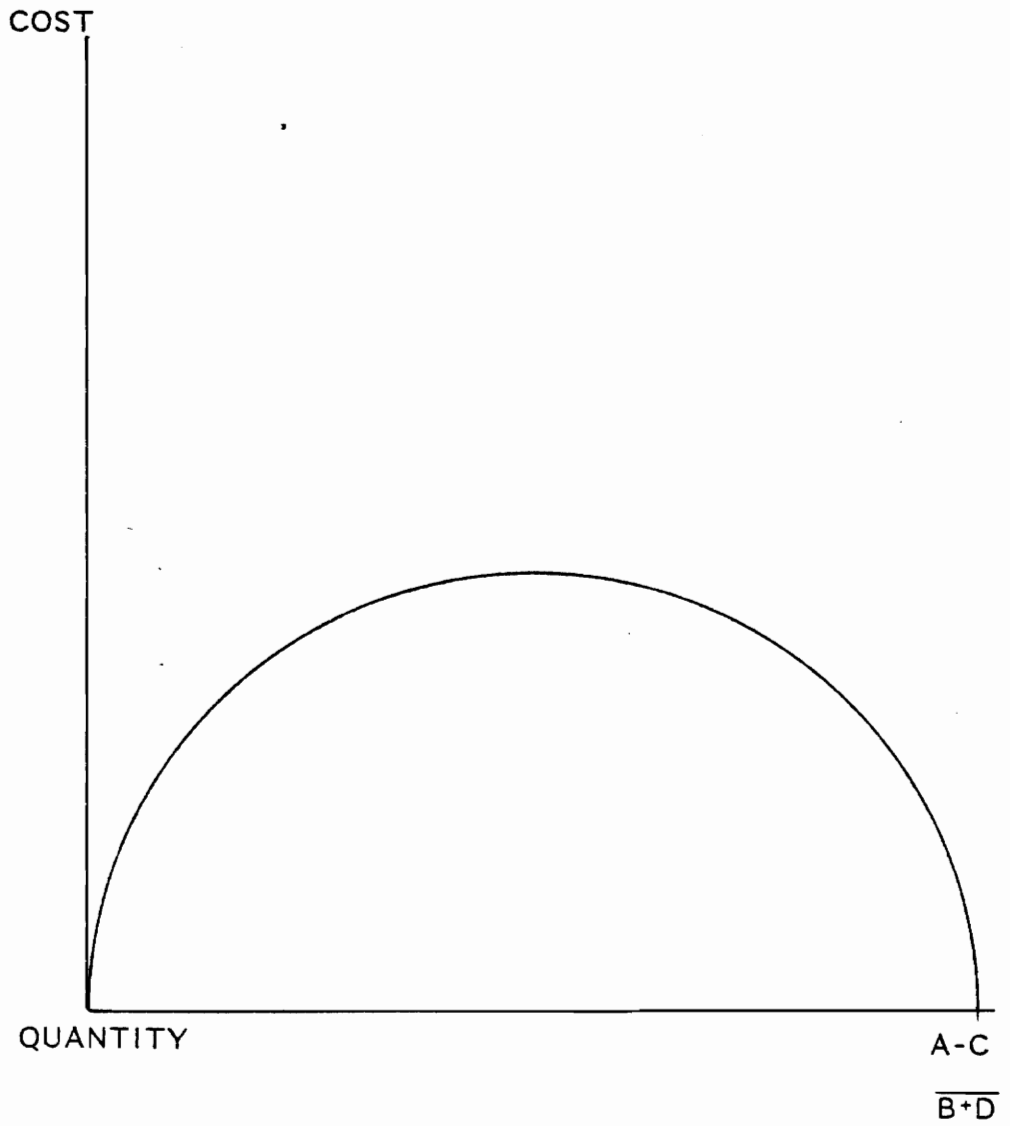


Figure 2: THE NISKANEN PREDICTION OF QUANTITY PRODUCED

2.3 MIGUE-BELANGER: DISCRETIONARY BUDGET

Utility maximization models of the firm have provided an alternative hypothesis to the more traditional idea of profit maximization.⁴⁰ Migue and Belanger applied the ideas inherent in the utility maximization model of the neoclassical firm to the model of bureaucracy developed by Niskanen.

2.3.1 A Bureau's Profit

Migue and Belanger have refined Niskanen's definition of the "budget" by arguing that one should not assume that the budget-maximizing bureaus will devote all of their budget to the production of an authorized level of output.⁴¹ Migue and Belanger define "managerial discretionary budget" as the amount of the budget less the amount spent for the production of output.⁴² Therefore, they accept the idea of the utility maximizing bureaucrat, but propose that some portion of the bureaucrat's budget will go for purposes unrelated to the bureau's designated product. They suggest that the discretionary budget would be used for special projects, increased staff, and other expenditures not required to provide an authorized level of output. Their conclusion is

⁴⁰ William Orzechowski has written an excellent review of the development of economic models of bureaucracy in "Economic Models of Bureaucracy: Survey, Extensions, and Evidence," Budgets and Bureaucrats, ed. T. E. Borcharding, (Durham: Duke University Press, 1977), pp. 229-259.

⁴¹ Orzechowski, p. 236.

⁴² Jean-Luc Migue and Gerard Belanger, "Toward a General Theory of Managerial Discretion," Public Choice, Spring, 1974, p. 27.

that managers of bureaus are concerned with the maximization of that discretionary budget.

2.3.2 The Migue-Belanger Model of Bureaucracy

Migue-Belanger use the same cost-output function to represent the actual minimum cost to the bureau as Niskanen.⁴³

$$C = cQ = dQ^2$$

However, Migue-Bellanger, in contrast to the Niskanen proposal, argue that discretionary budget is the maximand of bureaucrats. The Migue-Bellanger definition of discretionary budget (DB) is total revenue minus total cost.⁴⁴ Or, using the definitions of "B" and "C" from the discussion of the Niskanen maximand, the discretionary budget function ("DB") is

$$DB = B - C.$$

That function represents, in other words, a bureau's "profit." Substituting for "B" and "C" with the budget and cost functions from the discussion of Niskanen, the function

$$DB = (B - C) = (aQ - bQ^2) - (cQ + dQ^2)$$

defines discretionary budget in terms of quantity of output. For Migue-Bellanger's maximand, discretionary budget is maximized; therefore, as can be seen in Figure 3, we can maximize discretionary budget with

⁴³ Migue, p. 30.

⁴⁴ Migue, p. 30.

respect to quantity of output. At the point

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

the discretionary budget is maximized; it is also the point where an optimal amount of output is produced given that at this point the marginal budget (or marginal revenue) equals marginal cost. This optimal quantity of output point represents one-half of the quantity expected of bureaucracies operating consistently with the Niskanen maximand.

Figure 4 illustrates the discretionary budget-output function. In Figure 4, the curve represents both the budget constraint faced by the bureau and the marginal rate of substitution for additional output from the perspective of the sponsor. At the Migue-Bellanger maximand, where the marginal revenue equals marginal cost (or where the "profit" is maximized), the amount of output is optimal but at a high cost in inefficiency. This is in direct contrast with the results of the derivation based on the Niskanen maximand.

In contrast to Niskanen's budget maximization model, the Migue-Bellanger model provides for the analysis of government operations behavior consistent with the assumption that output may not be produced at optimal costs.⁴⁵ Their model allows for an examination of efficiency con-

⁴⁵ In his article "Bureaucrats and Politicians" in The Journal of Law & Economics (December, 1975, pp. 617-643), Niskanen claims the Migue-Bellanger hypothesis as an extension to his own theory. He adopts the Migue-Bellanger theory in a generalized version of his original model so that the "budget maximizing bureaucrat" becomes

$$DB = (aQ - bQ^2) - (cQ + dQ^2)$$

$$DB = (a - 2bQ) - (c + 2dQ)$$

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

Figure 3: DISCRETIONARY BUDGET MAXIMIZED

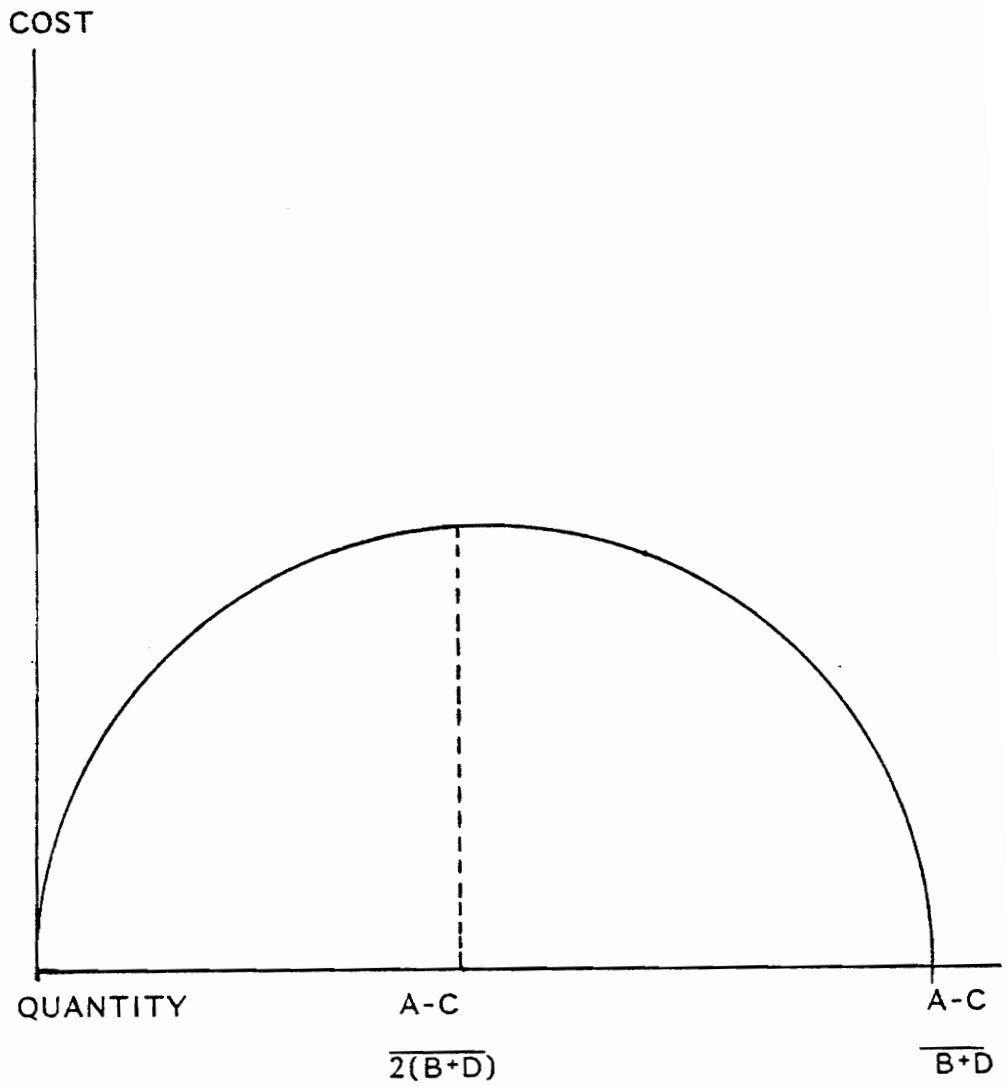


Figure 4: THE BUREAU'S BUDGET-OUTPUT FUNCTION

siderations in the government operations process in that it predicts that production will be inefficient. Therefore, relative to this thesis, investment decisions of federal bureaucrats should result in computer systems which maximize the difference between the operating budget received for an expected level of output and the actual cost of producing that output.

the "utility maximizing bureaucrat." That is, whether discretionary budget or total budget is maximized is dependent upon whether or not the bureaucrat values output. This later model has been generalized to the point that its value in explaining bureaucratic behavior is questionable. Since discretionary budget is a function of total budget, one may be difficult to distinguish from the other, especially if, as is the case with many public goods, output is ill-defined. For instance, in the case of federal computer investments, I believe what at one point appears to be budget maximizing behavior will, upon closer examination, be revealed as discretionary budget maximizing behavior. Nevertheless, Niskanen's original theory is the basis of considerable, continuing research on the behavior of bureaucrats. This fact alone justifies a comparative analysis based upon the predictions born of the original Niskanen theory and of the Migue-Belanger theory.

Chapter III

A MODEL OF THE FEDERAL COMPUTER SERVICES UTILITY

Thinking calls for images, and images contain thought.⁴⁶

Although we may accept the proposal that computers are production factors, disagreement exists as to an appropriate methodology for the quantification and valuation of the products of computers.⁴⁷ Questions on the production (or supply) side of the economic equation relate to the diversity of uses and the extraordinary rate of technological improvements applicable to computers.⁴⁸ Both of these characteristics lead to an examination of the state of the computer services utility through the analysis of its production factors. This analysis demonstrates the following:

1. that a computer utility's economic viability is defined by the residual value (i. e. market value) of its computer technology;
2. that with the conversion to, and development of applications on, a given technology, a federal computer services utility maximizes its discretionary profit;

⁴⁶ Rudolph Arnheim, Visual Thinking, (Berkeley: University of California Press, 1969), p. 254.

⁴⁷ Jack P. C. Kleijnen, Computers and Profits, (Reading, Massachusetts: Addison-Wesley Publishing Company, 1980), p 5.

⁴⁸ Charles H. Kriebel, Anthony A. Atkinson, Huntley W. H. Zia, "Optimal Investment, Pricing, and Replacement of Computer Resources", Naval Research Logistics Quarterly, 24 (1977), p. 537.

3. and, that at the point that the computer facility has reached the technological limit of the amount of total output it can produce, discretionary profit is maximized and the computer facility is well beyond the point of maximum marginal output per operating budget dollar;

A basic premise of this thesis is that federal bureaucrats are utility maximizers. At issue is the determination of what it is that these bureaucrats value. This chapter reviews those aspects of the federal computing organization and of the economics of computer technology that govern the structure of incentives and disincentives for investments in new computer technology. A model of the "computer services utility" is proposed which reveals that system of opportunities and risks from the perspective of the federal bureaucrat. In other words, the model is examined for its power to reveal the incentive/disincentive structure faced by the bureaucrat responsible for the operation of the federal computer services utility. The chapter concludes with a discussion of issues unique to the federal computer services utility.⁴⁹

⁴⁹ The phrase "federal computer services utility" is used as a convenient, descriptive classification of those organizations that provide a variety of general purpose computer services within the federal agencies. These organizations are like the "Administrative Support" groups mentioned in Chapter II. The computers used by these organizations are "general management" computers. This study will be confined to the decisions related to the investment in general management computers. The term "utility" is indirectly referenced in the General Services Administration's definition of general management computers - a "... classification of computer systems according to the environment in which the systems are used ... applies to computer systems used in a general utility environment." These general management computers may be contrasted to the other classification - special management computers. Special management

3.1 THE MODEL

The production function of the computer services utility in the federal government is illustrated in Figure 5. It is also a visual presentation of the model of the computer services utility used to analyze the Niskanen and Migue-Belanger theories of bureaucratic behavior. Figure 5 depicts the criteria upon which decisions about production factors are made within these federal organizations. For instance, the vertical axis represents the output potential per sponsor-committed operating budget dollar. Implicit in the production potential of the utility are the limiting production factors - the total annual operating budget and the computer technology utilized. The horizontal axis represents time - starting from the implementation of computer equipment of a specific technological age. The upper asymptote represents the limit to the output per operating budget dollar of the specific technology utilized by the computer services utility.

To better visualize the production problem from the perspective of the federal bureaucrat, Figure 5 may be viewed with the following illustrative constraints. Total operating budget for each time period is one dollar; the technological limit of output per operating budget dollar is 100 units of output. From Figure 5, the maximum system life of the specific technology is approximately 20 years (since at 20 years output per operating budget dollar is at its limit). The costs to operate the

computers are computer systems used in a "classified, control, or mobile environment." These definitions may be found in Automatic Data Processing Activities Summary (Washington: General Services Administration, April, 1980), p. 4.

computer system are predominantly fixed costs. In other words, the cost to actually operate a little utilized computer facility (e. g. at $t = 1$) is not significantly less than the cost to operate a fully utilized facility (e. g. at $t = 20$). At $t = 1$, only 5% of the operating budget is directly used to produce output. The remaining 95% of the budget is utilized to develop applications for the the still very new computer facility. For those not familiar with "computer" terminology, these development costs might be viewed as the marketing support costs necessary to bring the new facility to full utilization. The costs associated with the development of applications on a new computer system are called "conversion costs." (The costs of computing will be more thoroughly discussed in Section 3.1.2.) Therefore, as the conversion to the new computer facility is completed, federal bureaucrats have the opportunity to capture that portion of the operating budget not utilized in the production of the computer utility's output as their discretionary budget. So, as output per budget dollar approaches 100, bureaucrats taking advantage of this opportunity maximize discretionary budget.

In Figure 6, the function⁵⁰ is further defined. The rate of increase in the amount of output per operating budget dollar is positively affected by the rate of conversion (α) of applications to the new

⁵⁰ The function is called a "Gompertz Model." It was chosen because (1) growth is exponential, (2) growth in output over time may be represented as increasing at an increasing, then decreasing, rate, and (3) output increases as t increases given $\alpha < 1$ and $\beta < 1$. See Analytic Techniques in Urban and Regional Planning by John W. Dickey and Thomas M. Watts (New York: McGraw-Hill, 1978), pp. 131-141.

technology from the old technology. It is negatively affected by the rate of decay (β) in the market potential of new technologies due to the development of future technologies. This is because of its effect on potential new users and applications. For instance, although producible output stays at the same level, the cost, relative to market cost, will probably be too high. Finally, growth in the amount of output per operating budget dollar is constrained by the technological limit of a system's compute potential (λ).

3.1.1 Lambda: A Computer Utility's Capital

The model introduced in this chapter reflects the fact that the computer utility produces its output utilizing one type of capital - that capital stock is its computer systems.⁵¹ The model of the computer services utility assumes some initial budget level and a computer facility of a specific technology. Implicit in the specific computer technology and in the total budget is an expected level of output. This is consistent with Niskanen's proposal that a budget is received by the bureau as a lump sum commitment for an expected minimum level of output. Therefore, an important constraint in this model is the compute potential reflected in that initial capital stock.

⁵¹ S. J. Nickell, The Investment Decision of Firms, (Oxford: Cambridge University Press, 1978), p. 8.

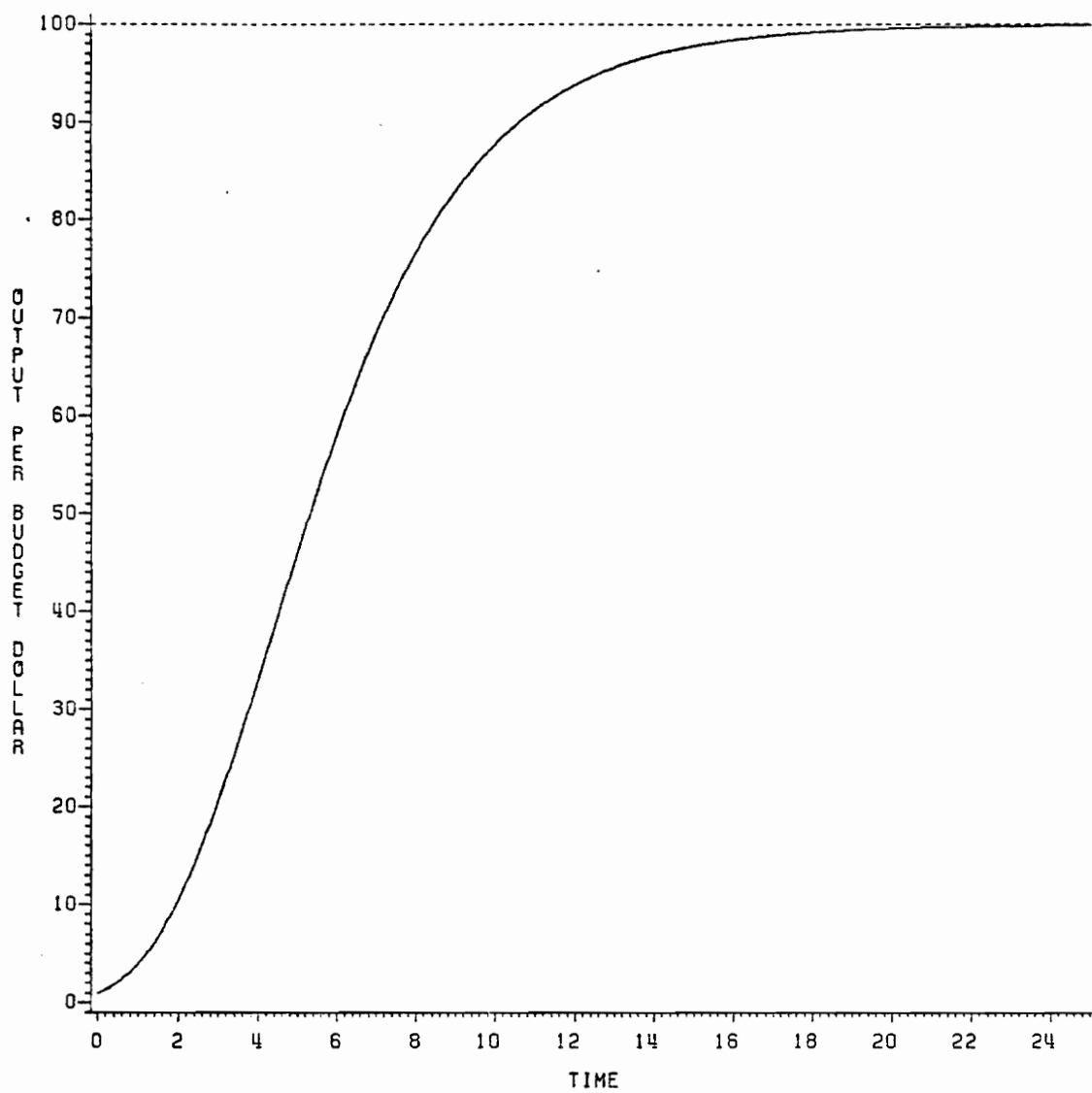


Figure 5: PRODUCTION LIMIT OF THE COMPUTER SERVICES UTILITY

$$Q_t = \lambda \alpha \beta^t$$

λ = technological limit as $t \rightarrow \infty$

α = rate of conversion (<1)

β = rate of decay in residual value (<1)

t = time

Inflection Point (I. P.) = $\lambda/3$
with respect to Q

Inflection Point (I. P.) = $\frac{\log[\log(\alpha)]}{\log(\beta)}$
with respect to t

Figure 6: PRODUCTION FUNCTION OF THE COMPUTER SERVICES UTILITY

Maximum output is determined by the production potential of the capital stock. This production potential, or limit, is represented in Figure 6 as λ and in Figure 5 as the upper asymptote. Normally, the total value (production potential) of the utility's current capital stock is equal to the quantity of output possible times its unit price. And the unit price is determined by the interaction of market supply and demand. However, in most federal government organizations, as was noted earlier, computer resources have appeared to the user as a "free good." Therefore, residual value, or market value, becomes an important indicator of value to both the computer user and to the computer utility.

In a free market, a computer services utility would not be expected to compete effectively if it provided its services with inefficient, obsolete computer hardware. However, on the demand side of the economic equation, an important characteristic of the federal computer services utility is its "captive market."⁵² Relative to the model of the computer services utility shown in Figure 5, that captive market may prevent an eventual downward spiral in output due to technological obsolescence.

⁵² Kleijnen, p. 53.

3.1.2 Alpha: Costs of Computing and the Conversion Factor

Very few of the costs associated with a computer services utility are variable with the level of output. The costs, whether the facility is totally utilized or not, are incurred for some minimal level of output - usually consistent with the maximum output potential of the specific technology.

The total cost of the utility's labor at a point in time is equal to the wage rate times the manhours required to produce the maximum output. The total cost of the utility's capital goods includes all remaining operating costs. For a computer facility, capital goods include the power and environmental requirements of the hardware, and software costs. Although software is not a consumable good, its utilization cost will vary with the processing power of a computer.

The operating costs not associated with the acquisition of the specific computer technology are assumed to increase each time period as a computer resource ages.⁵³ This, in addition to the effect of new technological innovations on the market for applications and users, explains the inflection point at

$$Q = \frac{\lambda}{3}$$

⁵³ Kriebel, p. 540.

(see Figure 6). Again, this means that eventually there should be decreasing output per operating dollar although the model in this chapter only reflects a decreasing rate. But, as noted earlier, due to the captive market characteristic of federal computer utilities, this probably has not occurred.

In the first year or two of the installation of new computer technology, considerable resources are consumed in the conversion of old software for use on the new facility, for required environmental modifications, for parallel operation of the old technology with the new technology, and for training of personnel on the operation of the new technology. As the the conversion process is completed, there exists the opportunity to utilize the excess resources for activities not related to the production of required levels of output. This level of surplus may even be maintained through annual, incremental increases in the budget which approximate the annual increase in certain costs associated with the operation on the utility (e. g. increases in salaries, power costs, software and hardware maintenance fees). It is possible to maintain this surplus because the utility controls the information on the way in which its resoures are utilized.⁵⁴ At the time the facility is installed, the bureau's budget equals total cost - which equals "real" operating costs plus anticipated conversion (including new software applications development) costs. Therefore, as significant conversion to the new

⁵⁴ This is consistent with Niskanen's argument that there is a significant disadvantage to the sponsor in obtaining information on the operation of the bureau. See Section 2.2.2.

technology is accomplished, levels of output can be maintained at decreasing total cost. That is, total cost to the bureau will then be less than the budget provided by the sponsor. However, no matter what the operating budget, total output can never exceed the maximum output potential of the specific computer technology.

3.1.3 Beta: Residual Value as an Indicator of Economic Viability

In addition to λ and β , another constraint is that the residual value of the capital is assumed to decay exponentially. The rate of decay is represented by β , which determines residual value with respect to time. The residual value is an approximation of market value.⁵⁵ An important issue is that any measure of the economic viability of a computer services utility relates the costs of production to the value of output. As will be explained below, direct measures of costs and of value are not feasible. A second issue, relating to β , is the definition of the relationship between residual value and operating costs. The final discussion explains the exponential decline in residual value.

An important proposition of this thesis is that the residual value and operating costs of a computer are significantly dependent upon its technological age. Relative to costs, two assumptions are that significant changes in technology are distinguishable among specific computer systems and that the variations in costs attributable to changes in technology are quantifiable. As noted earlier in this chapter, signifi-

⁵⁵ Kriebel, p. 546.

cant problems exist in the determination of benefits. However, if we are to "value" the computer production of output, this point warrants closer examination.

No universal methodology exists for the quantification of the product of computers.⁵⁶ Disagreement even exists as to the product of computers. Kleijnen, in Computers and Profits, emphasizes "information" as the product of computers.⁵⁷ Most computer centers, however, price services according to resources consumed.⁵⁸ A second problem in the valuation of benefits is revealed in the fundamental assumption that the product value is equal to the price a fully informed individual is willing to pay.⁵⁹ Although some computer centers, especially in the private sector, provide the user with cost information when computer resources are consumed, centers in the federal government do not charge for their services. To the federal user, computer service is a free good. However, the assumption will have to be made that there exists a relationship between the operating budgets (which reflect the ability to move to new technology) and the value of compute capacity. In other words, compute capacity limits total output, and, remembering the relationship expressed in Chapter II between total output and total budget, output potential limits the potential for increasing budget.

⁵⁶ Kleijnen, p. 63.

⁵⁷ Kleijnen, p. 63.

⁵⁸ Kriebel, p. 539.

⁵⁹ Peter G. Sassone and William A. Schaffer, Cost-Benefit Analysis, (New York: Academic Press, Inc., 1978), p. 44.

Residual value, as was pointed out in Section 3.1.1, decays exponentially. Driving the rate of decay, where computer systems are concerned, are the innovations in computer technology developed over the last 30 years. According to Charles Lecht, we have realized 300 to 400 times the general-purpose processing power available in the 1950's for one-tenth of 1% of its 1950's cost.⁶⁰ Capital costs have reflected dramatic decreases due to new technologies; but, perhaps more important have been the effects these innovations have had on operating costs. Given this continuing rate of technological development in the computer industry and due to the significant effect on operating costs, optimal timing is a critical element in effective, efficient investments in computer systems.⁶¹

Recognition of the technological age of specific computer systems, relative to the state-of-the-art of computer and electronic technology, is most important for its effect on the following cost factors:⁶²

⁶⁰ Charles P. Lecht, The Waves of Change, (New York: McGraw-Hill Book Company, 1979), p. 167.

⁶¹ For an excellent history of computing and the computer industry, see Katharine Davis Fishman's book, The Computer Establishment, (New York: Harper & Row, 1981), pp. 1-468.

⁶² For instance, as a tangent to this study, the data on the IBM computers in the federal inventory was examined for the relationship between residual value and maintenance costs/compute capacity (or maintenance costs per 1000 operations per second of compute potential). As residual value decreases, maintenance costs increases at a "reasonable" rate. However, once residual value drops below 1% of original price, maintenance costs explodes to extraordinarily high rates relative to those computers above 1% of original price.

1. the rate of decay of the salvage value of the computer system;
2. the operating labor costs;
3. the environmental operating costs;
4. the maintenance costs of the hardware;
5. the expected time of availability of the facility (i. e. the failure rate of the system with the inherent costs of down-time);
6. the operating costs of software relative to the capacity of the computer system to utilize that software.

With improvements in computer technology over the last 25 years and with increased compute power per production unit, the costs associated with all of the points listed above have decreased.

Technological age is a significant consideration in the efficient acquisition and utilization of computers. But how is the technological obsolescence of a computer system determined? A computer system is obsolete if it is significantly more costly to operate relative to state-of-the-art systems. In other words, an obsolete computer system is a system which is no longer economically viable.

A computer hardware system is a complex configuration of processors, memory, input-output channels, and various input-output devices. Given the multitude of hardware combinations, it would be difficult to compare complete computer facilities based on either compute capacity or cost. Significant technological improvements have been made by most vendors to every hardware element. However, innovations in the most critical elements, the processor and the memory, are probably the best indicators of significant technological developments. These innovations

explain much of the dramatic increases in computer speed and reliability - decreases in size, power requirements and maintenance costs.⁶³

The decay of residual value of computers varies with economic factors.⁶⁴ Therefore, residual value is an important indicator of technological age and economic viability. The model of the computer services utility, used in this thesis, assumes the exponential decay of the economic viability of computer systems. Although computers may be considered to have an infinite productive life, technological improvements actually lead to a finite economic life.⁶⁵ Economies of scale exist in the labor required for a specific computer facility relative to its compute power. The compute potential, and therefore the production potential, is affected by the tendency of the facility to fail. Reliability has improved with newer computer systems reflecting the latest technology.⁶⁶ Capital goods include the power and environmental requirements of the hardware, and software. The power, environmental, and maintenance costs per increment of compute power have decreased due to improvements in technology.⁶⁷ The decrease in these costs has been attributa-

⁶³ Montgomery Phister, Jr., Data Processing Technology and Economics, (Santa Monica, California: The Santa Monica Publishing Company, 1977), p. 168.

⁶⁴ Nickell, p. 305.

⁶⁵ Kriebel, p. 538.

⁶⁶ F. H. Dill. "Alternative Computer Architectures Using LSI," in Computers and Communications, ed. Robert J. Seidel and Martin L. Rubin (New York: Academic Press, Inc., 1977), p. 35.

⁶⁷ Phister, p. 168.

ble to both technological improvements and to economies of scale. Today, the most expensive part of a computer system is its application software. With new technology, there exist economies of scale in the utilization of software. Since software is normally licensed for specific computers, without considering production potential, there will be decreasing costs associated with the utilization of the software as the potential for using it increases. That is, as compute potential has increased, the ability to utilize the software applications has increased.

Under free competition, the price of the output produced by the utility is determined by the market. Given free competition, production factors must be efficiently acquired and operated. Most computer facilities, however, operate as monopolies with a captive market.⁶⁸ Output produced by these monopolies is often priced "...to balance (negotiated) budget costs on an annual basis...."⁶⁹ Demand, given this captive market characteristic, must be viewed as exogenous in the analysis of the investment decision. Once again, without free competition determination of price, the best indicator of operating efficiency is the information implicit in the specific computer technology's residual value (i. e. used market value). In other words, economic viability is limited by operating efficiency. Operating efficiency is a function of the operating costs of the technology utilized versus the operating costs consistent with state-of-the-art technology; it is revealed by the ratio of the uti-

⁶⁸ Kleijnen, p. 64.

⁶⁹ Kriebel, p. 539.

lized system's residual value to its original price. Because the compute potential per dollar has been growing at an exponential rate,⁷⁰ the economic viability (represented by the rate of decay in the residual value) of a specific technology may be considered to decay exponentially.

3.2 THE FEDERAL COMPUTER SERVICES UTILITY

What is the rationale for a change in computer technology? Obviously, the answer may vary according to whether the decision-maker is a Niskanen bureaucrat or a Migue-Belanger bureaucrat. In either case, however, the bureaucrat sees the same costs, risks, and opportunities in the system life of the current technology and in the investment decision for a new technology.

Certainly efficiency may be one consideration, especially for the Niskanen bureaucrat. However, efficiency must be considered from two perspectives. First, is all of the budget, which has been allocated for an expected level of output, used for the production of that output? Given the requirement for the bureau to commit resources to the conversion effort, all resources will not be allocated to the production of output unless the bureau is constantly upgrading its technology. Second, is the value (to the user) of the output equal to its cost? Due to the problem of quantifying cost/benefits of computing in federal bureaus, the evaluation of value versus cost is not feasible. Therefore, the question of efficiency is applicable only to the extent that it effects

⁷⁰ For example, using a base of 2, it has grown at a 2 to the t power rate with each time period (t) equal to about 20 months.

what is valued by the federal bureaucrat. It is neither an appropriate nor a feasible perspective from which to pursue the issue of the Niskanen versus the Migue-Belanger maximands. This brings the evaluation back to the definable parameters already revealed in the model of the computer utility. That is, the rate of increase in, and total amount of, output produced per operating budget dollar with respect to time.

A second rationale for acquiring newer technology is to raise the technological limit on output. The primary constraint to the total amount of output and to the rate of growth in output is the technological limit in compute capacity of the computer systems used by the services utility. Operating budget is also a limit - but it will expand as the number of dependent, satisfied customers of the service increase.⁷¹ The utility's operating budget will also expand as the utility demonstrates incremental increases in its costs for equivalent levels of output required by the sponsor.

Given the limits to the amount of output and rate of growth inherent in the technology utilized, the best alternative available to the bureaucrat intent upon expanding output is to acquire state-of-the-art computer technology which has greater compute capacity. Figure 7 illustrates the production gain possible with a shift to computers of a newer

⁷¹ Their satisfaction is in no small way dependent upon the characteristics of the service compared to what they feel is available to other computer users. Reliability and compute power are two examples of those characteristics. Eventually, these customers will become dissatisfied with their utilization of the old systems. They may not, however, have the option of going elsewhere for their computer services.

technology. The asymptote at output = 100 represents the technological limit per operating dollar using the old technology; the asymptote at output = 500 represents the technological limit for the new technology. The difference between the two asymptotes, is the gain in production potential possible with conversion to the new technology. (No conversion costs are reflected in Figure 7.) A computer services utility intent upon maximizing output will maintain state of the art technology. At issue in the federal computer services utility are the opportunity for and constraints to replacing old computer systems with systems reflecting new technology. In the next three sections, federal policy defining the constraints and incentives to computer acquisitions, the availability of funds for expansion, and the cost of conversion from old to new technologies are discussed.

3.2.1 Federal Computer Acquisition Policy

The Brooks Act, Public Law 89-306, has governed federal computer acquisition policy since its enactment in 1965. Policies implemented as a result of the Brooks Act are intended to insure

... the economic and efficient purchase, lease, maintenance, operation, and utilization of automatic data processing equipment by federal departments and agencies.⁷²

The adaptation of new technologies, improved accountability, and greater efficiency in the production of goods and services are all general objectives of reforms to the procurement process. These goals are

⁷² U. S. Dept. of Commerce, Federal Information, p. 20.

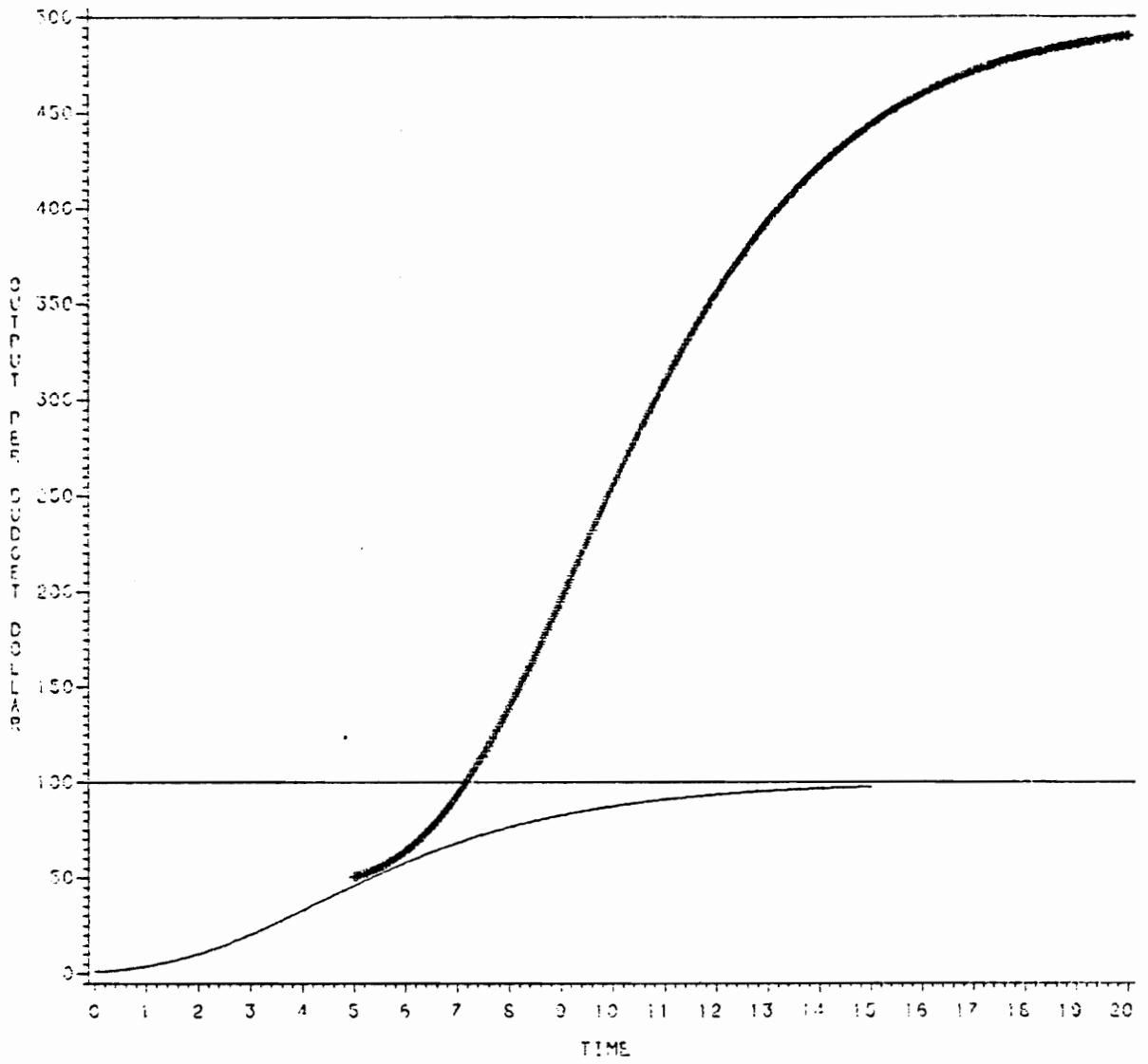


Figure 7: GAINS IN OUTPUT FROM A SHIFT TO NEWER TECHNOLOGY

generally applicable to the Brooks Act. Examination of the hearings prior to the enactment of the law and of the report on its implementation reveal three specific objectives of the act.

1. Emphasize the purchase rather than the leasing of information processing hardware by federal agencies.⁷³
2. Centralize the management of information processing equipment under the Administrator of General Services.⁷⁴
3. Increase competitive procurement of computers within the "Government market."⁷⁵

All of these points were intended to increase the federal government's utilization of computer systems. But is the opportunity in the form of capital available to the federal utility to upgrade technology? The answer is that the federal computer services utilities do have the capital to maintain state-of-the-art technology and, in fact, have been encouraged to upgrade their systems by the Congress. This opportunity to upgrade is discussed below.

⁷³ Committee on Government Operations, Report (To Accompany H. R. 5171), p. 3.

⁷⁴ Committee on Government Operations, Report (To Accompany H. R. 5171), p. 3.

⁷⁵ Committee on Government Operations, Administration of Public Law 89-306, p. 4.

3.2.2 Opportunities: The Availability of Capital

The computer services utility in the federal government may finance computer acquisitions in three ways. First, funds for computer acquisitions are available on a project basis. Second, the utility may finance the purchase of a computer system through the "ADP revolving fund" established by the Brooks Act. Third, the utility may fund the acquisition of a computer through its annual operating budget.

Congress will in a few cases appropriate funds on a project basis for the acquisition, development, and maintenance of a computer system associated with a special activity (e. g. Department of Defense research.)⁷⁶ From the utility's perspective, however, this method of acquisition gives the proposed facility extraordinary visibility with accompanying delays built into an extended review process.

The ADP revolving fund was established in 1965 by the Brooks Act. Its purpose is to strengthen the federal government's bargaining position in the acquisition of computer systems.⁷⁷ This appropriations mechanism was defined as follows:

The revolving fund would be used to consolidate volume acquisitions. GSA would acquire the ADP systems selected by the management of the agencies and, in effect, the agencies would then lease equipment from the GSA revolving fund reimbursing the fund periodically at rates reflecting the use value of the equipment. GSA could obtain direct appropriations covering overhead expenses incident to operating the

⁷⁶ Terry Miller, Federal ADP Procurement, (Annandale, Va.: Government Sales Consultants, Inc., 1974), p. 3-1.

⁷⁷ "Senate Report No. 938", United States Code: Congressional and Administrative News, (West Publishing Company: St. Paul, Minn., 89th Congress - First Session, 1965), Vol. 2, p. 3862.

revolving fund.⁷⁸

The fund was intended to alleviate any limitations inherent in an agency's annual operating budget when that agency was considering the acquisition of computer systems.

The Congress, since the early development of computer technology, has been extraordinarily sensitive to the need for agencies to maintain effective and efficient computer service facilities. It has taken special measures to insure that federal agencies have had the means (i. e. the opportunity) to maintain up-to-date computer technology. The establishment of the ADP revolving fund was, perhaps, the best indication of the political environment favoring new technology.

Acquisitions with funds from the the operating budget have implied a lease or rental agreement with a computer vendor. This is because, historically, the capital cost involved in a computer purchase has been quite high relative to the budget. Lease/rental agreements have been popular within the private sector.⁷⁹ However, these agreements have not been popular among federal computer services utilities. In the years immediately following the implementation of the Brooks Act, lease/rental proposals received special attention due to the Congress's interest in encouraging computer purchases. As pointed out earlier, increased visibility extends the review process which in turn leads to extraordinarily long procurement cycle.⁸⁰ Still, acquisitions out of the

⁷⁸ "Senate Report No. 938", p. 3862.

⁷⁹ Fishman, p. 17.

operating budget have been an available option to the federal computer services utility intent upon upgrading its technology. Such acquisitions have become especially attractive since the mid-1970's because hardware costs have become small relative to all other operating costs. Therefore, the extraordinary growth in computer technology has provided the best opportunity for maintaining state-of-the-art computer systems. As described earlier in this chapter, computer technology has been developed so as to maintain exponential growth in compute capacity for the same hardware price and lower operating costs. The net effect has been to allow many computer installations to maintain current technology and to expand capacity without adversely affecting annual cashflow.⁸¹

Federal bureaucrats have had the opportunity - the capital and the political support - to maintain efficient, effective computer systems reflecting state-of-the-art technology. But, given that opportunity and encouragement, have they opted to update their systems? Before that question can be answered, the risks associated with new technologies, as perceived by the federal decision-maker, must be evaluated. This is, perhaps, the key issue in a federal bureaucrat's evaluation of any investment in new technology - what are the risks to the computer ser-

⁸⁰ Report to the Congress of the United States: AFMD-81-9, By the Comptroller General, (United States General Accounting Office, : Washington, D. C., Dec. 15, 1980), p. 28.

⁸¹ For instance, Virginia Tech has installed state-of-the-art computer hardware, increasing compute capacity and replacing (or supplementing) obsolete technology, by trading on the residual value of its older computer systems. This upgrade in technology has been accomplished three times in the last four years without a significant change in cashflow.

vices utility inherent in a change in technology? To the Niskanen bureaucrat intent on increasing output, we will see that the risks are applicable only to "reserve" resources; to the Migue-Belanger bureaucrat concerned with the protection of discretionary budget, we will see that the risks are considerable.

3.2.3 Risks: The Cost of Conversion

The third objective of the Congress in enacting the Brooks Act was to increase the competitiveness of computer acquisitions. To accomplish this last key objective of the Brooks Act, GSA created the "functional specification."⁸² The functional specification defines information processing systems' requirements in terms of end-user requirements. Hardware and software interface requirements are not allowed in a functional specification. Therefore, federal agencies are often required to pay conversion costs in order to implement new computer systems. Conversion costs include the following:

1. the cost (primarily for labor and computer time) for conversion of old software applications for use on the new facility,
2. the cost of required environmental modifications,
3. the cost for parallel operation of the old technology with the new technology,

⁸² Committee on Government Operations, Administration of Public Law 89-306, p. 10.

4. the cost for training of personnel on the operation of the new technology,
5. the cost (again, primarily for labor and computer time) for development of new software applications to bring the new facility to full capacity.

These conversion costs may not "be considered in the evaluation of bids for the procurement of ADP systems."⁸³ These costs are charged to the utility's operating budget and, in effect, recapture for the sponsor the surplus operating budget which has resulted from a fully implemented (but quite possibly obsolete) computer technology.

Figure 8 depicts the potential cost of conversion to the federal utility. The vertical difference between the curve representing the old technology (beginning at $t = 0$) and the curve representing the new technology (beginning at $t = 5$) at the time of acquisition ($t = 5$) of the new technology represents the potential loss in output per operating budget dollar. That loss in output per budget dollar is the cost of conversion to the bureau. The horizontal distance between the two curves represents the time which may be required to recapture the previous level of output per operating budget dollar.

How significant are conversion costs? According to the General Accounting Office case studies, conversion costs for just five federal procurements were over 56 million dollars.⁸⁴ Private sector computer ser-

⁸³ Committee on Government Operations, Report (To Accompany H. R. 5171) p. 32.

⁸⁴ Report to the Congress of the United States: FGMSD-80-35, By the

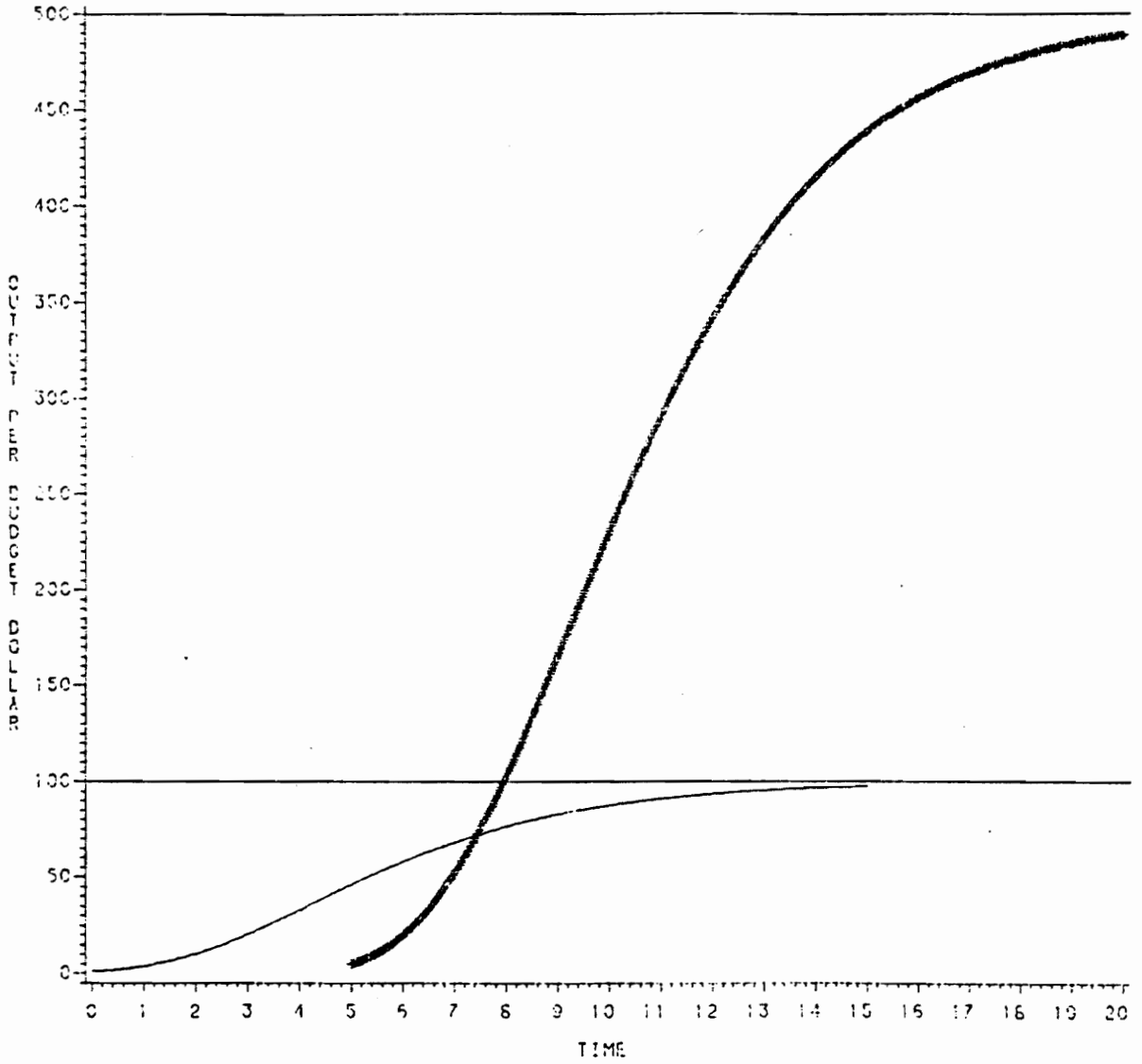


Figure 8: POTENTIAL LOSSES DUE TO CONVERSION COSTS

vice utilities minimize conversion costs by acquiring compatible computers - often without competitive bids. Federal computer utilities, however, given the requirement for "functional specifications," risk considerable conversion costs if they acquire computers reflecting new technology. These costs must be allocated out of the operating budget. The computer utilities have the reserve funds available because considerable organizational resources have been required to develop the current, possibly, obsolete systems to the point that they are fully utilized. Once the current systems are fully utilized, the resources dedicated to the conversion effort become reserve, or discretionary, resources.⁸⁵ In other words, from the perspective of the Migue-Belanger bureaucrat, the computer utility can install new technology only at considerable risk to its discretionary profit. But, from the perspective of the Niskanen bureaucrat, reserve resources may be continually utilized and output may be increased only through the timely installation of new technology.

Comptroller General, (United States General Accounting Office, : Washington, D. C., June 3, 1980), p. 10.

⁸⁵ One might ask the question - how have these discretionary resources been utilized? Where personnel are concerned, the resources are primarily divided among three functions. First, some personnel are always planning the next upgrade in technology - the planning may last for years compared to months in the private sector. Second, some personnel are always "maintaining," or fine tuning the already developed applications. Third, some personnel are working on special projects which have little connection to the assigned mission of the organization.

3.3 CONCLUSIONS

The significance of technological developments in computers affect the costs of providing computer services in two ways. First, there have been improved economies directly related to technological innovations. Second, there have been economies of scale made possible with dramatic decreases in the cost per unit of compute potential. The following list relates these two effects to specific cost factors common to computer centers:

1. The residual value of the computer system is related to the capacity and to the technological innovations inherent in the system.
2. The operating labor costs are functions of economies of scale.
3. The environmental operating costs are functions of both economies of scale and the technology inherent in the hardware.
4. The maintenance costs of the hardware are dependent on the technology.
5. The expected time of availability is a function of the technology.
6. The cost of software relative to its potential utilization is a function of economies of scale.

All of these cost factors are critical to the analysis of investments in computer systems. They affect both the maximum production potential of a center operating under an operating budget constraint and the rate of decay in the salvage value of the system. Because of these cost

factors, effective, efficient computing can only be delivered by federal computer utilities with up-to-date technology.

Federal computer services utilities have had the opportunity to upgrade computer technology. The incentive to convert capital stock to newer technologies has been increased compute capacity and output per operating budget dollar. Increased output and efficient operation are supposed to be characteristic of organizations managed by the Niskanen bureaucrat. But for the Migue-Belanger bureaucrat, the disincentive has been the potential costs - the risk to the way in which the current operating budget dollar is spent - of conversion to an incompatible technology. The model of the federal computer services utility will be used in the next chapter to analyze the Niskanen and Migue-Belanger theories of bureaucratic behavior.

Chapter IV

THE APPLICATION OF THE MODEL

I can call spirits from the vasty deep.

Why so can I, or so can any man; but will they come when you do call them.⁸⁶

Three issues must be resolved in order to apply the model of the federal computer utility to the evaluation of the alternative public choice theories of bureaucratic behavior. First, parametric values must be defined which are commensurate with the technological life cycle of computers in the federal government. Second and third, the specific behavioral expectations of the Niskanen and the Migue-Belanger bureaucrats, respectively, must be developed.

The parametric values to be assigned are for λ , for α , and for β . The values for those parameters are used to predict an average system life cycle and an average point of obsolescence for computer technologies of the past thirty years. The next section defines these parameters for the technological life cycle applied in this study of the Niskanen and Migue-Belanger bureaucrats.

The second issue is the identification of the behavioral expectations of the Niskanen bureaucrat. A derivative of Niskanen's model is that the bureaucrat will maximize output with little regard for the effect the expansion might have on future costs. The governing concern is for

⁸⁶ Shakespeare, King Henry IV, Part I.

the effect on future budgets; the critical effort is on maximizing production. Thus, with Niskanen's model, we have the image of the efficient, effective risk-taking manager - the entrepreneurial bureaucrat.

The third issue is the identification of the behavioral expectations of the Migue-Belanger bureaucrat. Migue and Belanger propose an alternative picture of the federal bureaucrat. We have the manager intent upon expansion - but with a wary eye towards that increased output's potential adverse effect on the way in which the current operating budget is utilized. As is revealed in Section 4.3, the Migue-Belanger bureaucrat is not a risk-taker. He will not jeopardize his discretionary budget. Forced to choose between expansion and lost discretionary profit, he will sacrifice expansion.

Sections 4.2 and 4.3 develop the expectations defined above for the two maximands. The last section defines the inventory data base used to compare the predicted states of the inventory to its actual state.

4.1 THE SYSTEM LIFE CYCLE

Parametric values may be assigned for λ , α , and β which provide for a number of predictions about a computer's system life. Figure 9 represents the predicted average life cycle of the computer technologies in the federal inventory. In generating the Figure 9 example, the Gompertz function was utilized to define the life cycle. The values assigned for the parameters of the model are explained in the following paragraphs.

An arbitrary value (or index) of 100 was chosen as the technological limit (λ). This index represents the maximum compute potential of a specific technology. This value does not have an effect on the predictions for either the length of system life or the beginning point of obsolescence.⁸⁷

A value of .01 per work week (to be exact, .01 per .025 of a year) was used as the rate of conversion (α) of applications to new technology from old technology.⁸⁸ Implied in this value is the high likelihood, for federal agencies, that the the new technology will not be upward compatible with the old technology - thus complicating the conversion effort.

A value of .7 was used as the rate of decay (β) in the market potential of a specific computer technology due to the development of new technologies. The extent of the decay in residual value is defined by the point at which a computer system is valueless as a production factor. For this thesis, a computer is defined as economically valueless, or obsolete, once its market value is less than 1% of its original retail value.⁸⁹

⁸⁷ Remember from Chapter III that the inflection point for time (t) is a function only of the rate of conversion and the rate of residual decay.

⁸⁸ I believe this is a quite generous (high) conversion rate for the federal bureaucracy; however, it is within reason and the key values (length of system life and beginning point of obsolescence) derived from the function are not very sensitive to it.

⁸⁹ This is consistent with the used computer market's tendency to treat computers as scrap at approximately 1% of original price. For instance, Computer Price Guide (published by TBI Computer Sales,

In Figure 10, these parametric values are summarized. For Figure 9, these values yield an average system life of about 13 years.⁹⁰ Rate of decay (β) is the critical element in the length of a computer system's economic life. The sensitivity of average system life to rate of decay (β) is revealed as follows: a β of .75 yields an average system life of 16 years; a β of .65 yields an average system life of 10 years.

Figure 11 represents the predicted time period of the beginning of technological obsolescence. The curve represents the marginal increase in output per operating budget dollar. It is a function of β and α in the model of the computer services utility. At its maximum value, the curve defines the peak marginal value of the old technology for the computer services utility. Put another way, once at its maximum value (at time = approximately 4.5 years), output per budget dollar will increase, but at a decreasing rate. The point of obsolescence is determined by the technological limit to the amount of output and by the rate of decay in the residual, or economic, value of the computer technology. The rate of decay in the residual value is defined by the state (i. e. availability) of the new technology. The point of maximum marginal

October, 1981, pp. 1-52), lists equipment valued at less than 1% of list price as obsolete with little-to-no market value.

⁹⁰ This is consistent with the average life of IBM's 1410's and 360's but may be a little high given the life of its other systems such as the 7074's, 1620's, 370's, and the 303X's. The life cycle of IBM's competitors' systems parallels the life cycle of IBM's systems since all of the vendors have been constrained by the same rate of development in component technologies. See Computer Price Guide, Used Computer Prices 1970 - 1975, (published by TBI Computer Sales, 1975, p. 15) for a discussion of the system life cycle of the earlier IBM systems.

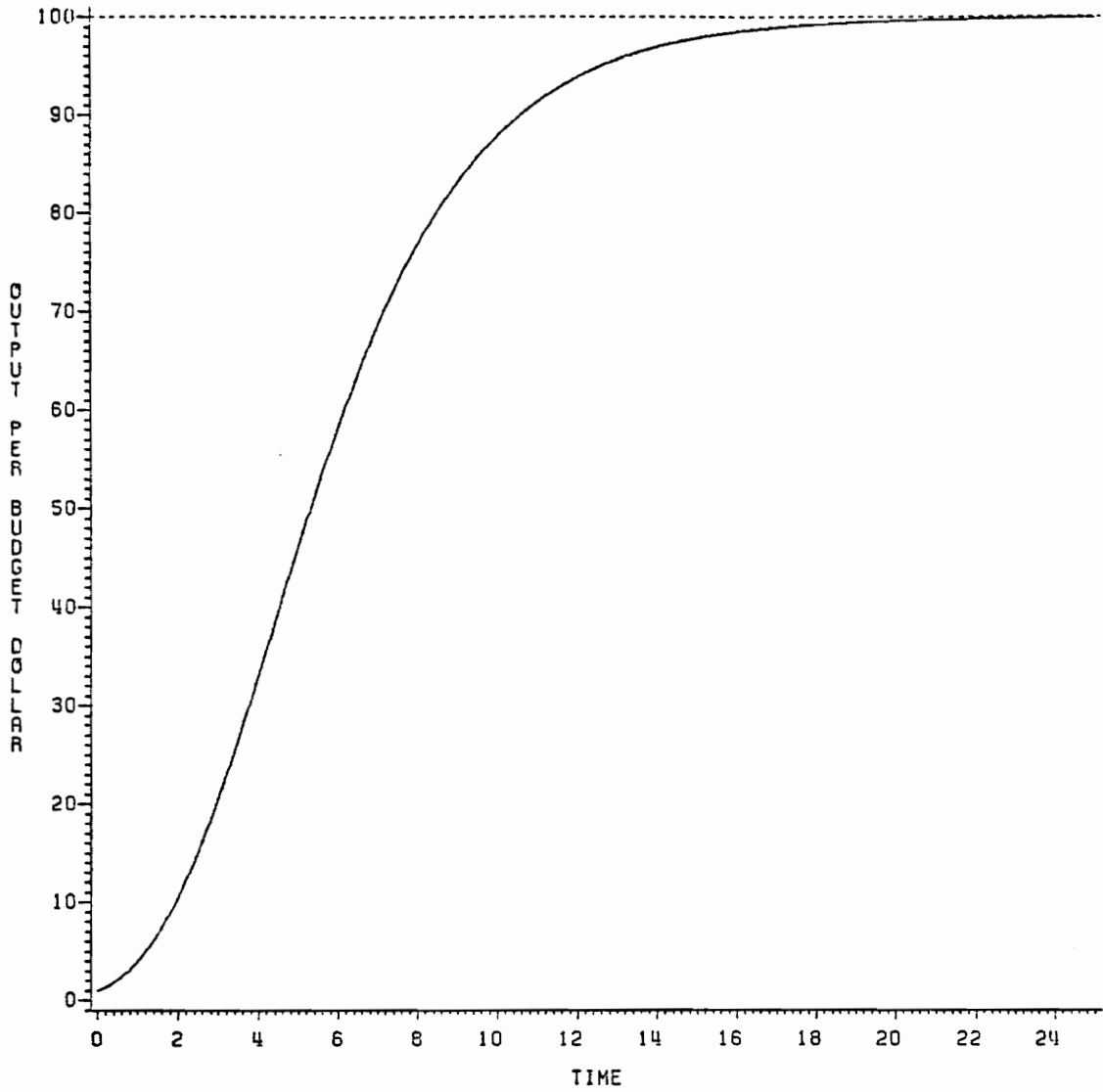


Figure 9: AVERAGE SYSTEM LIFE

$$Q_t = \lambda \alpha \beta^t$$

λ = technological limit as $t \rightarrow \infty = 100$
output units/dollar

α = rate of conversion (<1) = .01

β = rate of decay in residual value (<1) = .7

t = time, each period = .025 years

Inflection Point (I. P.) = approximately 33
output units/dollar with respect to Q

Inflection Point (I. P.) = +4 years
with respect to t

Figure 10: PARAMETRIC VALUES FOR THE GOMPERTZ FUNCTION

output ($T = 4$ in Figure 11) is based upon the same parametric values as those that defined (in Figure 9) the length of system life. Therefore, for this study, 4 years is defined as the average initial point of obsolescence for computer technologies of the past 30 years.

4.2 THE MODEL WITH THE NISKANEN MAXIMAND

At what point in the life of a computer system will the Niskanen bureaucrat choose to trade the current facility with one of the latest technology. The answer, given the output maximization objective, is that new technology will be acquired when there is a clear indication to the bureaucrat that the new technology will result in increased output per operating budget dollar. The tendency for computer services utilities to face insatiable demand was noted earlier in this study. This is especially true of federal computer services utilities given the free-good nature of the utilities' services. The amount of output produced by these federal utilities is constrained only by their budget and the efficiency with which they produce that output. Niskanen provides the following behavioral hypothesis:

Some bureaus, specifically those in the budget-constrained output region, seek out and use the minimum cost combination of the available factors and processes to supply the equilibrium output.⁹¹

This leads to the question - what are the minimum cost combinations available to the Niskanen bureaucrat in a federal computer services utility which is intent upon maximizing output per budget dollar?

⁹¹ Niskanen, Bureaucracy, p. 57.

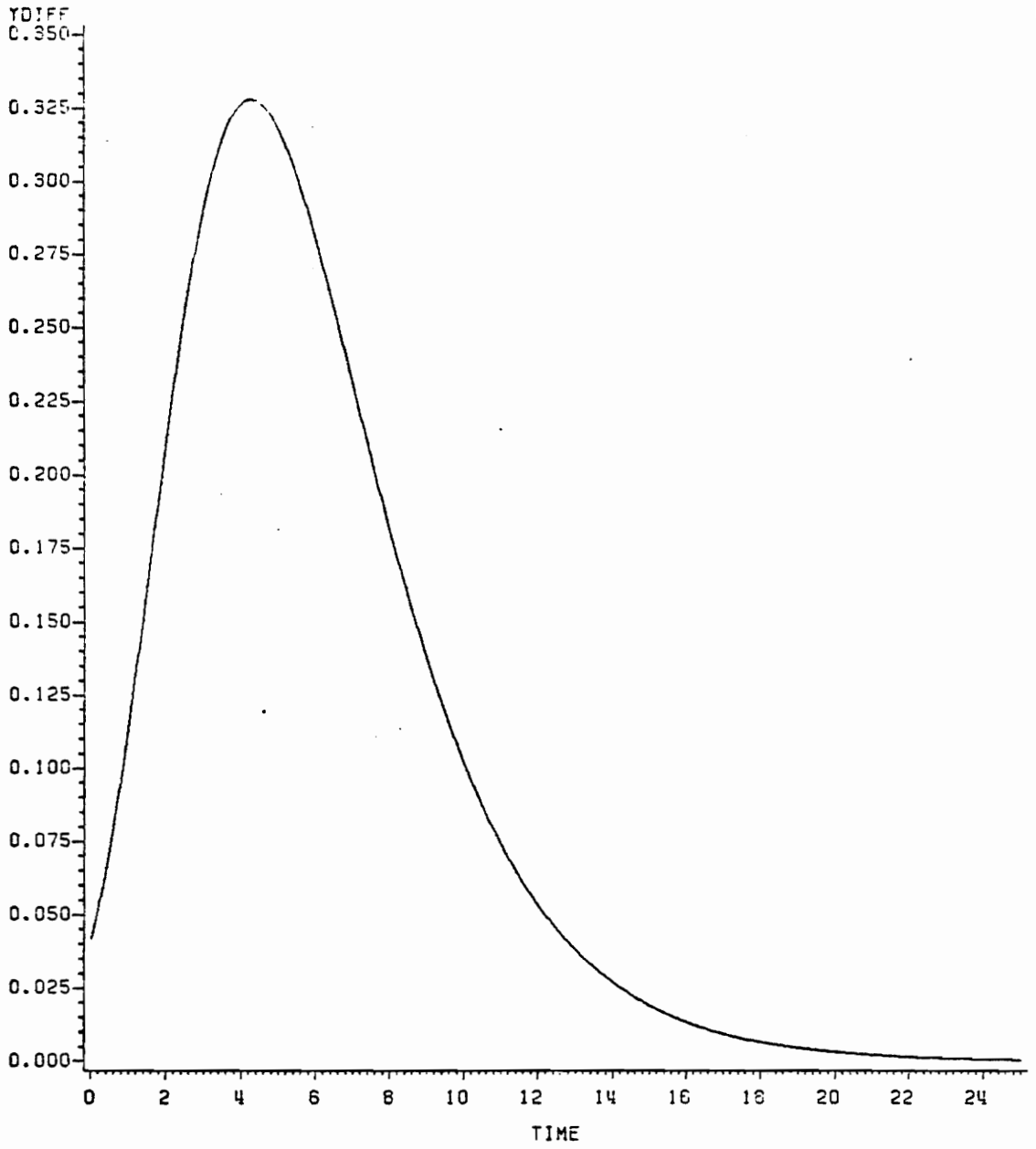


Figure 11: MARGINAL RATE OF GROWTH IN OUTPUT

Figure 12 illustrates the output gain possible with a shift to computers of a newer technology. The horizontal line at output = 100 represents the technological limit per operating dollar using the old technology; the horizontal line at output = 500 represents the technological limit for the new technology. As noted in Chapter III, the difference between the two asymptotes is the gain in production potential possible with conversion to the new technology. However, the peak marginal value of the output produced on the old technology occurs after 4 years (in Figure 12 at $T = 5$). In other words, after 4 years, the marginal output per budget dollar begin to decrease; therefore, even though the system is not yet fully utilized, the Niskanen bureaucrat would attempt to replace the old computer technology. The newer technology (in Figure 12, see the curve beginning at $T = 5$) would allow continued increasing marginal output per budget dollar. The resources required for conversion activities also begins to decrease with the decrease in the marginal output per budget dollar. These freed resources (potentially the computer utility's discretionary budget) are available for the conversion of applications to the newer technology.

4.2.1 The Hypotheses

The Niskanen bureaucrat will attempt to shift to a new technology at the first indication of the system's obsolescence; the system begins to become obsolete when, due to the emergence of a new technology, the output per operating budget begins to increase at a decreasing rate.

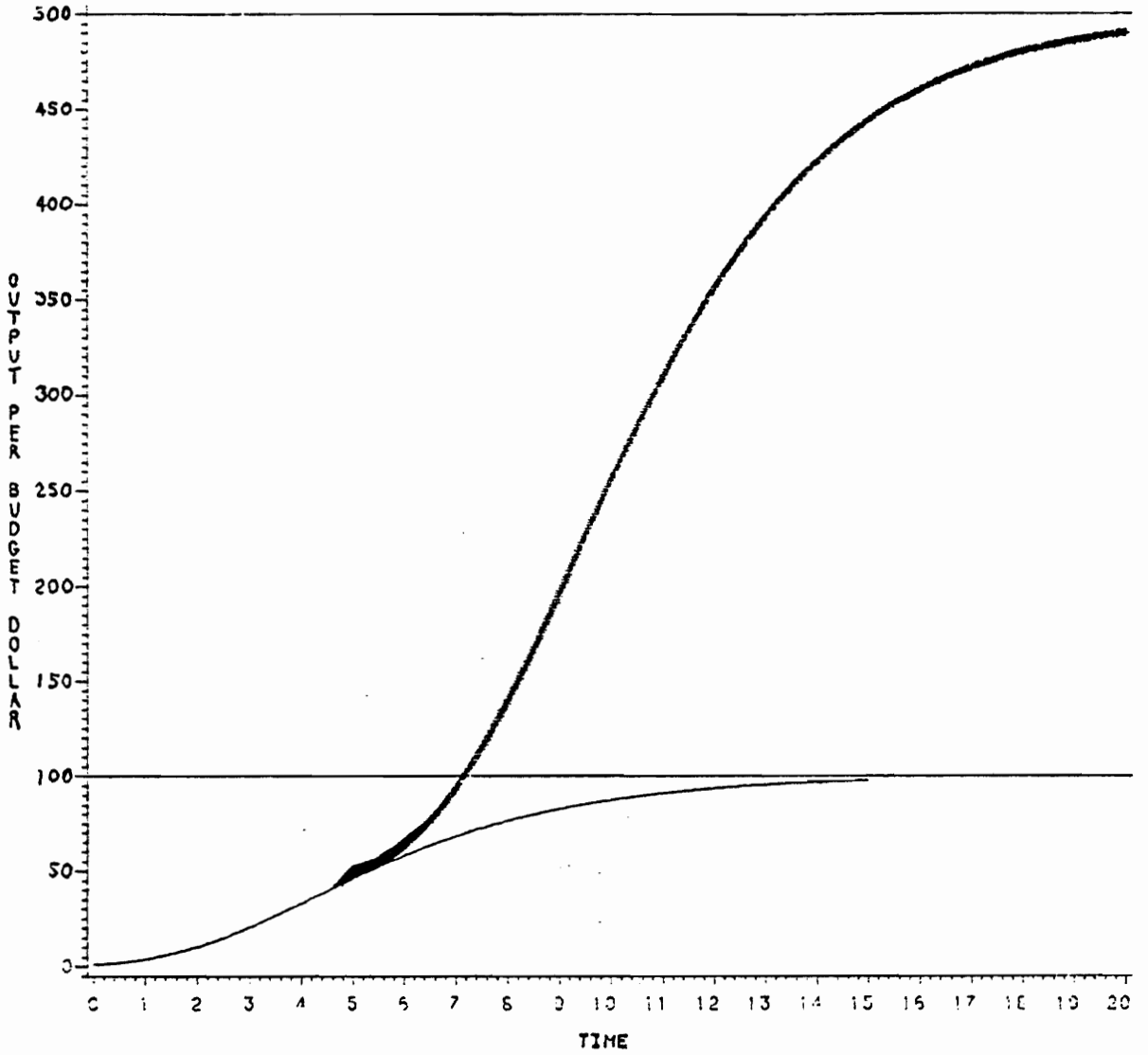


Figure 12: TIMING OF A SHIFT TO NEWER TECHNOLOGY

Remember, a computer system becomes economically obsolete when alternative technologies are available which provide significantly increased output per operating budget dollar. Given the emphasis on maximizing output per budget dollar, a Niskanen bureaucrat would not keep a computer system after it has become obsolete. Neither would a Niskanen bureaucrat acquire a system after it has already passed the point of beginning obsolescence; that is, the Niskanen bureaucrat would not purchase old computer technology. The defined limits of a computer's life cycle lead to the following null hypotheses:

1. No computer systems older than 13 years will be utilized in the Niskanen bureaucrat managed federal inventory.
2. No computer systems will exist in the inventory which were acquired more than 4 years after its introduction.

A data base of information on computers in the federal government will be examined for consistency with these two hypotheses.

4.2.2 Distribution of Residual Values

The primary test of this thesis is to predict the distribution of residual values of all general purpose computer systems in the federal inventory according to the year of their purchase. For instance, given the assumptions of the Niskanen maximand, Figure 13 represents the predicted distribution of residual values for all systems currently in the federal inventory and acquired in the years 1960 through 1981.⁹² In

⁹² The maintenance of accurate data on federal computer systems began with the hearings for the Brooks Act in the early 1960's. There-

order to develop a linear function, the log of the predicted residuals was computed and plotted on the vertical axis. Again, the expectations derived for the Niskanen bureaucrat and reflected in this model were the following:

1. no system will be kept after it has become obsolete as a production factor (13 years);
2. systems will be acquired which are still economically viable relative to the state of technology (not greater than 4 years old).

These assumptions yield parametric values of -11.740152 for the predicted intercept and 0.143405 for the slope. Using the traditional form, the linear model consistent with the Niskanen maximand is as follows:

$$Y = -11.740152 + 0.143405X$$

4.3 THE MODEL WITH THE MIGUE-BELANGER MAXIMAND

At what point in the life of a computer system will the Migue-Belanger bureaucrat choose to trade the current facility for one with the latest technology. The answer, given the output maximization objective, is that new technology will be acquired when there is a clear indication to the bureaucrat that the new technology will result in increased discretionary profit.

fore, very little information is available about systems acquired before that date.

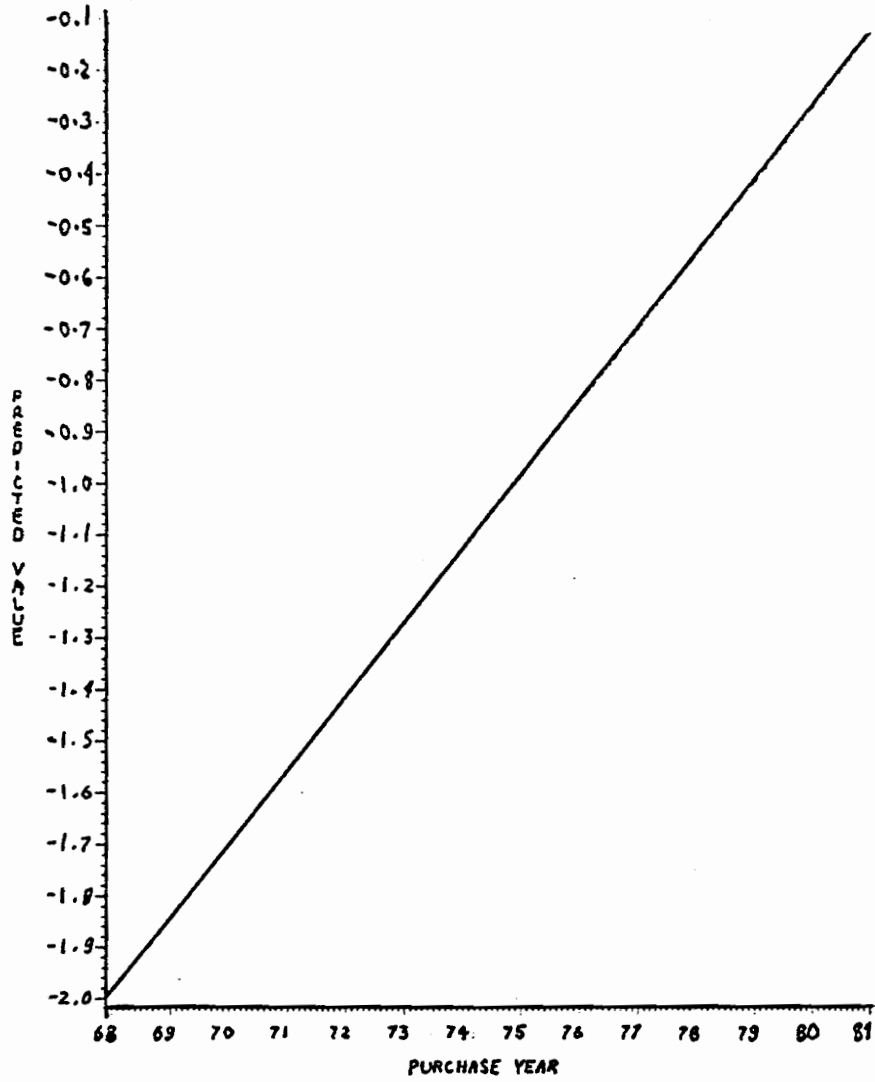


Figure 13: NISKANEN MAXIMAND: PREDICTED INVENTORY STATE

As seen may be seen in Figure 14, the output gain possible with a shift to computers of a newer technology is assured - but so is some initial cost in discretionary profit. Just at the point that the federal computer utility begins to acquire discernable discretionary profit, corresponding in Figure 14 with the point at which applications are converted to the system at a decreasing rate, a change in technology occurs which absorbs that profit. That even greater levels of discretionary profit are possible with the higher efficiency inherent in the newer technology is not a consideration.⁹³ Using Figure 14 as the illustrative case, that increased discretionary profit will not be realized for up to 3 years (or until $T = 8$). The bureaucrat will choose to preserve the current profit instead of investing in capital for potential future profit.

4.3.1 The Hypotheses

The Migue-Belanger bureaucrat will never willingly shift to a new computer technology. No incentive to shift to a new technology exists since, at the point the system is worthless in terms of market value, that bureaucrat has maximized the discretionary profit for that particular computer services utility. In fact, given his captured market,

⁹³ To support this argument, I use Niskanen's rationale - that a federal "bureaucrat's rewards are specific to his tenure...." Ironically, Niskanen uses this characteristic of bureaucrats to support his argument that they prefer production processes with higher capital costs and lower operating costs - or, in other words present spending to future spending. See "Bureaucrats and Politicians," Journal of Law and Economics, 18 (1975), 639.

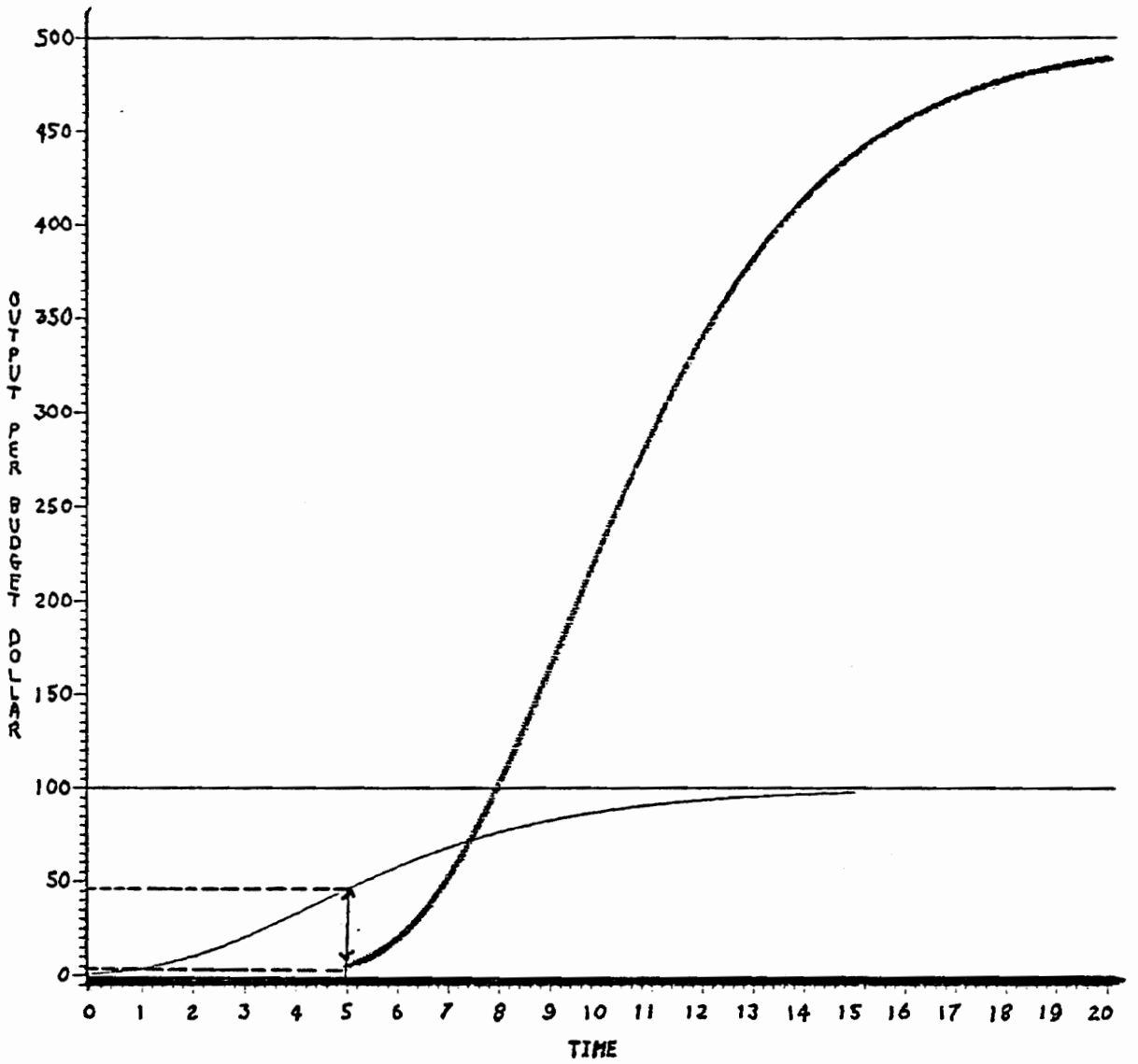


Figure 14: COST VERSUS OUTPUT IN SHIFT TO NEWER TECHNOLOGY

there is no reason to think that bureaucrat will not be able to maintain that profit with incremental increases in his budget based on the inflationary increase of his costs. The only rationale for additional computer systems will be to satisfy increased demand for computer services from captured users. And then, in order to control conversion costs, the tendency will be to acquire older technologies which are highly compatible with those systems already being utilized. The null hypotheses may be summarized as follows:

1. Computer systems will be maintained in the Migue-Belanger bureaucrat managed federal inventory regardless of technological age.
2. A significant number of computer systems will exist in the inventory which were acquired more than 4 years after their introduction.

A data base of information on computers in the federal government will be examined for consistency with these two hypotheses.

4.3.2 Distribution of Residual Values

Given the assumptions of the Migue-Belanger maximand, Figure 15 represents the predicted distribution of residual values for all systems currently in the federal inventory and acquired in the years 1960 through 1981. Again, in order to develop a linear function, the log of the predicted residuals was computed and plotted on the vertical axis. The Migue-Belanger maximand and assumptions yield parametric values

of -12.4929 for the predicted intercept and 0.145865 for the slope. Using the traditional form, the linear model consistent with the Migue-Belanger maximand is as follows:

$$Y = -12.4929 + 0.145865X$$

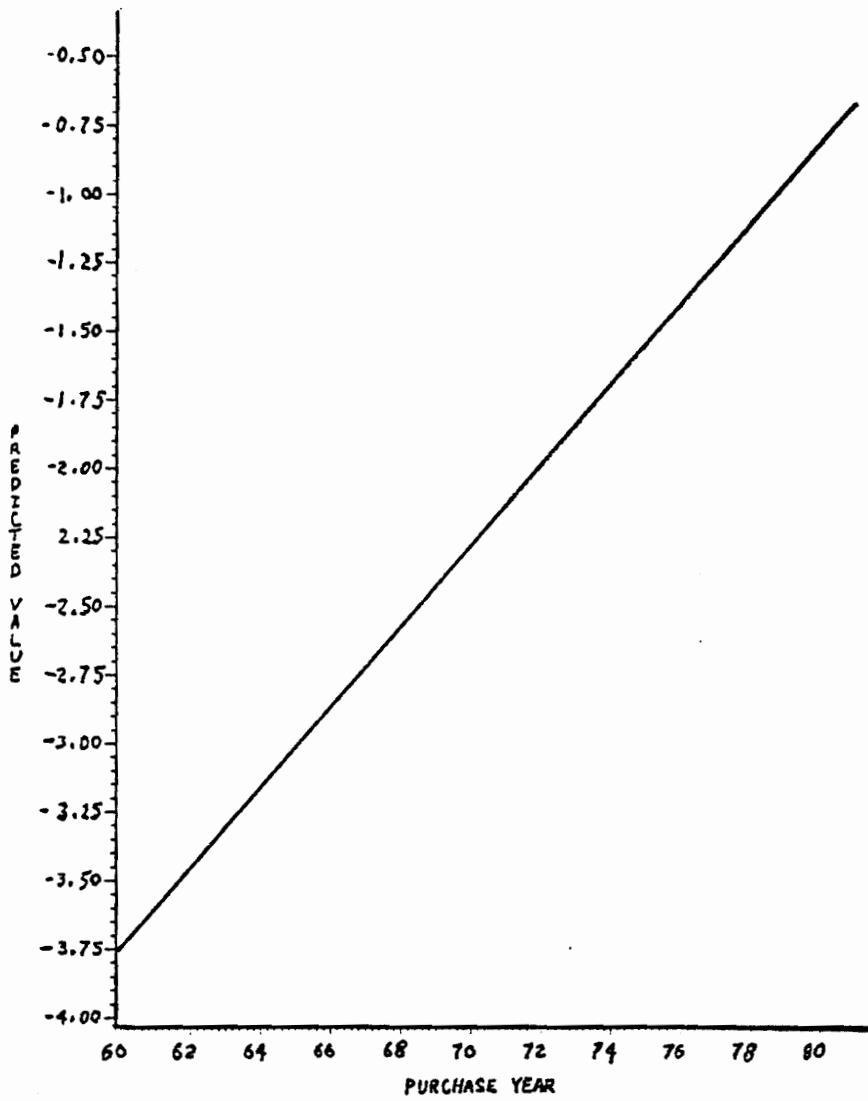


Figure 15: MIGUE-BELLANGER MAXIMAND: PREDICTED INVENTORY STATE

4.4 EVALUATION METHODOLOGY

The predicted outcomes associated with the decisions of the Niskanen and Migue-Belanger bureaucrats, respectively, in the federal computer services utility environment are compared to the actual state of the computer inventory. The inventory is first examined for any inconsistencies with the null hypotheses developed for the Niskanen and the Migue-Belanger bureaucrats. Second, the linear models, predicting the distribution of the residual values of computer systems in the inventory, are compared for their power in explaining the actual distribution of residual values.

4.4.1 The Federal Computer Inventory Data Base

The data base utilized in this study was created for this thesis from data on a tape containing records of all computers in the General Services Administration's "Management Information System on Automatic Data Processing." The tape was obtained in March of 1982 and reflected the status of the federal inventory at the end of October, 1981.⁹⁴ The records selected for inclusion in the data base were for systems which met all of the following criteria:

1. any systems which appeared to be utilized according to the General Services Administration classification of "General Purpose;"

⁹⁴ The inventory information is a requirement of Federal Property Management Regulations (FPMR) 41-CFR 101-36.5. See ADP Management Information System, (Washington: General Services Administration, October, 1981), p. 1.

2. any systems with a purchase price above fifty thousand dollars;
3. any systems obtained on a purchase or lease-purchase agreement.

The study was limited to systems of a "General Purpose" classification because it is these systems which are utilized in a computer services utility environment.⁹⁵ The alternative to this classification is "Special Purpose" computers. Special Purpose computers are used as single user or single application systems, or are used for classified projects. Special purpose systems are not subject to the same acquisition rules and regulations applicable to the federal computer services utilities.

The study was limited to systems with a purchase price above fifty thousand dollars for two reasons. First, systems with a purchase price below this amount would probably not be used to deliver general purpose computer services to a number of users of a computer services utility. Systems below fifty thousand dollars in price would tend to be small minicomputers and microcomputers dedicated to the service of a single application or user. Second, sole source procurements of systems below fifty thousand dollars are not subject to review outside of the agency initiating the acquisition.⁹⁶ Therefore, these systems would not be subject to the same rules and regulations limiting acquisitions of higher priced systems, e. g. the requirement for a functional specifica-

⁹⁵ Automatic Data Processing Activities Summary (Washington: General Services Administration, April, 1980), p. 4.

⁹⁶ Temporary Federal Procurement Regulations, E-149.

tion for competitively bid systems.

Only systems obtained on a purchase or lease-purchase agreement were included on the data base. In other words, systems which were being rented have been excluded. Again, special justification is required for systems not acquired on a purchase or lease-purchase plan. With that special justification, the agency obtains exemptions from the normal institutional rules associated with bureaucratic setting applicable to this study.

A total of 17,503 records, each representing one central processing unit (CPU), are in the 1981 inventory. Of that total, 5091 CPU's, or 29%, met all of the criteria and were selected for inclusion on the data base.

4.4.2 IBM Computers and Residual Values

The primary test of this thesis is to predict the distribution of residual values of general purpose computer systems according to the year of their purchase. Unfortunately, it is not possible to ascertain residual value as a reflection of economic viability for all systems in the federal inventory. Remember that residual value is defined by market value and is a reflection of economic value only if traded in a mature market. Only used computers by IBM are traded in a market which is reasonably mature - with a large number of potential buyers and a large number of potential sellers. Computer Merchants, Inc. explain this characteristic of the used computer market as follows:

... over the years it became apparent that only the market for used IBM equipment would mature and flourish. The reason was that most manufacturers, other than IBM, followed very restrictive maintenance policies, which made it nearly impossible to sell their used equipment.⁹⁷

Another publication makes the following statement on the same topic:

The well-developed second market for IBM equipment is due in significant measure to IBM's known policy of providing maintenance service for used equipment. Not only are purchases of new IBM equipment assured of higher resale prices than would otherwise be the case, but purchasers of used IBM equipment feel protected, secure in the knowledge that a system may even be purchased sight unseen Other manufacturers do not have such a well-defined and universally known policy.⁹⁸

Residual values have been included in the data base for all IBM systems, but for no other vendor's systems. The distribution of residual values for IBM computers should be a good indicator of what would be the distribution for all systems on the data base. IBM computers constitute 14% of the total systems on the data base - but over 26% of the aggregate investment of 1.4 billion dollars.

⁹⁷ Computer Price Guide, by Computer Merchants, Inc., (January, 1982), p. 45.

⁹⁸ Computer Economics Report, by Computer Economics, Inc., (January, 1982), p. 1.

Chapter V

OBSERVATIONS AND CONCLUSIONS

... I ask the reader to ask himself the following types of questions: Is this hypothesis consistent with my personal observation and understanding? Does this theory help organize my observations about related phenomena?⁹⁹

This chapter is organized into three sections. The section entitled "Observations" reveals the state of the federal computer inventory as indicated by the data base created for this study. The observed state is first compared to the hypotheses developed for the Niskanen, and then, the Migue-Belanger models of bureaucracy. This section concludes with an evaluation of the power of each of the two models of bureaucratic behavior to predict the current state of the inventory as indicated by the residual values of the computers. The section entitled "Conclusions" summarizes the findings of this study as reinforcing the Migue-Belanger proposal that bureaucrats maximize discretionary budget. The "Concluding Remarks" section reviews Niskanen's idea that the Migue-Belanger theory is a special case of his own model of bureaucracy. The Niskanen viewpoint is examined for consistency with several observations applicable to the behavior of bureaucrats in the federal computer services utilities over the last thirty years.

⁹⁹ Niskanen, Bureaucracy, p. 8.

5.1 OBSERVATIONS

The entire data base was examined for the evaluation of questions concerning the distribution of computer systems (currently utilized by the federal government) by purchase year. For those questions that required either residual value or technological age, the subset of information on IBM systems in the inventory was examined.

5.1.1 Niskanen and the State of the Inventory

The first of the derived hypotheses consistent with the Niskanen bureaucrat operating in the federal computer services utility was stated as follows:

No computer system older than 13 years will be maintained in the federal inventory.

As can be seen in Figure 16 and Figure 17, a significant number of obsolete computers are currently maintained in the federal inventory. Figure 16 is a reflection of the fact that 15% of the total number of computers on the data base were purchased prior to 1968. In fact, the median purchase year for computers on the data base was 1975. Figure 17 reveals that 20% of the total dollars spent (in 1967 dollars) for the purchase of computers on the data base were for systems acquired prior to 1968.

The second of the derived hypotheses consistent with the Niskanen bureaucrat operating in the federal computer services utility was stated as follows:

No computer will exist in the inventory which is based upon technology more than four years old at the time of its purchase.

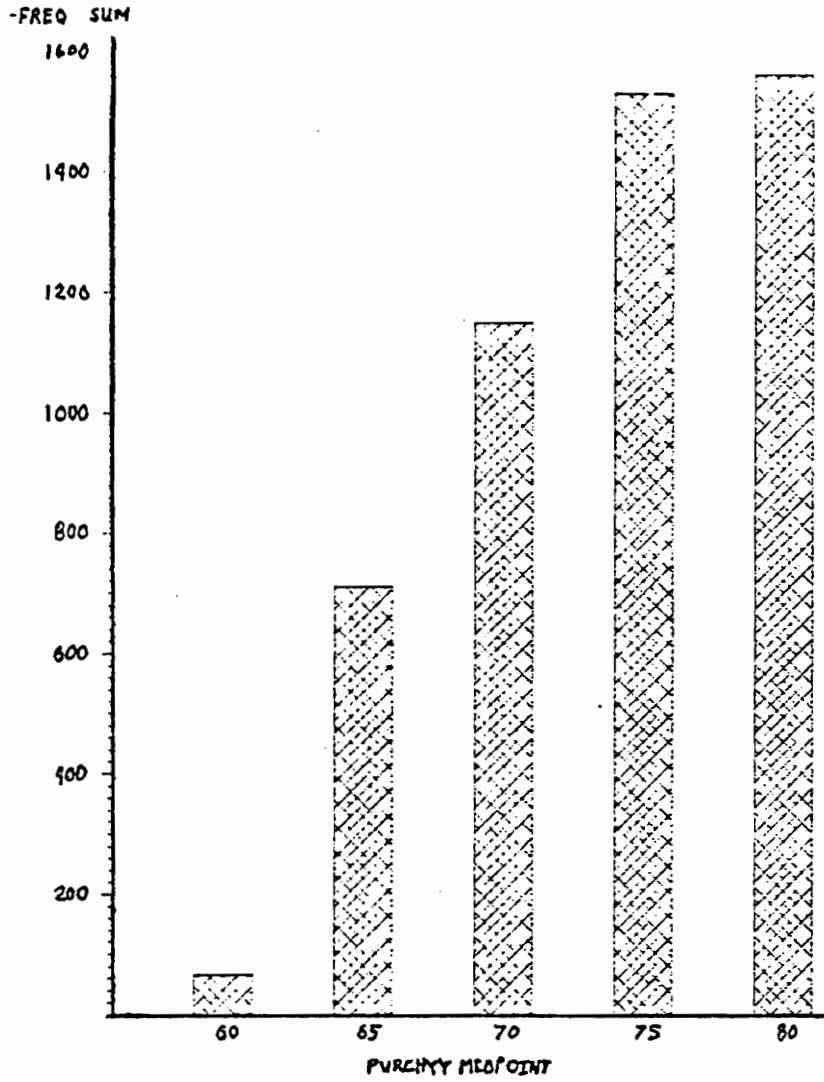


Figure 16: NUMBER OF COMPUTERS BY PURCHASE YEAR

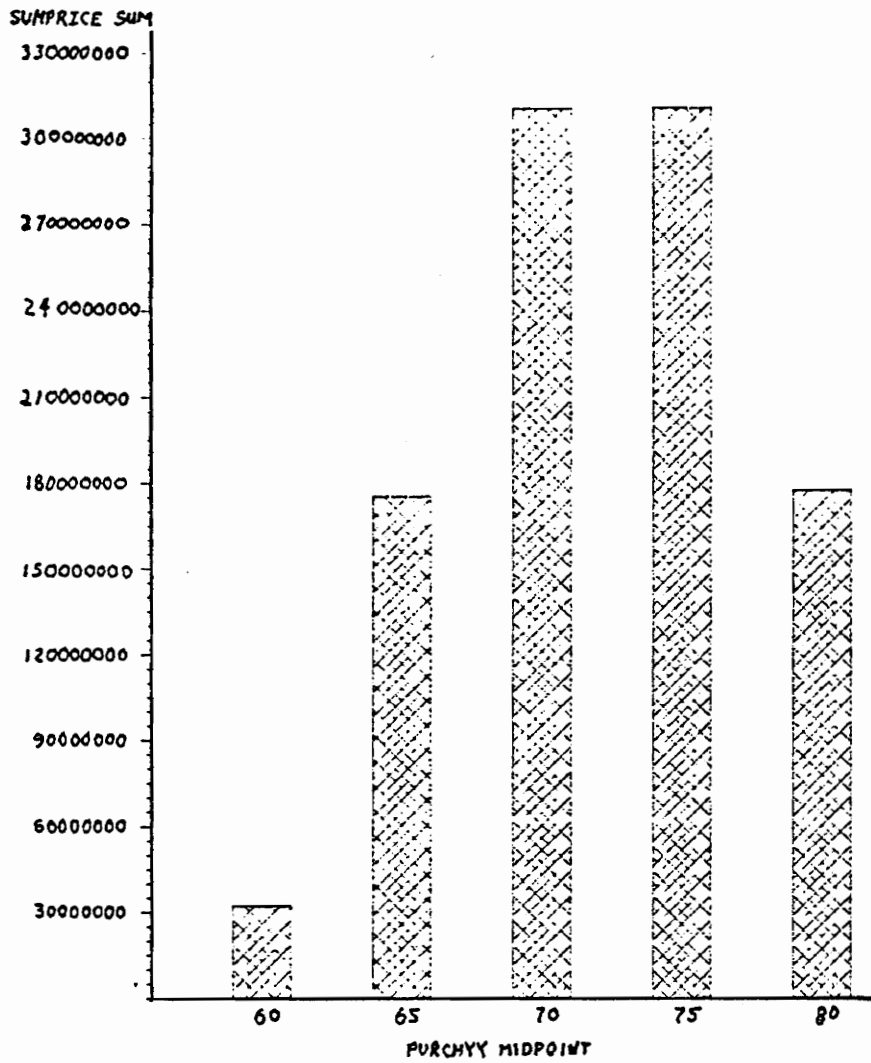


Figure 17: INVESTMENT IN COMPUTERS BY PURCHASE YEAR

Since accurate first production information could be obtained only for IBM systems, the IBM subset of the data base was used in the evaluation of this hypothesis. As can be seen in Figure 18, a significant number of computers were obtained which reflected technologies older than four years. In fact from Figure 18, it is apparent that the mean technological age of purchased computers has been increasing since 1965 - the year in which the Brooks Act was implemented with its implied emphasis on competitive purchases and the functional specification. The mean technological age for systems in the federal inventory, as indicated by the IBM systems, was 5 years.

Given the assumptions of the Niskanen maximand, Figure 19 represents the predicted distribution of residual values compared to the actual distribution for systems currently in the federal inventory and acquired in the years 1960 through 1981. Again notice that, although with the Niskanen maximand we would not expect systems older than 13 years, systems are in the inventory which are over twenty years old. We can visually note that the linear model

$$Y = -11.740152 + 0.143405X$$

does not yield a very good prediction of the economic state of the inventory. The slope is adversely affected by the excessive number of computer systems in the inventory which are over thirteen years old. As noted earlier, over 15% of the computer systems in the data base are older than thirteen years. (See Figure 16 for the distribution by pur-

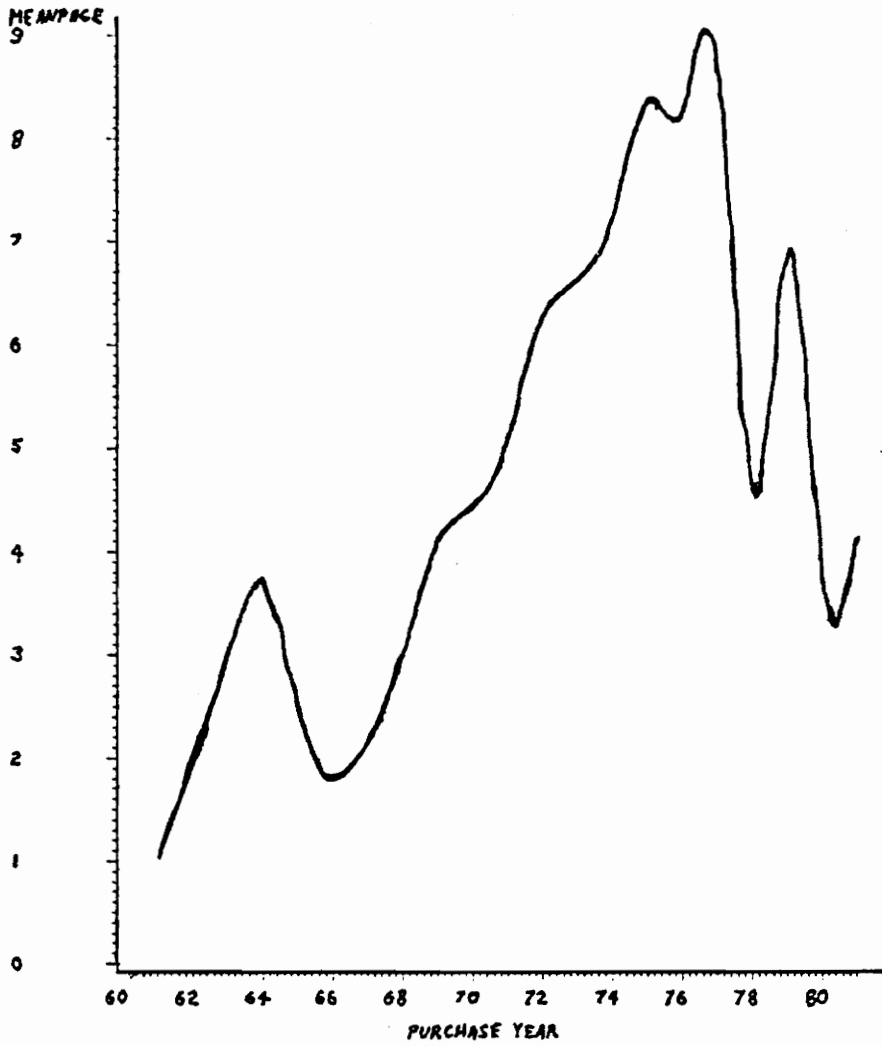


Figure 18: MEAN TECHNOLOGICAL AGE OF COMPUTERS BY PURCHASE YEAR

chase year.) The primary factor influencing the high intercept value is the tendency to purchase obsolete computers - indicated by technological age in excess of four years.

5.1.2 Migue-Belanger and the State of the Inventory

The first of the derived hypotheses consistent with the Migue-Belanger bureaucrat operating in the federal computer services utility was stated as follows:

Computer systems will be maintained in the inventory regardless of technological age.

We have already seen in Figure 16 and Figure 17 that a significant number of obsolete computers are currently maintained in the federal inventory.

The second of the derived hypotheses consistent with the Migue-Belanger bureaucrat operating in the federal computer services utility was stated as follows:

A significant number of computers will exist in the federal inventory which had a technological age greater than four years at the time of their purchase.

Again, from Figure 18, we already know that most computers in the federal inventory reflected technology older than four years at the time of purchase.

Given the hypotheses applicable to the computer services utility and derived from the Migue-Bellanger maximand, Figure 20 represents the predicted distribution of residual values versus that of systems currently in the federal inventory and acquired in the years 1960 through

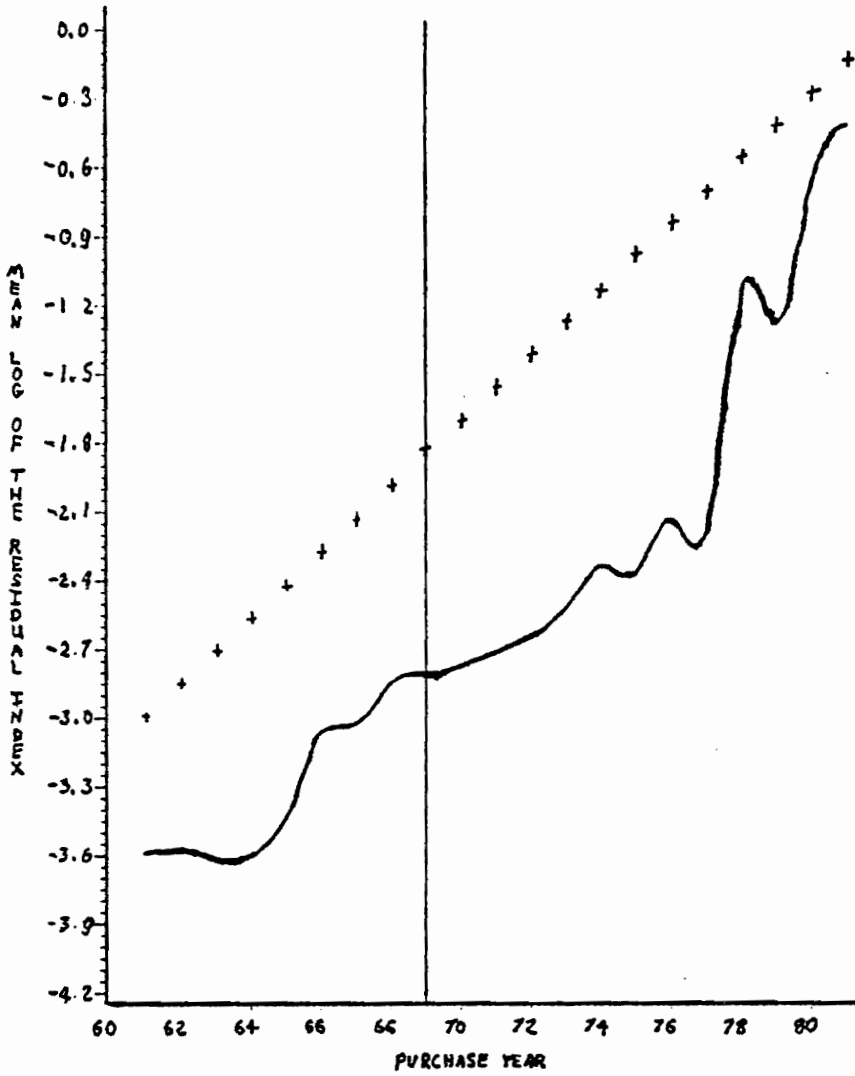


Figure 19: NISKANEN PREDICTED VERSUS ACTUAL INVENTORY STATE

1981. Again, IBM systems were used to determine the actual state of the inventory. The linear model based upon the Migue-Belanger maximand

$$Y = -12.4929 + 0.145865X$$

appears to provide a significantly better prediction of the economic state of the inventory. The "sketched" lines represent the interconnection of every IBM system in the data base; Each "plus" represents the predicted log of the mean residual value for the systems purchased in a particular year. The model appears to be a reasonably good predictor of the economic state of the federal inventory. By assuming that the Migue-Belanger bureaucrat will buy systems even further into their technological life (the assumption was that a system would never be acquired before the beginning of obsolescence) the linear model would show even better predictive power.

Figure 21 provides an even better comparison of the two models. The lower curve on the graph represents the "best fit" to the actual mean of the log of the residual values. The middle curve represents the model based on the Migue-Belanger maximand and the upper curve represents the model based on the Niskanen maximand. For 1980, the predicted mean residual value consistent with the Niskanen maximand is .53, the predicted mean residual value consistent with the Migue-Belanger maximand is .15, and the actual mean residual value as indicated by the sample is .045. For 1976, the values are .14, .04, and .01 respec-

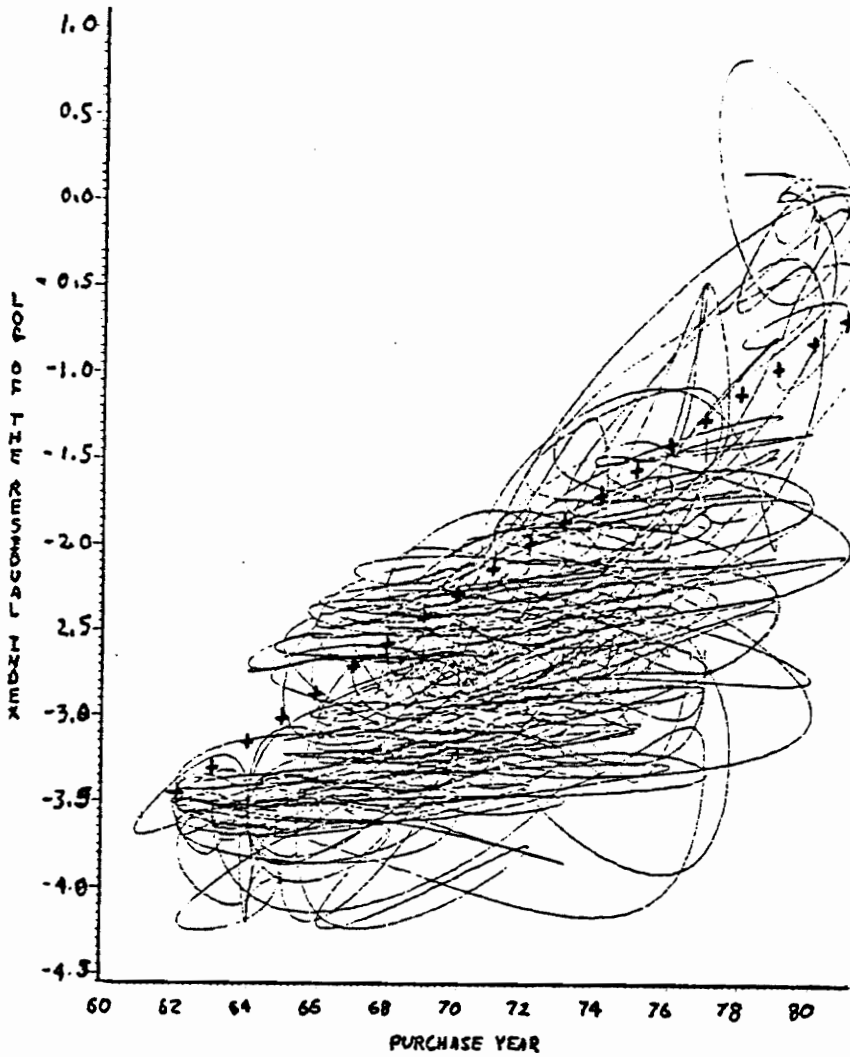


Figure 20: MIGUE-BELLANGER PREDICTED VERSUS ACTUAL INVENTORY STATE

tively. Once again, it is obvious that the model based on the Migue-Belanger maximand is the better predictor of the economic state of the inventory.

5.2 CONCLUSIONS

Institutional decision-units do quite probably respond exactly as they are instructed. The structural incentives and disincentives provide the instruction. As though instructing Hofstadter's smart-stupid's, the instructor must understand what motivates the federal bureaucracy's decision-units.

5.2.1 The Model with the Niskanen Maximand

The Niskanen bureaucrat is interested in maximizing output - an expected resultant characteristic is efficient production of output. This is clearly not the case for the federal government's computer services utilities. Because of the obvious gains in output potential and productivity, the Niskanen bureaucrat would have attempted to shift to new technology at the first indication of a system's obsolescence. However, the federal bureaucrat is acquiring old, highly inefficient computer technology and keeping it "forever."

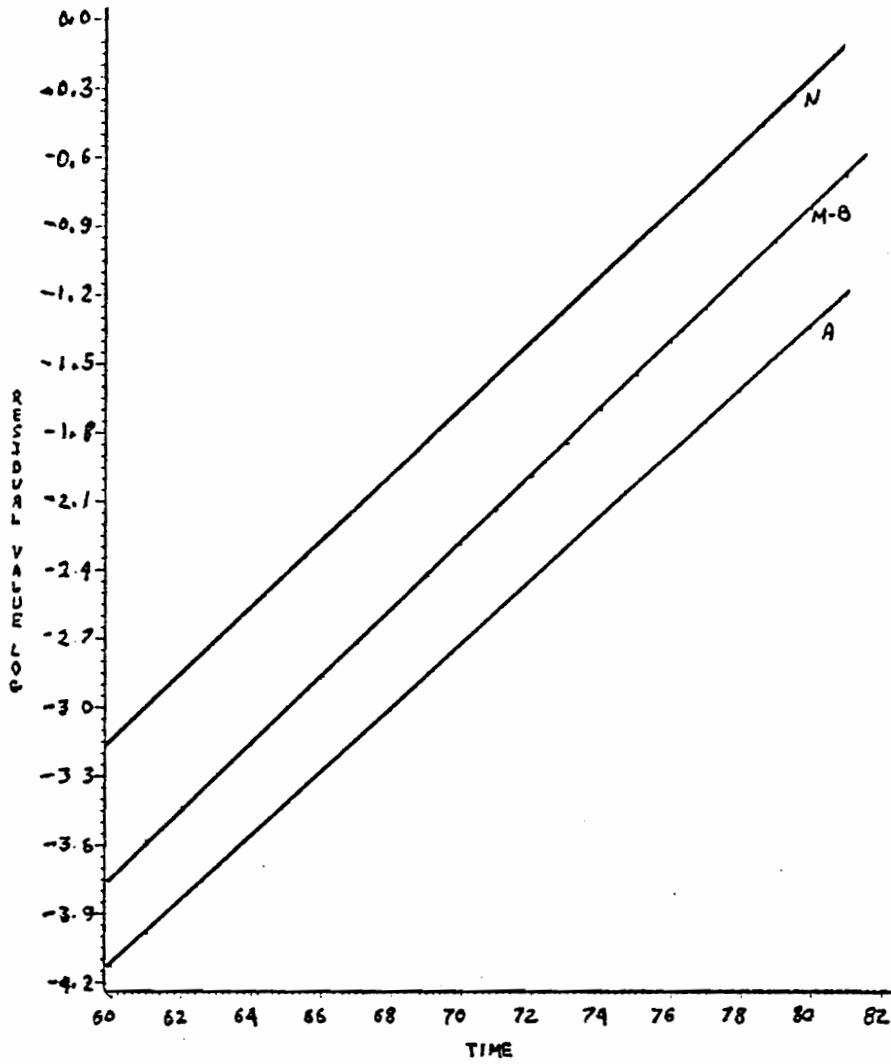


Figure 21: PREDICTED VERSUS ACTUAL INVENTORY STATE

5.2.2 The Model with the Migue-Bellanger Maximand

Bureaucrats managing federal computer services utilities are acquiring computers based upon obsolete technology. Once acquired, these systems are being utilized years beyond their normal economic life cycle.

Because of potential conversion costs, the federal bureaucrat can not be certain that new technology will guarantee increased discretionary profit. The current economic state of the computer inventory is consistent with the fact that the Migue-Bellanger bureaucrat has no incentive to shift to a new technology. In fact, the primary incentive is to keep and continue to develop old technology. At the point that the old system is worthless in terms of market value, the bureaucrat has maximized his discretionary profit. That this state of the federal governments utilization of computer technology is inefficient is also consistent with the Migue-Belanger model of bureaucracy.

The Migue-Belanger bureaucrat is responding to the disincentive-incentive structure implied in the United States policies governing the purchase of general purpose computer systems by the federal government. Those policies - those instructions - were established with the 1965 Brooks Act. With understanding of the bureaucratic maximand at work in the federal computer utility, the instructors would have least been able to predict the consequences of their instructions.

5.3 CONCLUDING REMARKS

Earlier, in Chapter II, Niskanen's claim that the Migue-Belanger hypothesis is an extension to his own theory was noted. The Migue-Belanger theory is identified as a special case in his "generalized version" of the original model - the "budget maximizing bureaucrat" becomes the "utility maximizing bureaucrat."¹⁰⁰ Niskanen states that whether discretionary budget or total budget is maximized is dependent upon whether or not the bureaucrat values output. Niskanen's argument is as follows:

Jean-Luc Migue and Gerald Belanger ... developed a model of bureaucratic discretion based on an assumption that a bureaucrat maximizes an objective defined in terms of his "discretionary budget" ... and the bureau's output. This model leads to the general conclusion that a bureau's budget is always too large. At one limit, if the bureaucrats do not value output, the output level will be correct but this output will be produced most inefficiently. At the other limit, if bureaucrats do not value the discretionary budget, the output level will be substantially too high, but will be produced efficiently - the conclusion of my earlier model. Migue and Belanger have started in the right direction, but they also fail to derive the bureaucrat's maximand from an explicit model of utility maximization in a specific institutional setting.¹⁰¹

Niskanen continues by developing a model of utility maximization which defines two alternative preferences of the bureaucrat:

1. output is not valued;
2. output is valued.¹⁰²

¹⁰⁰ William A. Niskanen, "Bureaucrats and Politicians" in Journal of Law & Economics (December, 1975), p. 619.

¹⁰¹ Niskanen, "Bureaucrats and Politicians," pp. 618-619.

¹⁰² Niskanen, "Bureaucrats and Politicians," p. 621.

The first case, he claims, is characteristic of discretionary profit maximization; the second case is characteristic of budget maximization. This generalization brings into question the value of the Niskanen model in explaining bureaucratic behavior. At first glance, we might conclude that one preference is indistinguishable from the other since, such is the case with many public goods, output is ill-defined. A more thoughtful analysis leads to the following question: since discretionary budget is a function of total budget and since total budget is a function of output, when, with either maximand, would a bureaucrat not be interested in increasing output? Certainly any analysis of bureaucracy which concentrates on production behavior and which is based on a revelation of output maximization would lack precision as regards any distinction between the two maximands. The behavior of bureaucrats in the federal computer services utilities provides an opportunity to investigate this point.

Today, it seems obvious that bureaucrats in the federal computer services utilities are operating in a way consistent with the the Migue-Belanger model based on the maximization of discretionary budget. For instance, the following characteristics are applicable to the current state of computing in the federal government:

1. general discontent with services (see Chapter 1) among the users of federal computing - which is symptomatic of computing resources operating at capacity;

2. significant utilization of economically obsolete equipment - which indicates inefficiency in the production of computer services.

A critical factor in the failure of bureaucrats to maintain state-of-the-art technology has been the rules-of-the-game which prohibit the minimization of conversion costs (i. e. the requirement for functional specifications). This inability to limit conversion costs has led the bureaucrats to choose to maintain obsolete technologies. This is not because output fails to contribute to additional discretionary budget, but because implementation costs result in a temporary, significant reduction in discretionary budget.

The emphasis on the functional specification did not begin until after the hearings associated with the passage of the Brooks Act in 1965. (See Chapter III.) Before those hearings, federal bureaucrats could expand output potential without significant conversion costs. Two characteristics appear to have defined the federal computer inventory at that time:

1. computer systems were under-utilized¹⁰³ - as would be expected if upgrades in technology were occurring early in the technology's life cycle;
2. a significant proportion of the computer systems in the federal inventory were of the latest technology.¹⁰⁴

¹⁰³ U. S. General Accounting Office, Study of Financial Advantages of Purchasing over Leasing for Electronic Data Processing Equipment in the Federal Government, (Washington, D. C., March, 1963), p. 26.

¹⁰⁴ U. S. General Accounting Office, Study of Financial, pp.12-13.

Does this mean that in 1965 bureaucrats in the federal computer services utilities preferred output over discretionary budget - but after 1965 they preferred discretionary budget over output. No - it means that prior to, and after, 1965 bureaucrats preferred discretionary budget. However, only after the rules-of-the-game resulted in significant risk to discretionary budget was the preference of these bureaucrats distinguishable. Before 1965, discretionary budget maximization was accomplished by minimizing the product related operating costs - increased potential output was an externality of that maximand.

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Ermy Z Blythe

The Maximization of Discretionary Budget:
an Explanation for the Pattern of Computer Investments
in the Federal Government

by

Earving L. Blythe

(Abstract)

This study of bureaucratic behavior is from the perspective of a particular federal government operations process - the management and delivery of computing services to the federal agencies. It supports the idea that federal bureaucrats are utility maximizers. The first of the two theories considered in this thesis is based upon William Niskanen's hypothesis that the primary objective of the government bureaucrat is to maximize the bureau's budget through the maximization of output. The second theory is based upon Jean-Luc Migue's and Gerald Belanger's hypothesis that the objective of bureaucrats is to maximize "discretionary budget" - the difference between the bureau's total budget and the cost of producing the bureau's authorized output. This thesis contends that the maximization of discretionary budget is the maximand of the federal bureaucrat evaluating the computer investment decision.