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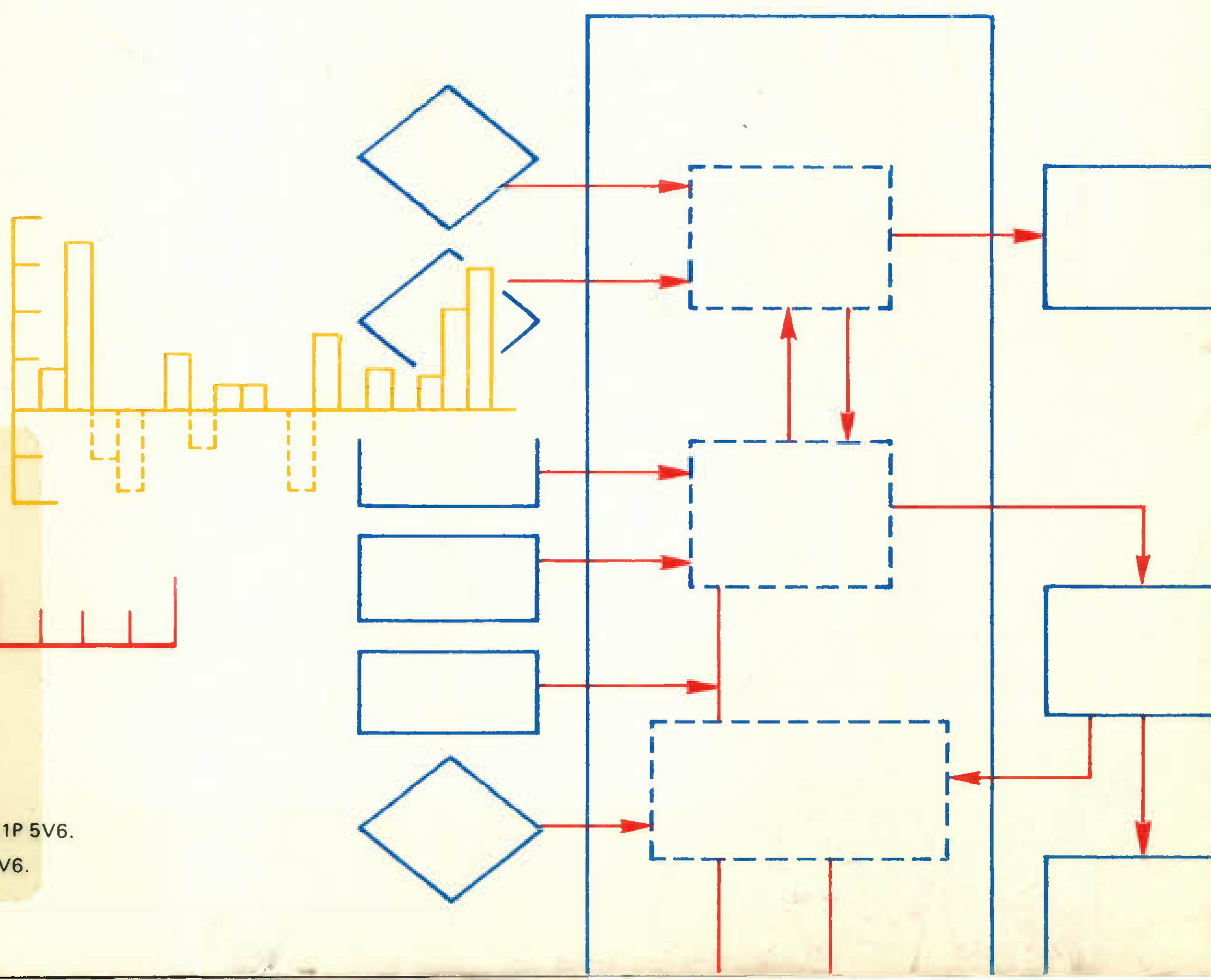

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DISCUSSION PAPER NO. 217

An Analysis of the Federal Make-or-Buy Policy

by A. B. Supapol and
D. G. McFetridge

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RÉSUMÉ

En vertu de la directive de 1972 sur la politique d'impartition, ou politique du "faire ou faire faire", toutes les nouvelles activités de recherche et de développement orientées, à l'exception de celles d'Énergie atomique du Canada Ltée, devaient être confiées par contrat à l'industrie privée. Puis, en 1977, la portée de la directive a été encore élargie afin d'englober "en autant que faire se peut" les travaux déjà en cours.

La directive donnait suite au rapport du Comité sénatorial de la politique scientifique (le Comité Lamontagne), selon lequel le Canada ne retirait pas suffisamment d'avantages de ses efforts de recherche et de développement, surtout parce que les travaux effectués dans le secteur public étaient rarement exploités commercialement. L'attribution de contrats de recherche à l'industrie rendrait le secteur privé plus conscient des possibilités d'exploiter commercialement les résultats des travaux de recherche et de développement financés par le gouvernement fédéral. Le Comité fondait son analyse sur le fait que les transferts de nouvelles technologies s'effectueraient plus facilement d'une entreprise privée à une autre, ou bien qu'une entreprise qui serait susceptible d'exploiter les résultats de certains travaux de recherche et de développement pourrait aussi se voir confier la tâche de les effectuer.

Les auteurs de la présente étude commencent par élaborer un cadre analytique qui permet d'évaluer les avantages et les coûts de l'adjudication des contrats à l'extérieur, ainsi que les motifs qui poussent à le faire. Ils tentent ensuite de déterminer statistiquement si l'esprit autant que la lettre de la directive ont été respectés. Ils ont constaté que certains ministères s'y sont complètement conformés, mais que d'autres n'en ont suivi ni l'un ni l'autre. Les auteurs recherchent ensuite les causes possibles des différences observées chez les divers ministères quant au degré d'observance de la directive.

Enfin, ils examinent les caractéristiques des entreprises qui ont acquis une certaine réputation dans les travaux de recherche et de développement, en vue d'évaluer les avantages qu'offre cette politique du "faire ou faire faire".

Les données recueillies indiquent que les ministères dont les activités de recherche et de développement offrent le plus de possibilités sur le plan commercial, et qui ont entretenu des relations étroites avec l'industrie avant 1972, n'ont pas respecté la directive. Par contre, ceux qui l'ont observée effectuaient en général des travaux de nature moins commerciale et n'entretenaient, avant la publication de la directive, à peu près pas de relations avec

l'industrie. En outre, leur façon de l'appliquer a été de conclure d'autres contrats avec les entreprises du secteur des services plutôt que de l'industrie. Il semble donc que, huit ans après, la directive ait abouti finalement à une baisse de la valeur réelle des contrats de recherche et de développement confiés à des sociétés industrielles.

Les auteurs concluent que, même si elle peut être éventuellement source d'avantages, la politique du "faire ou faire faire" n'en a pas produit de très importants jusqu'à maintenant. Ils proposent qu'elle ne s'applique désormais qu'aux ministères dont les contrats avec le secteur privé semblent devoir être profitables. En outre, il faudrait faire une étude sérieuse sur les raisons pour lesquelles ces ministères ne se conforment pas à la directive.

ABSTRACT

Under the federal make-or-buy directive of 1972, all new mission-oriented research and development, with the exception of that conducted by AECL, was to be contracted out to private industry. The directive was extended in 1977 to cover existing mission-oriented research and development "wherever possible".

The directive was a response to the report of the Senate Committee on Science Policy (Lamontagne Committee) which contended that Canada was getting an insufficient pay-off from its research and development effort principally because research and development conducted within government was seldom exploited commercially. The contracting-out of research to private industry would, in the view of the Committee, increase the awareness by the private sector of the opportunities for exploiting commercially the results of research and development financed by the Federal government. The Committee's analysis assumed either that new technologies would flow more readily from one private sector firm to another or that a firm which would be likely to exploit a given type of research and development would also be chosen to conduct it.

The study begins by constructing an analytical framework within which the benefits and costs of contracting-out as well as the incentive to contract-out can be assessed. It then attempts to determine statistically whether both the letter and the spirit of the make-or-buy directive have been adhered to. It is found that some departments have adhered to both the letter and the spirit of the directive while others have adhered to neither. The possible causes of observed inter-departmental differences in the extent of compliance with the directive are then investigated.

Finally, in an attempt to determine the magnitude of the benefits resulting from the make-or-buy policy, the characteristics of firms which have emerged as R&D contractors are examined.

The evidence assembled indicates that the departments which are engaged in R&D with the greatest commercial potential and which had histories of significant involvement with industry prior to 1972 did not comply with the directive. In contrast, complying departments were generally engaged in R&D with less commercial potential and had little or no history of involvement with industry prior to the directive. Moreover, their compliance took the form of additional contracts with service sector rather than industrial companies. The net result of eight years of make-or-buy appears to have been a decline in the real value of R&D contracts let to industrial companies.

The study concludes that, while it is potentially beneficial, the make-or-buy policy has not produced significant benefits to-date. It is suggested that the make-or-buy directive should be confined to departments in which contracting-out can be expected to be beneficial. Non-compliance by such departments should be thoroughly investigated.

INTRODUCTION

In 1972 the federal cabinet ordered that all new mission-oriented R&D funded by government departments be contracted out to industry. The new federal make-or-buy directive was a direct response to the recommendation of the Special Senate Committee on Science Policy (Lamontagne Committee). The committee argued that Canada was getting insufficient pay-off from its research and development effort and one of the reasons was that research and development conducted within government was seldom exploited commercially.

The contracting out of research to private industry would, in the view of the Committee, increase the awareness by the private sector of the opportunities for exploiting commercially the results of research and development financed by the federal government.

This study begins with a discussion of the background to the make-or-buy policy including an international comparison of the sectoral distribution of R&D activities in the advanced industrial countries.

Chapter 2 is concerned primarily with the economic foundations of the make-or-buy policy. It discusses the benefits and costs of extramural performance of government research tasks. The application of the theory of bureaus and the theory of contracts offers some insights into the impact and potential allocative effects of the make-or-buy policy.

The remaining chapters report the results of attempts to confirm empirically the propositions advanced in Chapter 2. Specifically, Chapters 3 and 4 determine statistically whether both the spirit and the letter of the make-or-buy directive have been complied with. Chapter 5 examines departmental research and development mandates and assesses their compatibility with contracting-out.

Chapter 6 measures the differences in the characteristics of the R&D operations of the departments which have complied with the directive and those which have not. The factors which explain inter-departmental differences in the extent of compliance are determined by estimating a pooled time-series-cross section model.

Chapter 7 examines the characteristics of R&D contractors which have emerged to undertake government research projects. This provides a rough indication of whether the contracting-out which has occurred is likely to generate the kind of benefits envisaged by the proponents of the make-or-buy policy.

Finally, Chapter 8 summarizes our results and discusses their policy implications.

CHAPTER 1

1.0 THE PROBLEM: TOO MUCH R&D DONE WITHIN THE GOVERNMENT, TOO LITTLE IN INDUSTRY

The Science Council[1] and the Lamontagne Committee[2] have been highly critical of the government's predominant position as a performer of Canadian research and development. They have expressed concern that, too little research and development effort is being conducted in university or industrial research establishments. In their report, the Senate Special committee on Science Policy (Lamontagne Committee) concluded that, a larger proportion of R&D was performed within the government sector in Canada than any industrialized country. It further demonstrated that federal financing of extramural R&D had been directed more towards the academic sector rather than towards the industrial sector. As a consequence, the industrial sector had remained relatively weak.[3] In their opinion, the uneven distribution of scientific performance between the federal in-house and the industrial research establishments had resulted in the selection of inappropriate research and development projects, and in inadequate exploitation of research results.[4] This criticism continues to be supported by the National Research Council of Canada, among others. On April 15, 1981, the Globe and Mail reported that, according to an official of NRC:

> An enormous pool of new technology is being created in government research laboratories that is available to industry but is not being used...[5]

At a meeting of the Air Industrial Association of Canada, Keith Glegg, Vice President of the NRC, stated that "there is a great opportunity here for commercial spin offs based on the work going on in these laboratories".[6] He further suggested that government agencies should identify and make these new technological innovations that are commercially applicable readily available to the Canadian industry.

The Lamontagne Committee believed that the performance of industrial research in government laboratories had resulted in a situation where selected R&D projects were chosen according to the individual's scientific interest rather than for possible commercial exploitation. The second volume of its report on Science Policy stated that,

> As long as there is little consultation with industry on the selection and formulation of programs, and the emphasis is on research rather than on development, research and development activities cannot be well adopted to industrial needs. A gap has developed between the results of research and the development of successful innovations. In addition, there is no effective means of transferring these results to industry.[7]

This opinion is shared by the Science Council of Canada. They have attributed the past failure of Canada Science policy to "the performance of too much basic research remote from the training of new scientists and the performance applied research far from the point of innovation."[8] A redistribution of R&D may lead to a greater R&D involvement by Canadian industry.

The Lamontagne report concluded in 1972 that it may be more difficult for the results of government intramural R&D to be exploited by the industrial sector. They have ascribed this inadequate flow of technological information to differences in attitudes and incentives of the parties involved.[9]

To help overcome these problems, the Science Council[10] as well as the Lamontagne Committee[11] advocated that industrial involvement in federal research and development activities be encouraged, by contracting out federal R&D programs, whenever the technological or innovative capacities of the companies concerned are likely to increase.

1.1 R&D PERFORMANCE BY SECTOR: AN INTERNATIONAL COMPARISON

An international comparison suggests that Canada's proportion of government-performed R&D is the largest amongst the medium and highly R&D intensive countries. The OECD's 1969 assessment of Canadian R&D activities noted that

> ...industry in Canada still does comparatively little research and development compared with industry in the other main industrialized countries.[12]

In a later report, issued in the summer of 1980, the OECD compiled statistics on R&D efforts of member nations.[13] An examination of 1977 R&D activity in Canada suggested that the federal government's share of performance continued to be significantly higher than most other industrialized nations. In Table 1, the breakdown of research and development activities in Canada as well as other OECD members, is presented. Only those countries whose Gross Domestic Expenditures for R&D is at least 1 percent of the country's Gross Domestic Product are included. The structure of the available funds shows that the amount devoted to Natural Sciences and Engineering in Canada is comparable with other OECD nations. However, in relation to the United States, Japan, Germany and other relatively R&D intensive nations, Canada seems to have an excessively large portion of its R&D performed within the government. In 1977 Canada carried out 30% of its national R&D effort in government research establishments. On the other hand, Germany, the United States and Japan had respectively, 16%, 15% and 12% of their R&D performed by the government.

When compared with other industrialized nations, the proportion of Canadian R&D performed by business enterprises is at the bottom of the international spectrum. Most OECD members with substantial R&D expenditures have more than half of their total R&D effort performed by the business enterprise sector. In the United States, Sweden and Switzerland, more than 67% of their total R&D is conducted by this sector. Contrary to the international situation, only 37% of the Canadian R&D effort occurs in the business sector.

The fraction of government-performed R&D in Canada can be decomposed into: (i) the proportion of national R&D funded by the government; and (ii) the fraction of federally funded R&D conducted by the government itself. That is

$$\left(\frac{\text{R\&D conducted by gov't}}{\text{Total R\&D}}\right)=\left(\frac{\text{R\&D funded by gov't}}{\text{Total R\&D}}\right)\left(\frac{\text{R\&D conducted by gov't}}{\text{R\&D funded by gov't}}\right)$$

Canada does not differ markedly from the U.S. and Germany in the proportion of total R&D supported by the government. It differs markedly from these two countries, however, the fraction of government supported R&D performed within the government.

In Canada, the proportion of federally funded R&D performed within the government itself in 1977 was 66.3% which was well in excess of the U.S., Switzerland, Sweden and Germany which averaged 32%.

The apparent rationale of the make-or-buy policy was to bring the proportion of government funded R&D conducted within the government into line with that of the major OECD countries.

Table I

	Australia	Belgium	Canada	Denmark	Finland	France	Germany	Italy	Japan	Netherlands
GERD										
% GDP	1.0	1.3	1.0	1.0	1.1	1.8	2.1	1.0	1.9	2.0
Sector of Performance %										
Business	24.8	67.9	37.3	49.1	51.9	60.3	65.0	53.6	57.8	51.7
Government	50.9	11.4	30.3	21.7	26.3	22.3	16.1	24.6	12.1	20.8
Source of Funds %										
Government	54.1	-	45.7	27.7	30.5	37.7	44.2	47.8	16.2	22.7
Government Performance (Of gov't. funded R&D)	94.0	-	66.3	78.3	86.2	59.2	36.4	51.1	74.7	91.6

	Norway	NSE Only Sweden	Switzerland	United States
GERD				
% GDP	1.4	1.9	2.3	2.4
Sector of Performance %				
Business	47.1	71.0	75.7	66.8
GOvernment	18.4	8.6	6.8	15.3
Source of Funds %				
Government	33.5	25.6	21.1	51.0
Sector of Performance (Of gov't. funded R&D)	54.5	33.6	32.2	30.0

Science Resources/Newsletter No. 5 Summer 1980.
OECD/DSTI "Science and Technology Indicators" Unit

Resources devoted to R&D in 1977 (Natural Sciences & Social Sciences)

CHAPTER 2

2.0 POLICY RESPONSES

To improve the scientific capability of the Canadian industrial sector, the government has enacted, over the years, numerous programs to provide an environment more conducive to industrial R&D. The major programs include the 'Make or Buy' policy, a contracting out policy for research with definite goals; the technological transfer programs, such as the Pilot Industry-Laboratory Program (PILP) formulated to assist in the application of government research and help Canadian companies recognize specific industrial opportunities arising from government in-house R&D efforts; and finally, the federal industrial assistance programs, a set of policies intended to increase incentives to private R&D.

2.1.1 The Make-or-Buy Policy

The Make or Buy policy was enacted in 1972 in direct response to the Lamontagne's recommendations. The need to direct government procurement in research and development toward the enhancement of the country's industrial technology base had been recognized earlier by the Glassco Commission and was later emphasized by the Lamontagne Committee and the Science Council. It was anticipated that the contracting out policy would shift government effort in research and development to the industrial sector, increasing both its scientific capability and its general performance. It was also hoped that it would increase the probability of sufficient exploitation of technology, and ensure a greater chance of economic spin-offs from government R&D.[14]

2.1.2 PILP

The second program designed to shift research and development activities from government laboratories to other sectors in the Pilot Industry-Laboratory Program (PILP), administered by the National Research Council.[15] This program provides funds to be used in helping Canadian industry to exploit NRC research commercially. This support is given in the form of contract or research agreement. Other efforts by the NRC to improve technology transfer between sectors include the establishment of the Industrial Program Office - a body designed to expedite the evaluation of unsolicited proposals, and the expansion of the NRC's Technical Information Services.

2.1.3 Industrial Assistance Programs

The industrial assistance programs are comprised of a number of subprograms, three of which will be discussed here.

In 1959, the ITC initiated the Defence Industry Productivity Program (DIP) to provide financial support to industrial firms involved in R&D related to the defence industry.[16] Following the removal of the Defence Industrial Research (DIR) program in 1970, the DIP program was expanded to include the applied research projects which were previously covered by the DIR program.[17]

Beginning in 1965, the department of Industry, Trade and Commerce was given the responsibility for the program for the advancement of industrial technology known as PAIT.[18] This was followed by the Industrial Research and Development Incentive Act (IRDIA) in 1967.

There are many other policies covered by the federal industrial assistance programs but only the major initiatives mentioned above will be briefly discussed in this paper.

In 1959, Cabinet approved a program to subsidize R&D activities in defence related industries known as the Defence Industry Productivity (DIP) program. The program was to be administered by ITC, was directed specifically at developing and sustaining the scientific capability in the Canadian industrial sector for the purpose of defence export sales or civil export sales. "A DIP subsidy generally takes the form of a grant of as much as 50 percent of the direct cost plus the overhead assignable to approved projects" (McFetridge, p. 57).[19]

The program for the Advancement of Industrial Technology (PAIT) was established earlier in 1965. It was intended to increase Canadian competitiveness in the international market by, initially, providing forgiveable loans to finance product and process development in the non-defence industry. The scope of the program was further augmented by a subsidy arrangement to support product and process development projects, in the area of advanced technology. A maximum grant of 50 per cent of current expenses plus overhead is available to all companies incorporated in Canada. R&D results may be exploited domestically or internationally, however, the manufacturing base is required to be in Canada[20] (McFetridge, p. 56). In 1977, the government incorporated the PAIT program with several non-research and development subsidy programs. The combined program is known as the Enterprise Development Program (EDP).[21]

The Industrial Research and Development Incentive Act (IRDIA) was designed to increase Canadian business' scientific efforts in areas where possible benefits to Canada may be realized. Generally, the policy objectives were to increase scientific capability within the Canadian business sector and to promote greater interaction between university and industrial research establishments. The program provides direct subsidies or tax credits for capital or current R&D expenditures. The IRDIA program was replaced by an R&D allowance system in 1978.[22]

Under the new program, R&D performing firms are entitled to "deduct 50% of the increase in their current research and development expenditures over the average of the preceding three years from their taxable income"[23] (McFetridge, p. 270). This new program allowed potential recipients to by-pass bureaucratic discretion associated with the former subsidy program and automatically credit their scientific efforts by completing their tax returns.[24]

To conclude, in its attempt to increase the fraction of the national R&D effort performed within industry, the government of Canada has relied, first on industrial R&D subsidies and, second, on a contracting out policy known as the make-or-buy policy. More recently it has attempted to increase the extent to which R&D conducted within the government sector is exploited by industry by assisting the process of transferring technology between these two sectors.

2.2 ECONOMIC IMPLICATIONS OF THE MAKE OR BUY POLICY

2.2.1 Benefits of Contracting Out: Introduction

The reliance on subsidy programs to encourage R&D activity in the industrial sector may not result in a sufficient increase in the proportion of national R&D effort performed by industry. Subsidy programs such as PAIT (now EDP) and DIP make private R&D activities more profitable. They raise a firm's rate of return from scientific investment through cash grants and tax credits.[25] However, a subsidization of projects that a firm had already decided to undertake, would not significantly affect the total amount of privately-performed R&D. The intensity of private R&D performance may be slightly increased if a subsidy is awarded in support of extra-marginal projects (i.e., projects that would not have otherwise been adopted).[26] On the other hand, by shifting part of the federal R&D effort out of government laboratories into industrial research establishments the Make or Buy Policy exerts a direct effect on the sectoral distribution of R&D performance.

In addition, contracting out places the production of new technological information in the hands of those who have a financial incentive to disseminate it. It therefore reduces the need for explicit technology transfer programs such as PILP. The Make or Buy policy lends itself to an increased potential for the efficient absorption of new technology, a greater rate of technological diffusion, and a larger probability of economic spin-offs.

Many successful innovations and inventions resulting from intramural R&D have not in the past, been fully exploited by the private sector. The main reasons for this situation according to the Lamontagne Committee are: (1) Firms are not aware of the government's activities and existing scientific opportunities, and (2) many developments resulting from federal laboratories are not suitable for commercial exploitation.[27] They suggest that greater industrial involvement be encouraged by contracting out federal programs whenever it is possible and feasible.[28]

By increasing interaction between government agencies and Canadian industry, a stronger informational link can be forged. This would indirectly increase the private sector's awareness of the opportunities for exploiting commercially, the results of federally financed R&D.[29] An information bridge would allow for increased knowledge by government science bodies of the continuously changing market conditions and increased awareness of scientific and technical requirements in private industry. An improvement in the degree of co-operation between the two sectors may lead to a more prosperous climate for the development of better products and production processes.[30]

During the course of its investigation, the Lamontagne Committee repeatedly emphasized that government should allocate more of its R&D activities into the manufacturing sector. Also, implicit in the committee's recommendation of 1972 is the assumption that a private firm likely to exploit a given type of research and development would also be the one chosen to conduct it. The policy although universally applied, is mainly designed for the manufacturing and service industries. The Department of the Environment stated to the Senate Committee in 1976 that

> the research and development with which the federal make or buy policy as a whole is concerned is mostly that which will lead to better products and techniques that can be sold on a wider market, and the 'industries' that are expected to benefit are very largely the manufacturing and services industries.[31]

The Committee had intended that appropriate performer selection would result in greater industrial spin offs. In view of this, the most desired recipients for federal R&D contracts would be manufacturing firms.

2.2.2 Benefits of Contracting out When Contractors are Also Potential Users:

Consider the situation of a private contractor performing federal mission-oriented R&D. The project is complex and as a consequence, the contract is not fully specified. By-product development may lead to a patentable and commercializable innovation. There is a greater probability that potential by-product innovations will be detected if the potential user of R&D results were also the performer. Because contractors are often given the proprietary rights (although non-exclusive) to the invention they were contracted to produce as well as any by-products, and because private contractors are profit-oriented and are directly rewarded for marketable innovations, they would have greater incentive to maximize all opportunities for turning research results into commercial advantage. In contrast, the commercial possibility would be of secondary importance to government researchers[32] (Vol. II, 586). The Lamontagne Committee also noted that

> The differences in behaviour standards imposed by government and industry indicate why the government sector is naturally more inimical to inventions and innovations aimed at the private market than is industry. These provide another reason for transferring industrial R&D programs out of government laboratories and into the private sector[33] (Vol. II, 588).

Benefits from R&D may also be better realized by private firms because the latter have better market information. The foregoing assertions can be summed up by what the Canadian Chemical Producers' Association pointed out to the Lamontagne Committee.

> ...the conduct of research on the scene of business operations provides the likeliest environment for the recognition and exploitation of commercially valuable 'fall-out', whether from basic or applied research.[34]

The justification for greater economic spin-offs is based on the implicit assumption that, the contractor chosen to provide scientific services to a department would be more likely to commercially exploit the new knowledge, domestically and internationally. Would there be the same incentive to detect any marketable 'fall out' from R&D if the contractor was not the one who can appropriate such valuable results? In this case, would it not be more efficient to carry out R&D intramurally and then transfer the findings to the appropriate firms?

2.2.3 Benefits of Contracting out when Contractors are not Potential Users:

Suppose R&D is contracted out to a firm which was not a potential user of the technology produced. In this case there are three parties involved. The government which commissions the R&D, the contractor who performs it and a third firm or set of firms which exploit the R&D. Two sets of contractual arrangements must be negotiated and enforced. There will be an agreement between the government and the R&D performer and another agreement between the performer and the user of the R&D. This has the obvious effect of raising the cost of contracting out relative to that of intramural R&D performance.

Although its advantage will be reduced, contracting-out may continue to be preferable to intramural performance. The reason is that while the contractor is not the ultimate user of the R&D, the former continues to have a commercial incentive to detect and find potential users for by-product innovations. As has been argued above, government researchers have no such incentive.

The importance of the commercial incentive for a private contractor to detect and find users for R&D it performs will be smaller the more costly it is to reach and enforce the appropriate contractual arrangements with these users. Thus the potential advantage of the make or buy policy depends on the cost of contracting, first, between the government and the R&D performer and, second, between the performer and the potential users of R&D. There may be cases in which the cost of contracting at either or both stages is such that there is no advantage to contracting out. It is to the discussion of the circumstances under which this might be the case that we now turn.

2.2.4 The Costs of Contracting:

In the simplest terms the contracting-out policy involves the replacement of non-pecuniary with pecuniary incentives. R&D contractors have a pecunlary incentive both to orient research along commercially exploitable lines and to exploit or facilitate the exploitation of all research they conduct.

Government researchers have no such incentive. This has been noted above. What has not been noted is that, while the government researchers have no pecuninary incentive to enhance the commercial results of their work, they also have no pecuniary incentive to mislead those who have commissioned the research or to engage in other types of opportunistic behaviour.

Thus, while there are clear and widely noted disadvantages associated with performance of R&D within the government, there are also some clear but perhaps less widely noted advantages. The implication is that contracting-out will be advantageous in some situation and not in others. There will be cases in which an increased reliance on pecuniary incentives reduces the cost of transacting that is, of getting the research done and exploited. There will also be cases where increased reliance on pecuniary incentives increases the cost of transacting. Can we distinguish ex ante one set of circumstances from the other?

Williamson (1975)[35] has suggested three environmental factors which combine to make reliance on pecuniary incentives (contracting-out) especially costly. He argued that where information relevant to transaction is costly and unequally distributed, where events bearing on the obligations of the transacting parties are not known with certainty and where irreversible commitments are required of the transacting parties, reliance on pecuniary incentives will increase the cost of transacting.[36]

Williamson's reasoning is well-known and need not be repeated here. What is important for present purposes is that Williamson's approach implies that contracting-out is less likely to be advantageous: (a) the more costly it is to determine the extent to which research objectives have actually been met; (b) the greater the possibility that unforeseen events will impair the performance of the contract and the greater the cost of determining the extent to which it was these events rather than the malfeasance of the contractor which impaired performance; and (c) the greater is the extent to which the government and the contractor lock themselves into a bi-lateral monopoly situation as a result of their agreement.

The cost of measuring research performance will be lower in cases where the research objective is to produce a specific technology the success of which can be determined by inspection. The research required to produce a new artillery shell can be deemed not to have been performed if the shell will not explode.

At the other pole is the case of experimental research. Were the tests which the contractors claimed to perform actually performed? Were they performed as described? The validity of experimental results cannot be determined simply by reading them. Their validity can be determined only by replication or by inspection and supervision both of which are costly.

The problem posed by uncertainty regarding the circumstances under which a research task is to be carried out will be more severe the more advanced is the research relative to the state of the art. In cases where the technology involved is well-known, there will be little in the way of disputes regarding responsibility for any failure to meet research objectives. Where the properties of the technology are not well known it will be costly to assign responsibility for failures to perform.

In the case of highly complex advanced research it is likely that as research proceeds, research objectives will change. This will require a renegotiation of the governments contract with the research-performing firm. This renegotiation will be more costly if by virtue of their specialized and irreversible commitments the government and the R&D contractor would find it costly to turn to alternative suppliers and buyers respectively. This kind of bilateral monopoly problem whether ex ante or ex post is generally solved by the internalization of the transaction.[36] In the present context this implies intramural performance of the research.

In sum, the transaction cost literature would suggest that it will be advantageous to contract out research tasks where: (a) the objectives can be clearly specified and where performance can be readily measured; (b) the technology involved is relatively well known; and (c) where the research does not require a significant investment in specialized facilities.

It will be advantageous to perform intramurally research tasks where: (a) the objectives are general rather than specific; (b) where performance is costly to measure; (c) where the outcome of the research is subject to considerable uncertainty; and (d) where significant specialized facilities are required.

2.2.5 The Social Gain From Contracting Out: A Summary

The preceding discussion implies that the social net benefit of R&D carried out under contract can be written as

$$SC = GI + (1+a)BI - c(R) - c(C)$$

where GI = present value of the gross social benefit on new technology to which government has title.

BI = net income accruing to the contractor as a result of spin-off innovations.

a = value of inappropriable benefits on spin-off innovations ÷ BI.

c(R) = resource cost of conducting the R&D specified in the contract.

c(C) = costs of contracting.

The net social benefit of R&D carried out within the government is

$$SG = GI - g(R)$$

where g(R) = resource cost of conducting a specified R&D project.

Contracting out is socially beneficial provided

$$(1+a)BI - c(C) - (c(R)-g(R)) \geq 0$$

or if $(1+a)BI + (g(R)-c(R)) - c(C) \geq 0$

In the simplest terms, contracting out is socially beneficial if the spin-off benefits (which would not be realized under intramural performance) plus the excess of the cost to the government over the cost to the contractor of performing the research task exceeds the cost of contracting. If the government and the contractor can perform the research task at the same cost, contracting out is socially beneficial if the total spin-off benefits (both appropriable and unappropriable) exceed the cost of contracting.

2.3 THE INCENTIVE TO CONTRACT OUT

2.3.1 The case of an agency which minimizes the cost of performing a given set of research tasks

Using the terms defined in Section 2.2.5, the cost to the government of performing a given R&D task intramurally is g(R).

The cost to a contractor is c(R). Assume for the moment that these two are the same.

Suppose the R&D task is contracted out. What is its cost to the government? Its cost will be the contract price, P, plus the government's share of the cost of contracting $\phi c(C)$.

The contract price may be determined in a variety of ways. If the contract is up for competitive bidding, the winning bidder will quote a price which just exhausts any rents resulting from the performance of the contract. This "zero-profit" price will be

$$P = c(R) - BI + (1-\phi)c(C)$$

Thus, with competitive bidding the contract price will equal the cost to the contractor of conducting the research task plus the contractor's share of the cost of contracting less the net income accruing to the contractor from spin-offs. The existence of spin-off income makes the contract more valuable to potential contractors and this is reflected in their bids.

Given a contract price, P, the cost to the government of R&D performed extramurally is

$$P + \phi c(C) = c(R) - BI + c(C)$$

The cost to the government of R&D performed extramurally will be less than the cost of the same project performed intramurally if the present value of privately appropriable spin-off benefits exceeds the cost of contracting and if the value of the latter is reflected in the winning bid.

A government agency which has the objective of minimizing cost subject to the constraint that a given number of R&D tasks be completed will choose extramural performance whenever

$$g(R) > P + \phi c(C)$$

or $$g(R) > c(R) - BI + c(C)$$

If $g(R) = c(R)$ a cost-minimizing bureau will contract out whenever appropriable spin-offs exceed the cost of contracting, that is when

$$BI > c(C)$$

While a bureau which has been instructed to minimize cost subject to a research performance constraint will contract out in the absence of explicit instructions to do so, it will not push contracting out to the point required for the maximization of social net benefits. That is, the marginal project performed extramurally will be such that appropriable spin-off benefits are just equal to the cost of contracting.

$$BI^* = c(C^*)$$

The net social value of spin-off benefits on this project will be $(1+a)BI^*$ so that in cost minimizing equilibrium the social net benefit of spin-offs will exceed the cost of contracting

$$(1+a)BI^* > BI^* = c(C^*)$$

The implication is that the social net benefits of contracting out will not be fully realized even by a cost-minimizing government agency. This conclusion is stronger the smaller is the extent to which appropriable spin-off benefits influence the bid prices of potential R&D contractors.

2.3.2 The Incentive to Contract Out: The case of a utility maximizing government agency.

The objective of this section is to examine the contracting-out decision within the context of a model which assumes that bureaucrats maximize utility rather than minimize cost. We then compare the contracting out decisions of cost-minimizing and utility maximizing government agencies.

Suppose the bureaucrat's utility depends on (1) staff size and (2) number of R&D projects. The determination of the combination of staff and projects contracted out which will yield the highest utility level given the relative costs of intramural and extramural R&D performance is reported in Appendix A.

If we assume as before that the contract price is given by the "zero-profit" price and the cost of performing R&D intramurally is the cost of resources required for the specified R&D project, a government agency which has the objective of maximizing its utility subject to the departmental budget constraint will exhaust its staff option whenever the contract price is greater than or equal to the cost of intramural performance. That is, the "all-staff" option will be chosen whenever

$$g(R) \leq c(R) - BI + C(c)$$

This is hardly surprising since the bureaucrat has nothing to gain and something to lose if he decides to employ outside contractors.

The bureau's choice is not so clear, however, when the submitted contract price is less than the cost of performing the research task in house.

While a bureau which has the objective of minimizing cost subject to a given number of R&D tasks will choose an all-extramural performance option whenever $g(R) > c(R) - BI + C(c)$, the utility maximizing bureau will, in general, prefer a combination of some staff (i.e., intramural projects) and some extramural projects given the same relative cost of carrying out R&D.

It is nevertheless possible for a bureau which is maximizing utility to choose an all-extramural option. This conceptual possibility is ruled out only if we assume that staff is indispensable in the bureaucratic utility function.

In the case where the main objective of the bureau is to minimize costs, we found that, in equilibrium, the social net benefit of spin-offs is greater than the cost of contracting out. Even a cost minimizing agency will not fully realize the social net benefits of contracting out.

Similarly, a utility maximizing government bureau without explicit instructionsto contract-out will not contract-out to the point where net social benefits are maximized. More importantly, the utility maximizing bureau will not, in general, push contracting out as far as will a cost minimizing government agency. As a consequence, there is an even greater divergence between the contracting behaviour of utility maximizing bureau and the behavior which maximizes social net benefit.

The implication is that the stronger the bureaucratic preference for intramural performance the larger is the gap between the bureau's effort to contract out and the effort required to maximize the net social value of spin off benefits.

Bureaucratic utility maximization provides an additional reason to expect that a make-or-buy directive which involves explicit instructions to contract out might be socially beneficial.

2.4 Conclusion

In this chapter, we have argued that the make or buy policy may be socially beneficial where: (a) only a fraction of the net value of social spin-off benefits is appropriable; (b) the appropriable spin-off benefits are not fully reflected in bid prices of potential R&D contractors; and (c) the government agency's primary objective is to maximize utility rather than minimize cost.

It is essential to recognize that, while a make or buy directive is potentially beneficial, its "universal application" may be ill-advised. In general, it will not be efficient to force contracting-out of research tasks on all departments to the same extent. A universal contracting out rule may waste resources. The reason is that the factors which determine the net benefit of contracting-out will be present in different degrees in each department. Specifically: (1) contracting cost will vary across departments and will depend upon the nature of R&D conducted; (2) the value of social benefits from spin-offs may differ; (3) the inappropriable fraction of spin off benefits may be different for each department; and (4) the objectives and incentives of government bureaucrats may differ from department to department.

To illustrate, let us consider two extreme cases: (1) where the government agency's objective is to minimize cost, and the net social value of spin-off benefits is fully appropriable and is fully reflected in the bid price of the winning R&D contractor; and (2) where the government agency's central motive is to maximize utility, a large fraction of net social benefit is not capturable and contract prices do not reflect spin-off benefits appropriable by the contractor.

In the first case, the agency would already be contracting out sufficiently to maximize social net benefits. Hence the make or buy policy is redundant. It may even be considered "harmful" to the extent that it forces contracting out beyond the point at which social benefit is maximized.

In the second case the make or buy directive may be regarded as socially beneficial. It is the departments which are in situations such as that described in this case upon which the make or buy directive should be brought to bear.

In general, the departments with high contracting costs and minimal potential spin offs will not be observed to be contracting out in the absence of a make-or-buy directive. The application of a make or buy directive to them will waste resources.

If it is the case that spin-offs can be more readily exploited within the context of a manufacturing firm, departments dealing with research of interest to the secondary manufacturing sector would be more likely to have contracted-out in the absence of the make-or-buy policy. While there may be come marginal benefit resulting from the application of make-or-buy to such departments, the directive will be at least partially redundant and may even be harmful.

Departments undertaking research tasks that are relatively more advanced would likely find it difficult to contract-out because of high contracting costs. This may also be true for departments engaging in curiosity-oriented and experimental research. In the absence of explicit instruction to do so, these departments would not have contracted-out their research tasks. The application of make-or-buy to these departments is also potentially harmful.

The implication of our analysis is that evaluation of the make-or-buy policy requires more than the determination of the extent of bureaucratic response to it. The ultimate success of the policy also depends on the characteristics of both the dpeartments which have responded and the firms with whom they have contracted.

CHAPTER 3

3.0 THE POLICY

The Make or Buy policy, enacted in 1972, stated that all new mission-oriented research and development in the natural sciences should be contracted out to Canadian industry. Mission-oriented research and development is defined as "research and experimental development, minus free basic research, plus feasibility studies". The directive applies to all departments and agencies listed in schedules A and B of the financial Administration Act.[37] Not included in the policy were on-going research and development projects and new or existing research and development activities of some government departments (e.g., AECL, ITC).

In 1974, the policy was extended to cover unsolicited proposals from the private sector in support of government science objectives. The contracting-out procedures are carried out and managed by the Department of Supply and Services on behalf of the departments involved.[38]

The Make-or-Buy policy was subsequently expanded to include some new and on-going R&D, as well as other scientific activities. In addition, the unsolicited proposals program was broadened to include projects deemed to satisfy priority science and technology requirements in general, and not only those in support of departmental science missions.[39]

3.1 Previous Analysis

Aside from Peter Meyboom's article in 1974 and a later effort by MOSST in 1975, to-date there has been no extensive economic analysis of the Make or Buy policy.

In his 1974 article, Peter Meyboom examined the trend of intramural research versus industrial contracts and concluded that over the fiscal years 1966 to 1974, the gap between in-house and industrial R&D contracts has widened significantly.[40] Aggregating the five major science departments, Meyboom found that the combined estimates showed that the ratio of intramural to industrial contracts expenditures has risen from 5:1 to 9:1. He further asserts that the momentum created by the earlier growth in the in-house science expenditures had inhibited industrial involvement. In spite of these findings, Meyboom concluded that the policy was being implemented and that the first year of implementation was successful. Recognizing the apparent inconsistency of his analysis and his conclusions he also noted that

> The true purpose of the policy - to enhance the scientific and innovative capability of Canadian industry - can only be achieved over time, and only with significant inflows of money...The most important contribution towards that goal will come from the science budget, its size, its make-up, and its disposition.[41]

The second effort to evaluate the Make-or-Buy policy was by the Ministry of State for Science and Technology in 1975. The Ministry concluded that the industrial share of government research had increased from 4.4 percent to 12.9 percent over the preceding five years (i.e., 1970-75).[42] However, the report also showed that the fraction of R&D contracted to industry was generally higher in the 60's. MOSST analysts found that after removing the effect of increased salaries of government scientists, the actual increase in expenditures on R&D by eleven government departments was about the same as the amount awarded to industry under the make or buy policy. This seems to imply that virtually all new money has been contracted out and that departments are adhering to the directive.[43] The MOSST assessment was summarized by McFetridge (pp. 266-67) who concluded that:

> The Make or Buy directive may well have been adhered to as the MOSST report concluded. Given its limited scope, however, the implementation of the directive could not and, indeed, did not result in any significant change in the fraction of federal research and development activities, taken as a whole, which were conducted extramurally.[44]

Both Meyboom and the MOSST analysts agree that the Make or Buy policy was implemented. However, there are several reasons why a more comprehensive exploration of the Make or Buy policy is called for. First, previous studies were superficial in terms of the methodology employed. Second, the studies were conducted using only preliminary statistics. It was simply to early to judge the effectiveness of the policy. Third, since the initial directive in 1972, the Make or Buy policy has been changed in several respects and this may have added to its impact.

3.2 Fraction of R&D Payments to Industry: 1963-80

As a preliminary to the main empirical study, some important descriptive data should be presented. In Table II, the trends in the proportion of R&D contracted out to Canadian industry by the seven major R&D performing departments are reported.[45] Some indication of the success of the Make or Buy policy to-date can be obtained by examining the expenditures on R&D directed to the industrial sector as a fraction of the total current R&D expenditures in natural sciences. The seven relevant departments are the Departments of Agriculture; Energy, Mines and Resources; Environment (including Fisheries and Oceans); National Health and Welfare; National Defence; Transportation and Communications.

Without performing a rigorous statistical analysis at this stage, the data in Table II seem to indicate upward trends in the proportion of R&D contracted to industry in the Departments of Agriculture, Environment, National Health and Welfare, and Transportation. Although these time series data suggest that these departments are moving in accordance with the directive, the Departments of Agriculture and National Health and Welfare still allocated less than 1.3% of their 1980 current R&D budget to the industrial sector. The trends evident in Environment and Transportation are positive but modest and the fraction of R&D contracted to industry relatively volatile.

No discernible trend is evident for National Defence, Communications nor Energy, Mines and Resources. The Department

Table II

PROPORTION OF R&D CONTRACTED TO INDUSTRY BY PERFORMERS IN NATURAL SCIENCES

Department	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
									%									
Agriculture	0	0	0	0	0	0	0	0	0	0	0	0.05	0.27	0.48	0.65	0.93	1.62	1.29
Communications	0	0	0	0	0	46	37	35	44	58	59.0	44.0	38.9	20.0	13.9	12.6	36.3	34.9
E.M.R.	0.3	0.18	0.00	0.5	0	1.4	0.6	3.4	9.8	9.5	10.5	4.3	5.1	8.3	10.3	9.7	8.8	7.5
Environment (F.O.)	0	4.1	8.4	3.8	1.0	0.2	1.4	0.7	1.4	1.4	6.16	4.66	5.28	5.65	6.87	7.11	12.4	12.36
N. Defence	20.7	34.5	49.5	38.7	32.7	32.7	27.2	20.5	21.0	20.9	17.2	19.1	22.3	20.2	19.0	24.1	30.5	30.2
N.H.W.	0	0	0	0	0	0	0	0.24	0.36	0.28	0.21	0.43	0.26	0.31	0.42	0.72	0.46	0.54
Transportation	0	5.9	1.6	12.7	19.3	12.5	34.4	10.6	18.98	19.9	56.3	27.7	35.9	38.8	58.95	46.8	42.2	33.1

NOTE: Calculated by $\left(\frac{\text{Payments to Industry}}{\text{Total Current R\&D in Nat. Science}}\right) \times 100$

of National Defence had generally higher fraction of their R&D contracted out prior to the policy in 1972, and had actually reached a peak in 1965, when 49.4% was allocated to industry.

Including the Communications Technology Satellite Program, research contracted to industry in communications rose to the maximum of 59.5% in 1973. However, during the fiscal years 1974-78, Communications experienced a drastic decline in this proportion, reaching a minimum of 12.6% in 1978. Although both National Defence and Communications exhibited generally lower proportions contracted out in the 70's than in the 60's, they seem to have been affected more than EMR, NHW and MOT, by the revision of the Make or Buy policy in 1977. In 1979 and 1980, both departments showed moderate increases in the proportion of R&D expenditures contracted out.

In 1971, Energy, Mines and Resources' total expenditures directed to industry were approximately 3 million dollars, and in 1980 were about 10 million dollars.[46] In nominal terms, it seems that EMR has more than tripled its involvement with the industrial sector; but, when we look at the relevant fraction, it has actually declined.

In sum, a naive examination of the evidence suggests that the departments which adhered most clearly to the make or buy directive, Agriculture and National Health and Welfare, are also the departments which have done and continue to do relatively little R&D contracting. There was no apparent response among departments which had a relatively significant involvement with private

R&D contractors prior to the implementation of the policy.

This examination of the proportion of departmental R&D expenditures contracted to industry has not been and cannot be conclusive. This fraction is subjected to random variation and, perhaps to systematic variation resulting from other changes in the environment.

In order to determine whether observed changes in the fraction of departmental R&D contracted to industry are systematically related to the issuance of the make-or-buy directive, a fully specified statistical model is required. A discussion of this model appears in the next section.

3.3 Statistical Analysis: Payments to Industry

The purpose of this section is to determine statistically the extent, if any, to which the make or buy directive has been complied with.

Our empirical analysis takes the form of a time series regression model in which the fraction of R&D contracted to industry is the dependent variable. If the policy has been implemented, the dependent variable will follow a positive linear time trend beginning in 1973.

The data used in this analysis were annual data from 1963 to 1980. Regression equations are estimated by Ordinary Least Squares and the Cochrane-Orcutt method. Each department was considered separately. However, the foregoing methods of estimation may not be desirable for those cases in which the dependent variable does not satisfy the assumptions of the general linear model. Here, the variable to be explained is expressed as a proportion which is restricted to values between zero and one. James Tobin (1958) has suggested a more appropriate method of estimation for such limited dependent variables known as TOBIT.[47] The multiple regression model may be applicable when observations are not concentrated around the limits or when limiting observations can be omitted from the sample without seriously reducing the sample size.

The dependent variable takes on the limiting value of zero for several years in the case of both the Department of Agriculture and the Department of National Health and Welfare. In both cases TOBIT estimation is employed.

The single equation statistical model adopted is expressed as below:

$$\left(\frac{I}{R}\right)_t = \alpha_0 + \alpha_1 TD_t + \alpha_2 G_{-1_t} + \alpha_3 TD_t{*}G_{-1_t} + u_t$$

where I = total expenditures on R&D in natural sciences contracted to industry plus total expenditures on feasibility studies contracted to industry.

R = total current real expenditures on R&D in natural sciences.

TD_t = 0 prior to the implementation of the policy

= 1 the year the policy was implemented and increasing linearly with time thereafter.

G_{-1_t} = Real growth in the department's science budget and is calculated by dividing present year's total real current R&D expenditures by last year's total real current R&D expenditures. That is,

$$RR/RR_{-1} \text{ where } RR = \frac{\text{total current R\&D expenditures}}{\text{government services price deflator}}$$

u_t = Random disturbance.

The variable (I/R) represents the proportion of federal R&D contracted to Canadian industry. It takes on the value of zero for the years when no-mission-oriented R&D was contracted out. The maximum value for (I/R) is one. This represents the hypothetical case of no mission-oriented R&D being carried out intramurally.

3.3.1 Time Dummy Variable

An important feature of this time series model is the cumulative time dummy. The policy dummy, TD, takes the form of a linear time trend. Implicit here is the assumption that the dependent variable is increasing continuously over time but at a decreasing rate. Although this may not be suitable over a long period, it is an adequate approximation over short periods.

While a constant growth rate model might be a superior specification, it is precluded here by the zero value which is often taken on by the dependent variable.

Two different years were proposed as to when the initial effects of the policy would be evident. Peter Meyboom asserted that

> ...contracts are being awarded daily, and one can conclude that the policy is indeed being implemented. In fact, if we confine our attention to new money and discount for inflation, it can be estimated that the $18.8 million that was contracted out in fiscal year 1973-4 represented virtually all new money that was available for R&D in that year. The first year of implementation was therefore successful (p. 585).[48]

On the other hand, Statistics Canada suggested,

> Because the 'Make or Buy' policy applies only to new federal R&D programs or additions to existing programs and due to the length of the budgetary cycle (2 year minimum), the impact of this policy is not expected to be known before the 1974-75 fiscal year (1974, Federal government Activities in the Natural Sciences, p. 31).[49]

In light of the two sources mentioned above, both years were tested.

Estimated responsiveness to the 'Make or Buy' policy by departments may be obtained by the coefficient of the policy variable (TD). The magnitude of the department's response is reflected in this coefficient. Its Student -t statistics determine the significance of the time trend. In the case where the interaction term (G*TD) is included, the combined influence must be considered. That is, the departmental marginal response for a given growth rate is partly represented by the coefficient of the interaction term.

3.3.2 Growth Variable

The amount directed to industry relative to total current expenditures, depends, in part, upon the behaviour of the departmental science budget. One would expect a positive relation between the growth rate of the departmental science budget and the proportion contracted out for two reasons. Firstly, when a department experiences a growth in their science budget, it is faced with the choice of whether to enlarge their research facilities or to contract out. The costs of adjustment to an increased demand for scientific activity may be large if the department decides to establish new research facilities and to search for and train additional researchers. It could be less costly if the department adjusts to this higher budget by using established research facilities in the private sector through contractual arrangements. Furthermore, a department may be required to perform to scientific investigation within a time constraint, in which case it would be more inclined to utilize any available scientific capability of the private sector.

Second, the departmental cost of response to a variable budget could be reduced if contractual arrangements were employed. That is, a department may view its budgetary growth as transitory and may therefore be hesitant to enlarge its research capacity.

It may be costly for a department to acquire additional scientific resources for use during peak periods, and then to maintain them as idle resources during off-peak periods. Moreover an institutional constraint also restricts the employment of government scientific resources during off-peak periods. In the private sector, in contrast, a firm can even out a fluctuating demand for R&D by seeking research contracts with other firms.

Given the costs of adjustment and the cost of response to transitory budget increases, one would expect the proportion of extramural R&D contracted to industry to vary directly with the departmental growth rate.

3.3.3 Multiplicative Growth Variable

It is not unreasonable to expect that the department's willingness and/orability to comply with the directive is also a function of growth.[50] In the absence of real growth in science funds, the full brunt of the policy would be borne by intramural scientific staff. A plausible reaction of government bureaucrats would be to resist the policy.

In addition, since the initial phase of the make or buy policy covered only 'new R&D' or 'new money', long delays in policy response would be expected with slow budgetary growth.[51]

Departments with different growth rates will respond differently to the policy, and departments which respond differently to the directive will also respond differently to a change in the growth rate. To allow for the interaction effect between these two variables, the multiplicative growth term is introduced into the model. This interaction term will measure the additional effect of the combined influence of growth and the make or buy policy. Multicollinearity between the interaction term and each of the explanatory variables is likely and therefore, the standard t-test may not be appropriate. A special test will be used to determine whether or not the joint effects of the policy and departmental growth are statistically significant.

3.4 Statistical Results

The detailed results of the statistical analysis of the 1963-80 period are presented in Appendix B. They include both the case where the time dummy first takes on a non-zero value in 1973 and the case where it first takes on a non-zero value in 1974. Also, the equations with and without the interaction term were estimated. Results from TOBIT estimation for Agriculture and National Health and Welfare are also included. Without going into detail, the conclusions of this analysis may be summarized as follows.

3.4.1 Coefficient of the Time Dummy

In Table III, the estimated values of the coefficient and the t-ratios of the time dummy variable are summarized. The t-ratios of the respective departmental time dummies are the basis upon which we determine departmental compliance with the letter of the make-or-buy directive. The justification for adopting this approach is that the policy variable t-ratio reflects the effects of: (a) the size of the estimated regression coefficient, which measures the magnitude of the marginal policy response; and (b) the standard deviation of the estimate of the regression coefficient which indicates the volatility of I/R over time. Thus, a high t-value implies a large and/or stable response to the directive while a low t-value implies a small and/or unstable response. For those departments with a policy variable has a t-ratio that is significant at the 5% level, we can infer policy compliance.

The t-statistics of the policy variable show that the make-or-buy policy has been complied with to some degree by Agriculture, Environment, National Health and Welfare, National Defence and Transportation. In all cases except that

TABLE III

MAGNITUDE OF THE DEPARTMENTAL RESPONSE TO THE MAKE OR BUY POLICY

Estimated Without Interaction Term

	$\alpha_1$1973		$\alpha_1$1974	
	α_1 (S.E.)	T-ratio	α_1 (S.E.)	T-ratio
Agriculture	.176843E-02* (.210714E-03)	(8.39)	.209703E-02* (.155617E-03)	(13.48)
Communications	-.391239E-01 (.268061E-01)	(-1.46)	-.387193E-01 (.282406E-01)	(-1.37)
E.M.R.	-.289559E-02 (.756694E-02)	(.38)	.277251E-02 (.869544E-02)	(.319)
Environment	.137974E-01* (.342271E-02)	(4.03)	.106222E-01* (.187737E-02)	(5.66)
N. Defence	.177032E-01 (.994113E-02)	(1.78)	.257091E-01* (.105757E-01)	(2.43)
N.H.W.	.518382E-03* (.164789E-03)	(3.15)	.580122E-03* (.199320E-03)	(2.91)
Transportation	.357811E-01* (.140048E-01)	(2.55)	.344260E-01 (.186119E-01)	(1.85)

Estimated With the Interaction Term

	Combined Effect: 1973 include α_3		Combined Effect: 1974 include α_3	
Agriculture	.17928E-02* (.9925E-04)	(18.1)	.21341/-02* (.3077E-03)	(6.94)
Communications	-.515768E-01 (.272265E-01)	(-1.89)	-.2401289E-01 (.19785E-01)	(-1.21)
E.M.R.	.39804E-02 (.07757E-01)	(0.51)	.38387786E-02 (.9498E-02)	(0.40)
Environment	.124201E-01* (.34532E-02)	(3.60)	.1274841E-01* (.4226E-02)	(3.02)
N. Defence	.204109E-01 (.104283E-01)	(1.96)	.264395E-01* (.1162E-01)	(2.37)
N.H.W.	.5186E-03* (.168625E-03)	(3.08)	.5828667E-03* (.199726E-03)	(2.92)
Transportation	.421696E-01* (.114846E-01)	(2.97)	.38731498E-01* (.177078E-01)	(2.19)

of Communications, the sign of the time dummy variable was consistent with compliance. The evidence indicates that in most departments, the policy has had a positive impact in rechannelling federal R&D into the private sector. However, the success of the policy does not depend on the existence of a response alone, it depends also on the magnitude of the responses.

The question to be considered here is to what extent did each department respond. In order to perform an interdepartmental comparison, interval estimates for the true values of the dummy coefficients were constructed and ranked. In the absence of the interaction term, the ranking of the interval estimates for the departments concerned is shown in Table IVa. Including the interaction variable, the confidence interval estimates are ranked in Table IVb.

Upon examining the magnitude of the departmental responses, the Department of Transportation seems to have been most affected by the make or buy policy. The coefficient of the time trend suggests an annual increase of 3.5 percentage points in the amount contracted out by this department.

TABLE IVa: Confidence Interval Without Interaction Term

	1973		1974	
AGR	.2215E-02	.13218E-02	.33001E-02	.26405E-02
COMM	.198761E-01	-.981239E-01	.234382E-01	-.1008768
EMR	.189373E-01	-.131463E-01	.212067E-01	-.156617E-01
ENV	.210535E-01	.65413R-02	.14602E-01	.66424E-02
NDEF	.387783E-01	-.33719E-02	.481295E-01	.32887E-02
NHW	.7009E-03	.27E-05	.10026E-02	.1576E-03
MOT	.654712E-01	.6091E-02	.738832E-01	-.50312E-02

TABLE IVb: Confidence Interval With Interaction Term

	1973		1974	
AGR	.19889E-02	.15967E-02	.27864E-02	.14818E-02
COMM	.83487E-02	-.515768E-01	.195339E-01	-.675595E-01
EMR	.204252E-01	-.124644E-01	.239744E-01	-.16297E-01
ENV	.197408E-01	.50994E-02	.217075E-01	.37893E-02
NDEF	-.1697E-02	.425188E-01	.18051E-02	.510739E-01
NHW	.876E-03	.1612E-03	.10061E-02	.1595E-03
MOT	.665169E-01	.178223E-01	.762719E-01	.11909E-02

The responses of National Defence and Environment were positive but moderate. EMR, Agriculture and Health and Welfare Canada would rank third. The magnitude of the increase in their contracting activity was very small. Unlike the other departments, the estimated coefficient of the time dummy for Communications was negative implying no response to the directive.

3.4.2. Sensitivity to the Growth Variable (G)

The coefficient of the growth term is positive and significant for the Departments of Energy, Mines and Resources and National Defence. It is negative for Communications and Health and Welfare Canada, but not significant. When the year 1974 is employed as the first non-zero value for the time dummy variable, the coefficient of the growth variable for the Department of Environment is negative and statistically significant. This suggests that the Department of Environment responded to the increased growth in its science budget by intensifying its intramural R&D effort. This is not in accordance with the earlier hypothesis that a greater proportion of extramural R&D will be contracted out to industry as the departmental growth rate increases. The results for Energy, Mines and Resources and National Defence are consistent with our expectations and robust with respect to the year in which the first impact of the policy is assumed to be evident. Moreover, there were no discernible differences in the results obtained from the two alternative methods of estimation.

3.4.3 Sensitivity to the Multiplicative Growth Variable (GTD)

When the interaction variable is incorporated into the regression equation, it is assumed that the departmental marginal response to the policy depends in part, upon the rate of budgetary growth. It is assumed also that the policy has brought about a change in the departmental marginal propensity to contract out with respect to growth of the science budget. For all seven departments, the coefficient of the multiplicative growth term is insignificant. When the Ordinary Least Squares estimation method is employed the Department of Communications has a negative and statistically significant coefficient for the interacted growth terms. This confirms our earlier conclusion regarding the response of this department to the Make-or-Buy Directive.

3.4.4 Sensitivity to the Year in which Time Dummy = 1

The estimates obtained from the two alternative years in which the time dummy first takes on a non-zero value were virtually identical. Only for the departments of National Defence and Transportation were there any differences in the significance of the estimatedcoefficient of the time dummy variable. Using the Cochrane-Orcutt method of estimation, the results demonstrate no apparent response by the Department of National Defence when time dummy equals 1 in 1973. However when the first impact is assumed to appear in 1974, the coefficient of the time dummy variable is positive and significant. In contrast, the coefficient estimated for Transportation is significant when TD = 1 in 1973 but not when TD = 1 in 1974.

3.5 A Forecast of Contracting Out in 1985

It is essential to recognize that the model employed may under-estimate I/R in the long run. Short term predictions should not be seriously biased and will provide some indication of the future impact of the make-or-buy policy. In Table V, 1985 forecasts of the fraction of extramural R&D conducted by Canadian industry with and without the influence from the interactive growth term are presented. The average growth rate over the past 17 years is assumed to prevail in 1985.

TABLE V

Forecast of the Fractions of R&D Contracted Out to Industry by 1985

	Predicted (I/R) 1985			Predicted (I/R) 1985 ($\bar{c}$ GTD)	
	TD73	TD74		TD73	TD74
AGR.	.022129	.0246407	AGR.	.0224243	.0250869
COMM.	.0387047	.0441641	COMM.	.123244	.1247036
E.M.R.	.0140701	.0868031	E.M.R.	.1034773	.1000172
ENV.	.1944762	.163722	ENV.	.17471125	.1730764
N.DEF.	.3690396	.408355	N.DEF.	.36086097	.40639699
N.H.W.	.01212	.0088137	N.H.W.	.0043253	.0088756
MOT	.6755574	.6446773	MOT	.74952017	.69215066

3.6 Conclusion

In conclusion, the Department of Agriculture, National Health and Welfare and Environment have exhibited an upward trend in the fraction of natural science R&D contracted to industry. The magnitude of the increase in this fraction was very small for Agriculture and Health and Welfare and relatively large (1.3 per centage points annually) in the case of Environment.

Ranking departments in terms of the magnitude of policy response, Transportation has by far the largest annual increase in the proportion of extramural R&D commissioned to Canadian industry. In 1985, Transportation is expected to have approximately 70% of its mission-oriented R&D performed by the industrial sector.

National Defence and Environment rank second in the relative degree of policy response. They are expected to have respectively about 38% and 17% of their R&D tasks contracted out by 1985.

The proportion of government funded R&D conducted by private firms actually declined in the case of Communications. However, the negative trend evident in this period is not statistically significant.

CHAPTER 4

4.0 FRACTION OF R&D PAYMENTS TO UNIVERSITIES AND OTHER NON-PROFIT INSTITUTIONS: 1963-80

In Table VI, the proportion of extramural R&D contracted out to universities and non-profit organizations by the seven departments is presented.[52]

Of the seven departments, Agriculture has had the least involvement with academic and other non-governmental establishments. Over the period 1963-64 to 1980-81 less than 5% of its annual current R&D in natural sciences was contracted to this sector. There does appear to be an upward trend in the proportions of R&D contracted out to universities and other non-profit organizations by Agriculture.

During the 1970's, EMR's proportion of extramural R&D contracted to universities and other non-profit institutions grew rapidly. The increases in these fractions were most pronounced during the years 1975-76 to 1980-81. From 1963 to 1969, an average of 2% of mission-oriented R&D was conducted by universities and non-profit organizations, while the average proportion increased to about 17% in the 70's.

There were no discernible trends for the Departments of Communications, Environment, National Health and Welfare, National Defence and Transportation. Communications contracted its largest fraction of extramural R&D to the academic sector in 1972. This was followed by a continuous decline in proportions over the next few years. The proportion of mission-oriented R&D performed by non-profit firms on behalf of

TABLE VI

PROPORTION OF PAYMENTS TO UNIVERSITIES AND NON-PROFIT ORGANIZATIONS

Department	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
Agriculture	0.7	0.3	0.6	1.1	1.5	1.6	1.5	1.4	1.4	1.2	1.1	1.4	2.2	3.4	3.5	2.7	3.2	4.4
Communications	0	0	0	0	0	0	0.8	0.9	0	9.1	6.0	8.1	6.0	3.8	2.5	2.1	4.3	4.6
E.M.R.	0.3	1.0	1.0	1.9	2.3	2.5	3.2	2.2	24.6	4.1	4.2	4.3	7.1	15.2	21.9	18.4	32.8	36.4
Environment (F.&O.)	0	0.6	0.8	1.7	0	3.2	6.5	5.3	4.7	5.1	6.4	10.2	6.0	5.4	7.0	7.8	5.3	6.4
N. Defence	6.2	4.7	3.7	4.7	6.9	9.5	9.3	8.3	6.6	7.6	6.9	8.0	7.1	4.4	4.0	4.1	4.8	5.0
N.H.W.	62.7	62.7	61.7	67.9	71.4	76.3	69.3	66.0	66.5	61.9	63.1	56.0	41.2	44.6	50.2	46.9	33.9	38.0
Transportation	5.5	6.4	5.7	7.6	6.2	8.0	8.8	7.1	9.6	19.1	8.0	19.3	17.6	14.2	8.1	9.8	8.1	8.0

NOTE: Calculated by $\left(\frac{\text{Payments in Univ. \& Non Prof}}{\text{Total current R\&D in Nat. Science}}\right) \times 100$

Environment and National Defence fluctuated from year to year and follows no definite trend. The fractions were generally higher in the 70's for Environment, but the evidence suggests the opposite for National Defence. Transport Canada showed no sustained trend in either direction.

The most striking feature in Table VI is the proportion of extramural R&D contracted to universities and non-profit firms by Health and Welfare Canada. During the 1960's, the average fraction contracted out was ten times that contracted bout by National Defence or Transportation. This proportion has since exhibited a definite downward trend.

In conclusion, although the fraction involved is very small there has been a strong positive trend in contracting out to universities by the Department of Agriculture. In contrast, Health and Welfare Canada exhibited a modest negative trend following the issuance of the make or buy directive. Even so, National Health and Welfare contracted out ten times as much as Agriculture to universities and non-profit organizations in 1980-81. Naive analysis of the time-series statistics as above cannot offer conclusive results with regard to the effect of the Make or Buy policy on the share of R&D performance by the academic and non-profit sector. A more rigorous statistical test is introduced in the following section.

4.1 Statistical Analysis: Payments to Universities and Non-Profit Organizations

In the previous section, we have determined statistically those departments which have and have not responded to the Make or Buy directive. An essential question now, is whether there has been a response to the 'spirit' as well as the 'letter' of the make or buy directive. It may have been the case that the affected departments have attempted to comply with the directive by shifting extramural research and development from universities to industry rather than shifting intramural research and development to industry.

To examine empirically whether the departmental compliance was to the spirit, as well as the letter of the policy, a time series regression model is employed. The dependent variable is the fraction of mission-oriented R&D contracted out to universities and non-profit organizations. The model is specified as a single linear regression equation. The dependent variable, as before, will follow a positive linear time trend. Methods of estimation are Ordinary Least Squares and the Cochrane-Orcutt iterative technique. The model employed is expressed as

$$\left(\frac{E}{R}\right)_t = \beta_0 + \beta_1 TD + \beta_2 G_{-1_t} + \beta_3 G_{-1_t} * TD + v_t$$

where E = total expenditures on R&D in natural sciences contracted to universities and non-profit organizations, plus total feasibility studies contracted out to universities and non-profit organizations.

R = total current real expenditures on R&D in natural sciences.

TD = 0 prior to the implementation of the Make or Buy policy
= 1 the year the policy was implemented, and increasing with time thereafter.

G_{-1_t} = Departmental real growth rate.

v_t = Randon Disturbance form.

The variable $(\frac{E}{R})_t$ represents the fraction of federal R&D contracted to universities and non-profit organizations.

4.1.1 Coefficient of the Time Dummy (TD)

The coefficient of the time dummy, β_1, captures the influence of the Make or Buy policy, on the fraction of R&D contracted out to universities. The combined influence from the interaction of the time dummy and the growth term must also be considered.

If the coefficient of the time dummy variable is negative and significant, we could infer that the policy has had an adverse effect on the universities' share of federal mission-oriented R&D.

If the coefficient of the time dummy variable is negative, and the department considered has complied with the Make or Buy directive in terms of a significant increase in the proportion contracted out to industry over the years policy has been in operation, then we could infer that the department has followed only the letter and not the spirit of the policy.

In the case where there was a significant reduction in the fraction of R&D contracted to universities, and no significant change in the fraction of R&D contracted to industry, then, over the years, the department has increased its intramural R&D capacity and has ignored the make or buy directive altogether.

Finally, if the coefficient of the time dummy variable is insignificant or positive and significant, and if the department has responded to the directive by significantly increasing the industrial share of R&D performance via contracting out, then the department has adhered to the essense of the Make or Buy policy.

4.2 Empirical Results

The estimates of the β_i are reported in Table VII. The coefficient of the time dummy variable is significant for Agriculture, EMR, National Defence and Health and Welfare Canada. Of the departments with significant trends, National Defence and National Health and Welfare have a negative time dummy coefficient. The evidence suggests, therefore, that the proportion of extramural R&D contracted to universities and non-profit organizations by DND and NHW, was significantly reduced after the introduction of the make or buy policy.

The proportion of R&D contracted out to universities has significantly increased for EMR, while Communications shows no statistically significant change.

The influence of the growth variable is significant only for the Department of National Defence. The multiplicative growth term is insignificant throughout.

To summarize, the following conclusions can be drawn: (1) Of all the departments which have complied with the letter of

TABLE VII(a): Estimated Without Interaction Term

	1973	1974
Agriculture	.339248E-02* (6.19)	.392071E-02 (6.64)
Communications	.124911E-02 (.23)	.580902E-03 (.097)
E.M.R.	.349842E-01* (4.67)	.417112E-01* (5.59)
Environment	.277237E-02 (.85)	.226536E-02 (.56)
N. Defence	-.437866E-02* (-2.38)	-.476764E-02* (-2.26)
N.H.W.	-.386342E-01* (-7.23)	-.427356E-01* (-5.10)
Transportation	-.534559E-02 (-.747451	-.488146E-02 (-.63)

TABLE VII(b): Estimated With Interaction Term

	1973		1974	
Agriculture	.3482E-02* (.0150108E-02)	(6.96)	.39957E-02* (.1308E-02)	(3.05)
Communications	.50018E-02 (.5857E-02)	(.85)	.36372E-02 (.6474E-02)	(.56)
E.M.R.	.329591E-01* (.9497E-02)	(3.47)	.396388E-01* (.1304E-01)	(3.05)
Environment	.37308E-02 (.3454E-02)	(1.08)	.34622E-02 (.411E-02)	(0.84)
N. Defence	-.43271E-02		-.41213E-02* (.7998E-03)	(-5.23)
N.H.W.	-.386522E-01* (.6894E-02)	(-5.61)	-.420256E-01* (.10563E-01)	(-3.98)
Transportation	-.51439E-02 (.7358E-02)	(-0.69)	-.43394E-02 (.5703E-02)	(0.76)

the make or buy directive, namely, Agriculture, Environment, National Defence (1974), National Health and Welfare and Transportation (1973), only the Departments of Agriculture, Environment and Transportation (1973) have adhered to the 'spirit' of the policy; (2) The Departments of National Defence and Health and Welfare Canada have complied with the make or buy policy at least in part at the expense of the universities and non-profit organizations.

CHAPTER 5

5.0 Departmental R&D Mandates

In most departments, the establishment of scientific priorities begins with an examination of departmental mandates. They may include policy formulation, regulatory responsibilities, safety standard determination and enforcement, or responsibilities in support of industrial development. Research and development activities required are, in general, supportive of agencies' various objectives.[53]

In order to assess whether or not the contracting out policy is compatible with the departments' principal missions, mandates of each of the seven applied research-oriented departments considered throughout our report are examined. We will investigate the nature of R&D carried out by each agency and its suitability for industrial contracting.

On the basis of the documents submitted to the Special Senate Committee on Science Policy, it appears that departmental science policies have not been and perhaps cannot be stated explicitly. Moreover, in some departments the R&D effort cannot be easily assigned categories such as basic research, applied research or development. However, since an agency's mandate determines its science priorities and thus R&D. requirements, we can assess the orientation of a department's science activities by examining its responsibilities. The following investigation is based on briefs submitted to the Lamontagne Committee, various precedings before the Senate and MOSST's Background studies.

It is generally agreed that industrial R&D is almost all applied and associated with the development of specific products and processes, while university R&D is mostly basic in nature. Government R&D is for the most part applied, but includes some basic research (MOSST, 1981, p. 3).[54]

The Ministry of State for Science and Technology listed four fundamental justifications for federal support of science activities:

> "(a) the benefits of the R&D accrue to society and can be captured only with difficulty, if at all, by the performer of the R&D (externalities);
>
> (b) there are economies of scale to be achieved by having the R&D performed by the government rather than by a large number of small units (economies of scale);
>
> (c) the functions which the R&D supports are not divisible, e.g., defence (indivisibilities); and
>
> (d) the risks or costs associated with the R&D are too large for the private sector alone to assume".[55] (Background Study 1981, p. 2)

While scientific activities differ with departmental responsibilities, the make-or-buy directive is applicable to all mission-oriented R&D supported by agencies listed in Schedules A and B of the Financial Administration Act. The discussion below briefly examines scientific activities adopted by each department and assesses their suitability for contracting out.

5.1.1 Agriculture

On August 10, 1976, the representatives from the department of agriculture appeared before the Senate Committee on Science

Policy. Briefing the Committee on the role of science in Agriculture Canada and the use of the contracting-out policy, Dr. Migicovsky stated that the indiscriminant application of the make-or-buy policy to everything and everyone would be ill-advised.[56] He noted that the clients of the Research Branch of the department are mostly farmers who represent the production end of the industry. They do not have the means or the capability of carrying out research to improve the efficiency of food production.[57] A significant proportion of food research is in seed variety development. New seed varieties have not been patentable[58] and this activity has held little interest for private firms.

On the non-production side, there are some companies involved in food processing who are prepared to take up contracts, but in general, the food industry is very hesitant to perform research and development where results of the investigation will apply outside their particular company.[59] According to statements made by Dr. Migicovsky, Agriculture Canada is prepared to issue contracts to interested individuals and companies where suitable and is prepared to consider seriously unsolicited proposals from various companies or a pool of companies.[60]

The make-or-buy policy itself does not appear to conflict with departmental objectives. However, many research tasks cannot be conducted efficiently by individual farmers and food processing companies are apparently of the opinion that spin-off benefits are minimal and/or largely inappropriable.

5.1.2 Communications

Long before the make-or-buy directive was issued, the Department of Communications emphasized the practice of contracting-out their mission oriented R&D. From 1968 to 1972, an average of 44% of the total current R&D expenditures in natural sciences was contracted out to Canadian industry.[61] No other departments contracted-out as great a fraction of its R&D activity. A large part of this was attributable to space related programs, specifically the Communications Technology Satellite program. The Space Program accounts for about 70% of the departmental science budget.[62]

In a report published in January 1981, the Ministry of State for Science and Technology cited the Department of Communications as an example of a department which has supported industrial R&D by contracting out.[63] It is the view of MOSST that Communications has a responsibility to strengthen their scientific capability of space and communications industries and that contracting-out policy can be used productively to encourage socially desirable high risk projects in this area.

In June 1977, Communications department expressed its views with regard to the government support of risky programs:

> "In Communications field there are areas in which Canadian industry has and will continue to be very successful on its own. There are also areas in which the risks are such that products and services likely can only be developed and introduced with the support of the Federal government".[64] (Brief to Senate 10A:114)

It is apparent that the objectives of DOC have included industrial support via contracting out. Moreover, the nature of the R&D for which it is responsible is such as to generate the type of spin-off benefits which would have given DOC an incentive to contract-out in any case. It is, therefore, not surprising that the make-or-buy directive has not induced any additional contracting-out on the part of DOC. We may also offer the conjecture that further contracting-out could be potentially wasteful.

5.1.3 Energy Mines and Resources

In terms of total Federal Expenditures on scientific activity, the department of Energy, Mines and Resources (EMR) is one of the larger departments in the federal government. Energy, Mines and Resources is an amalgamation of various federal agencies. It was formed by incorporating part of the previous Department of Mines and Technical Surveys and of the Water Resources Division of the former Department of Northern Affairs and Natural Resources.[65]

As a continuation of the former Department of Mines and Technical Surveys, EMR has long engaged in many earth science and geoscientific activities.[66] A large part of the department's R&D is to promote resource development, ensure resource availability for indigenous industrial activities and provide sound rational resource management. Research work of EMR is connected with several basic industrial sectors and therefore with industry in general.[67] According to a Science Council report issued in 1971, 86% of Canadian expenditures on overall geoscientific activities were made by industry and less than 8% by the federal government. Moreover, 63% of R&D in this area was supported by industry and slightly over 20% by the Federal government.[68] This seems to indicate that the nature of R&D conducted by EMR has the potential for a high degree of industrial participation.

Presently, departmental scientific activity is determined by the National Energy Program. The National Energy Program (NEP) of 1980 noted that "fully two-thirds of federal research and development expenditures ($160 million in 1979-80) is now devoted to the nuclear option, including research on nuclear fusion".[69] The program allows for some nuclear R&D related to radioactive waste management but otherwise stipulates that the overall R&D should concentrate on new energy sources.[70] The National Energy Program asserts further that in order for new research and development priorities to be realized, more contracting-out to industry as well as reorganization of the federal science activities are required.[71] It is apparent, therefore, that the overall research mandate of EMR is compatible with contracting-out to industry. If the future R&D projects of Energy, Mines and Resources are in the nuclear oriented areas as NEP has emphasized, however, industrial involvement via contracts may not change discernibly because much of the proposed R&D would be directed to Atomic Energy of Canada Limited (AECL).

In sum, the departmental R&D mandate is consistent with the contracting-out policy. Moreover, the type of R&D undertaken by EMR is likely to result in the type of spin-offs which can make contracting-out socially beneficial.

5.1.4 Environment

In a brief to the Senate Committee on Science Policy, Dr. Roots, a science advisor to the Department of the Environment asserted that

> "We have a mandate which gives us responsibility for the land, the air, the water, and most of the natural living things that are in it, on it, or in some cases, under it".[72]

The department is concerned with controlling undesirable externalities created through industrial and other activities. Also, Environment is devoted to the protection of natural resources and provision of high quality scientific information to increase the safety, efficiency and profitability of many industrial operations. With respect to the make-or-buy policy, Dr. Roots contended that

> "...the application of the "make-or-buy" policy, namely, that transferring government scientific work from in-house laboratories to industry will stimulate industrial innovation and technology transfer, and thus lead to more competitive and profitable Canadian industry - has little relevance in many cases for many of the scientific activities of the Department of the Environment".[73]

and

> "Although there are conspicuous exceptions, such as with our program of pollution abatement technology, by and large the scientific activities of the Department of the Environment are not the type that are directly relevant to the immediate development of marketable products, and the contractor who provides scientific services to the department is very rarely able to turn around and find a large number of national or international customers for his new knowledge."[74]

A great deal of the R&C carried out by the Department of the Environment is related to environmental protection. In

Dr. Roots' views, "not very much of the contracted science can be expected to have industrial spin-offs of the type envisaged in many statements that have been made to justify the policy in general."[75]

While many projects may not have direct industrial spin-offs, MOSST argues that environmental R&D activities may have a direct positive effect on the development of industrial scientific capability, which is nothing other than a very weak spin-off. By performing R&D of any kind, industry may learn and thus increase the chance that it may discover something in the future.

In sum, the R&D activities of the Department of Environment appear to be characterized by an absence of spin-offs. As a consequence there appears little to be gained from the application ofthe make or buy directive to this department.

5.1.5 National Defence

The role of scientific activities within the department of National Defence is by and large determined by present and future departmental objectives. In addition, its science policies depend upon the availability of resources and the general government policies relevant to science and technology.

The Department of Defence has and is giving consideration to the proposal that it be part of DND R&D policy to assist in developing Canada's defence industrial capability by use of industry for defence R&D and by transfer of appropriate technology from government to Canadian industry.[76]

Among the responsibilities of National Defence Headquarters (NDHQ established in 1974) is that of "recommending industrial research policies and programs, for providing direction, coordination and administration of all R&D related to the government "make-or-buy" policy on R&D, and for identifying, selecting, promoting and implementing the transfer of appropriate innovations in defence technologies to the private sector".[77,78] The management of DND thus appears to recognize that scientific activities of this department have a significant impact on the Canadian defence industry.

During the period 1969-1975 inclusive, 183 patents were filed in Canada by DND. Thishas far outranked all other departments, including Communications. If the number of patents received indicates the relative degree of commercial potential, then defence R&D is likely to be associated with large commercially exploitable spin-offs.

Notwithstanding the apparent commercial potential in Defence related R&D, DND has contended:

> "The government introduced its "Make or Buy" policy in 1973. Much defence research and development work is not amenable to Make or Buy since it is difficult to interest industry in any applied research and development projects that do not promise a large production for Canadian defence or a substantial export opportunity".[79] (9a:247)

5.1.6 National Health and Welfare

The Department of National Health and Welfare (NHW) is often viewed as the department which protects the public from social and economic hazards.[80] The primary mission of the department is regulatory in nature. One of the nine duties and powers stipulated in the Statutes of Canada, 1944, is the responsibility to "investigate and research into public health and welfare".[81] The formulation and support of research in National Health and Welfare, as in most other departments, is to enable them to accomplish their missions more effectively.

The department is divided into five branches, three on the health side and two on the welfare side. Most of the mission-oriented R&D in natural sciences is concentrated in the Health Protection Branch (HPB).[84] The responsibilities of HPB are to ensure

> "adequate standards for the public sale of foods, drugs, cosmetics and medical devices, the surveillance, control and research of environmental factors and of communicable diseases in order to protect the general public."[83] (How Ottawa Spends Your Tax Dollars, p. 93).

With respect to the department's relation with industry, in the brief summitted to the Senate Committee on Science Policy, National Health and Welfare expressed the following views:

> "The relationship to industry of Health and Welfare's scientific activities is both indirect and direct, resulting in standards, regulations or programs which have an impact on industry, for instance, research in areas such as environmental contaminants, foods and drugs."[84]

Evidently, a large part of the department's scientific activities are in support of its regulatory functions, and thus, involve weak potential for industrial spin-offs. Furthermore, innovative activities of NHW are gradually being redirected towards social science research. Health priorities are being shifted from specific health problems to broader programs involving preventitive medicine, environmental hazards and occupational health. With greater emphasis on 'social technology' on the welfare side and the application of social sciences on the health side, the proportion of departmental R&D covered by the make-or-buy directive is declining.[85]

From a superficial assessment of the department's R&D orientation and direction of research, it appears that much of the R&D activity of NHW is not suitable for contracting out.

5.1.7 Transportation

The document summitted by Transport Canada to the Senate Committee stated that, although the department has no specific mandate with respect to scientific activities, all of the department's responsibilities involve activities which require a great deal of competence in the physical and human sciences".[86] All of the department's R&D activities are mission-oriented and development intensive. More than 90% of total science resources concentrate on the development phase. There is no curiosity-oriented research performed or supported by Transport Canada.[87] To the extent that they involve development as opposed to basic or applied research, Transport's R&D projects are suitable for contracting-out to the industrial sector.

Transport Canada is divided into various groups and branches, each responsible for various activities which may or may not require the support of science and technology. In the late 1970's, the research and development function in Transport Canada was given to the Strategic Planning Group. Apart from the formulation of long range policies affecting several modes of transportation, the group is responsible for "providing a stronger link between R&D activities and transportation policy and system requirements".[88] (Annual Report 79/80).

The Strategic Planning Group is further subdivided into seven branches. Transportation research and development (R&D) policies, plans and programs for the government and private sector are developed by the Research and Development Directorate. The Planning and Coordination Branch assists in the development of future government research strategy, levels of funding and priorities. The Transport Development Centre in Montreal undertakes R&D activities for various sections of the department. Research plans are developed in consultation with advisory boards (Air, Marine, Highway and Rail) to promote the discovery and application of techniques to enhance the safety and efficiency of the Canadian transport system.[89]

To date, Transport Canada has let many R&D contracts to industry. With respect to the make or buy policy itself, the Department expressed the following view to the Senate:

> "The question arises as to whether the wholesale contracting of research activity is being overdone. Most of the contracting out has been in the field of human sciences and the most direct effect of this has been the proliferation of consulting firms whose chief function appears to be the preparation of government sponsored studies. This is not synonymous with contributing to Canada's scientific and research capabilities. In the physical sciences, the case is frequently that the laboratories and scientists needed by the administrations to perform their statutory functions are in fact those most capable of carrying out the research function and for that reason, the contracting out of research becomes impracticable".[90] (Senate Brief, 9A:149).

It also indicated further that "indiscriminate application of this policy might be counter productive".[91] (Ibid.)

CHAPTER 6

6.0 RELEVANT DEPARTMENTAL CHARACTERISTICS

Having determined statistically which departments have complied with the letter and spirit of the Make or Buy directive, it is now appropriate to isolate the characteristics of each department's R&D operations which may have influenced their ability and/or willingness to comply. To predict which characteristics explain inter-departmental differences in the degree of policy compliance, the economic theory of the bureaus and the concept of transactions costs will be employed.

6.1.1 Cost of Response

There are numerous costs associated with conducting R&D under contract. The economic theory of contracts can be employed to predict which departments are able to farm out their mission-oriented R&D efficiently. Some of the costs which may explain the systematic inter-departmental differences in the magnitude of policy compliances are: (1) the cost of securing a suitable contractor; (2) the difference between the marginal and average cost of research when there are indivisibilities in the research function and; (3) the cost of employing arm's length contractual arrangements.

6.1.2 Search for Contractors

Determining the appropriate firm to carry out required R&D

is a costly process. The department must determine the various factors at the outset which may contribute to the cost of a contractual arrangement, such as the contractors' attitudes toward risk, their propensity for moral hazard and their scientific capability. Government departments which have had many transactions with private firms in the past would already have incurred many of these costs and would, therefore, be able to let additional contracts at a relatively low marginal cost.

6.1.3 Natural Monopoly

If there are economies of scale or of scope in the research function, a department will find it less costly to continue to conduct research intramurally than to contract it out. The duplication of indivisible and specialized government research facilities in the private sector solely to facilitate contracting-out results in higher average research costs for the department concerned. Moreover, given the existence of indivisibilities, the government and the contractor will be in a bilateral monopoly situation. As a consequence, the contracting process itself will be beset with haggling, and possibly, with opportunistic behavior.

Irregardless of willingness to comply with the Make or Buy directive, those departments having undertaken R&D projects requiring specialized and indivisible facilities will find it more costly to comply with the directive. Agriculture Canada would be an example of a department in this situation. Their extensive research facilities are highly capital and land intensive. Because the facilities required to perform R&D are in place and cannot costlessly be put to other uses by the department, the marginal cost of carrying out research projects intramurally would be much smaller than the average cost of contracting it out. To acquire scientific knowledge through purchasing policy would seem to be inefficient.

By the same token, departments with relatively less capital intensive research facilities may find it less costly to comply with the directive. Here the incremental cost of intramural R&D will approach the cost incurred by a private contractor. In addition, it may be possible for a number of contractors to operate. The competition this implies will reduce the amount of haggling and the potential for opportunism; that is, it will reduce the cost of contracting itself.

6.1.4 Nature of the Contract

Departmental research may be such that it is costly to measure whether or not specific research objectives have been met. Research projects may involve a high degree of uncertainty. It may be costly to determine whether an observed failure to achieve a given objective is due to malfeasance on the part of the researcher or to uncontrollable factors. When it is costly to measure the quality of the research product and to determine the responsibility for shortcomings that are detected, the contracting process itself increases in cost and it becomes advantageous to conduct research intramurally. This eliminates the financial incentive to mislead and while it does not eliminate the moral hazard problem, it allows for the use of monitoring to control it.

This type of problem will be typical of basic research. It will also characterize advanced mission-oriented research. Other things being equal, departments involved in research which are advanced relative to the state of the art will find it more costly to comply with the make or buy directive.

6.1.5 Goals of Departments

Given the cost of contracting-out, some departments may be more willing than others to comply with the Make or Buy directive. The theory of bureaucracy may help explain these inter-departmental differences. There are reasons to believe that departments with larger science complements will be less likely to respond.

There may be a bureaucratic incentive to resist the policy. Since federal science bureaucrats cannot directly appropriate the surplus resulting from successful projects, they may tend to search for and acquire other, non-pecuniary benefits.[92] These additional benefits may take the form of a greater staff size which in turn, will imply an increase in responsibility, prestige, and security.[93] The policy effort to shift scientific activities from inside to outside may represent a reduction of the department's and bureaucrats' power, prestige and security. In his well-known book, Inside Bureaucracy (1967), Anthony Downs contended that:

> Another major cause of inertia is that self interest motivates officials to oppose any changes that cause net reduction in things they personally value...Most of the items personally valued by officials are positively correlated with the amount of resources under their control. These items include personal power, prestige, and income..., and security. It is hard to conceive of many situations in which these elements are enhanced by decreases in the resources controlled by the officials concerned. (p. 196)

He further asserted that:

> ...The more officials affected, the greater will be the resistance to significant change. Hence:
>
> (1) The larger the organization, the more reluctant it will be in adopting any given change.
>
> (2) Small bureaus tend to be more flexible and innovation minded than larger ones.
>
> (3) One way to speed the adoption of a given change is to design it so that it affects the smallest possible number of persons.[94] (p. 16)

According to Downs' reasoning, effective resistance to the make or buy directive is likely to be more apparent in departments where the scientific establishment is relatively large and influential.

6.1.6 Measurement of Departmental Characteristics

The factors which may influence the departments' ability and/or willingness to comply with the directive can be measured and empirically tested. Among the possible determinants are:

(a) Scientists as a fraction of total employment: To measure the influence of each department's scientific establishment, the proportion of employed scientists and technicians performing intramural R&D is used as a proxy. This variable approximates the researchers' political clout within the bureau. The theory of bureaucratic behaviour would predict a negative relationship between the percentage of officials opposing the directive in the department and the dependent variable, which is the proportion of R&D contracted to private industry.

(b) Capital Intensity: Those departments with capital intensive research facilities may find it less costly than others to continue to conduct their R&D intramurally. That is, greater is the role of specialized facilities in the departmental R&D effort, the lower will be the incremental or out-of-pocket cost of intramural R&D and the greater will be the cost disadvantage of contracting out. The capital intensity value is calculated by dividing the department's total capital expenditure on R&D in natural sciences by its total current intramural R&D expenditures. This is calculated yearly for the period 1963 to 1972. The variable used in the analysis was the arithmetic mean value over the 10 year period. We would expect a negative partial correlation between the average capital intensity and the fraction of R&D contracted to Canadian industry.

(c) Previous Extramural Expenditures: The cost of complying with the directive will also depend upon the number of potential research contractors in the areas of interest to each department. The availability of private research personnel to be employed depends upon a department's degree of interaction with the private sector in the past. The fraction of extramural R&D contracted to the industrial sector by each department, during the period 1963-1972, is used to measure the degree of departmental involvement with industrial contractors prior to the issuance of the directive. The variable utilized in the analysis was the arithmetic mean value of the extramural proportions calculated over the relevant period. A positive partial correlation is expected.

(d) The variation of growth rates: A widely fluctuating growth rate within a department may reduce the optimal number of internal research personnel. The Ministry of State for Science and Technology recently contended that:

> It is virtually impossible to plan and conduct research programs that require several years to produce results when the funding committments are uncertain from the outset (MOSST Background Paper, 1981, p. 15).

Variation of growth rates may affect the departmental cost of compliance with the make-or-buy directive in two ways: (1) greater variability may imply greater gain from contracting out as a way of handling the "peak load" problem; and (2) greater variability will also increase the cost of contracting in that the department cannot use the promise of a stable, long-term flow of business to reward honest, non-shirking contractors. The final effect of the variation in growth rates on the fraction of R&D contracted out to industry is ambiguous.

(e) Departmental Growth Rates: Departments with different growth rates may respond differently to the make or buy policy. Irregardless of their willingness to comply, departments with relatively larger growth rates may find it easier to conform to the directive. Departments with relatively little growth in their scientific budgets may find that, after providing for the activities of their own, tenured science personnel, there is little left for contracting out. For this reason, the growth rate was employed as a discriminating departmental characteristic.

(f) Proportion of R&D contracted to universities and non-profit organizations: The variable designed to capture the nature of R&D being carried out by the departments. It is assumed that research projects with ambiguous outcome and high cost of product measurement.(characteristics typical to basic research and advanced mission-oriented research), were mostly contracted out to the academic sector. Departments whose scientific interests are typified by these types of R&D will find it more costly to contract-out to industry than to perform the work intramurally. Hence, we would expect a negative partial correlation between the dependent variable and the average proportion of R&D contracted out to universities and non-profit organizations.

6.2 Statistical Analysis

The above propositions can be empirically tested by estimating the following pooled time-series-cross-section model.

$$\left(\frac{I}{R}\right)_{it} = \sum_{i=1}^{7} b_{oi} d_{oi} + \sum_{j=1}^{J} b_j X_j TD + b_G G_{-1} + b_9 G_{-1} TD + b_\ell TD + u_{it}$$

where I = industrial extramural research and development

R = departmental total current R&D

d_{oi} = dummy = 1 for i^{th} department, zero otherwise.

TD = dummy = 0 prior to the implementation of the policy

= 1 the year the policy was implemented and increasing with time thereafter.

X_{ji} = j^{th} discriminating departmental characteristic.

u_{it} = Random Disturbance Term.

Departmental characteristics include:

M = Proportion of staff and personnel employed in intramural R&D.

K = Proportion of intramural capital expenditures in natural sciences.

E = Proportion of extramural R&D contracted to industrial sector.

VG = Variation of growth rates measured by the coefficient of variation.

PE = Proportion of extramural research contracted to universities and non-profit organizations.

MG = Departmental average growth rate over 10 years.

To capture the influence of these variables response to make or buy directive, discriminating departmental characteristics were entered as multiplicative interaction terms with the time dummy. As before, response to the directive is assumed to take the form of a positive linear trend in I/R. The policy dummy, TD, is zero until the directive was issued and increases linearly thereafter.

6.2.1 Estimation Method

The Generalized Least Squares estimation method is employed. Having pooled annual time series data across the seven departments, we assume in our estimation that the error terms, ε_{it} are autocorrelated over time and heteroscadastic cross sectionally.[95] Under the assumption of first order correlation, the systematic correlation time wise in the error terms can be corrected as follows: First, ordinary least squares method is applied to the observed data to estimate the equation

$$\left(\frac{I}{R}\right) = \sum_{i=1}^{7} \beta_{oi} D_i + \beta_1 G + \beta_2 GTD + \sum_{j=0}^{N} \beta_j X_j TD + \beta_\ell TD + \varepsilon_{it}.$$

From this, estimated regression residuals can be calculated, and therefore, rho values for all seven departments can be attained.

$$\hat{\rho}_i = \frac{\Sigma e_{it} e_{i,t-1}}{\Sigma e^2_{i,t-1}} \qquad i = 1,\dots 7,\ t = 2,\dots,18$$

where e_{it} is an unbiased estimator of ε_{it}.

Next, all observations are transformed by subtracting from each of the observed values its one period lagged value, weighted by the relevant rho estimate.[96]

Homoscadasticity can be achieved by regressing the foregoing transformed variables, using the estimated residual to calculate the variances of the departmental random disturbance terms and, finally, normalizing all observations by the estimated departmental variances.[97]

TOBIT method of estimations was also employed in situations in which the dependent variable took on zero values. Data used in the estimation were pooled data from six departments over the years 1963-1980, and from Communications over the years 1968 to 1980.

6.3 Empirical Results

Estimates of pooled cross-section time series regression equations are presented in Table VII. Consider, first, the equation containing three discriminating departmental characteristics, N, E and K.

$$\widehat{\left(\frac{I}{R}\right)}_{1973} = \underset{(-2.85)}{-.145974}\, D_1 + \ldots + \underset{(3.29)}{.974798\text{ E-01}}\, G_{-1} + \underset{(2.93)}{.7788\text{ E-01}}\,TD$$

$$- \underset{(-2.09)}{.2445\text{E-01}}(G_{-1}.TD) - \underset{(-2.94)}{.70957\text{ E-03}}(E.TD) - \underset{(-.41)}{.2115\text{ E-03}}(K.TD)$$

$$- \underset{(-2.57)}{.122284}\,(N.TD)$$

and

$$\hat{(\frac{I}{R})}_{1974} = \underset{(-2.87)}{-.102078}\, D_1 + \ldots + \underset{(3.05)}{.130705}\, D_7 + \underset{(3.35)}{.9896\text{ E-01}}\, G_{-1}$$

$$+ \underset{(3.40)}{.91998\text{ E-01}}\, TD - \underset{(-2.36)}{.3530\text{ E-01}}(G_{-1}.TD)$$

$$- \underset{(-3.31)}{.79777\text{E -03}}(E.TD) - \underset{(-.19)}{.10453\text{ E-03}}(K.TD)$$

$$- \underset{(-2.85)}{.136605}\, (N.TD)$$

The coefficient of a discriminating variable gives the average marginal effect of that departmental characteristic on compliance. Our results seem to indicate that the proportion of intramural scientific personnel and the proportion of previous extramural R&D contracted out to industry are significant discriminating variables. The fraction of capital R&D expenditures is not significant.

Contrary to our expectation, the fraction of previous extramural R&D contracted our, (E), has a negative coefficient which implies that departments which have had relatively small involvement with private firms (i.e., departments with smaller pool of potential contractors) have adhered more closely to the policy during 1963-1980. The average proportion of department R&D personnel has a statistically significant negative effect on the departments' response to the make or buy policy.

Although it exhausts our cross-sectional degrees of freedom, we have included some additional departmental characteristics in the model. In the previous section we discussed some important factors which may help in accounting for the systematic interdepartmental differences in the degree of compliance with the directive. It was suggested that the departmental growth coefficient of variation, average growth rate over the years 1963-1980 and finally the average proportion of contracts commissioned to universities and non-profit organizations be included.

First, to check the effect of the coefficient of variation of growth rates we have estimated the augmented regression equation in which the results are given below:

$$\left(\hat{\frac{I}{R}}\right)_{1973} = \underset{(-2.94)}{-.1514}\,D_1 + \ldots + \underset{(2.79)}{.9691E\text{-}01}\,D_7 + \underset{(2.09)}{.6251E\text{-}01}\,TD$$

$$+ \underset{(3.15)}{.9388E\text{-}01}\,G_{-1} - \underset{(-2.01)}{.2357E\text{-}01}\,(G_{-1}.TD) - \underset{(-0.53)}{.2555E\text{-}03}\,(E.TD)$$

$$+ \underset{(0.74)}{.7655E\text{-}03}\,(K.TD) - \underset{(-.80)}{.59597E\text{-}01}\,(N.TD) - \underset{(-1.09)}{.1632}\,(CV.TD)$$

and

$$\left(\hat{\frac{I}{R}}\right)_{1974} = \underset{(-2.92)}{-.1041}\,D_1 + \ldots + \underset{(3.04)}{.1302}\,D_1 + \underset{(2.15)}{.7314E\text{-}01}\,TD + \underset{(3.25)}{.9649E\text{-}01}\,G_{-1}$$

$$- \underset{(-2.29)}{.3441E\text{-}01}\,(G_{-1}.TD) - \underset{(-0.67)}{.3580E\text{-}03}\,(E.TD)$$

$$+ \underset{(0.72)}{.83678E\text{-}03}\,(K.TD) - \underset{(-.93)}{.7579E\text{-}01}\,(N.TD) - \underset{(-.92)}{.136915}\,(CV.TD)$$

where CV = Coefficient of variation of growth rates over the period 1963-1972.

The regression coefficient for (CV.TD) has a positive sign but is statistically insignificant. With the inclusion of the additional discriminating factor the proportion of a department's scientific employees, N, and the fraction of R&D previously contracted out, E, continue to have negative coefficients but are no longer statistically significant. This is probably due to multicollinearity which is often associated with such interactive specifications.

Next, two additional factors are incorporated into our equation. They are the average rate of growth of the departmental science budget (MG) and the average fraction of R&D activities contracted to universities (PE) prior to the issuance of the make-or-buy directive.

The estimated coefficient of the mean growth rate has a positive sign as expected. Contrary to our hypothesis the coefficient of the variable PE is positive. The latter finding, although not statistically significant, suggests that the more commercially-oriented the research activities adopted by departments, the greater the fraction performed within the government.

6.4 Conclusion

The basic conclusions of this chapter are as follows. First, we have adopted a pooled cross section time series model to explain the systematic inter-departmental differences in the magnitude of response to the make or buy policy. Assuming that the dependent variable follows an increasing linear time trend with the implementation of the make or buy policy, tested regression equations performed quite well for the period

1963-1980. About 71% of the variation in the fraction of mission-oriented R&D contracted out to industry could be explained and, after having appropriately transformed the data, no auto-correlation is detected.

Second, the average proportion of departmental scientific personnel (N) and the average proportion of R&D contracted to industry prior to the announcement of the make or buy directive (E), proved to be significant in explaining the inter-departmental differences in the degree of policy compliance. However, the coefficient of the latter variable, which was designed to reflect the relative cost of issuing additional R&D contracts, has a negative sign which contradicts our hypothesis.

Third, in specifications including all departmental characteristics as independent variables, only the year to year growth term, year to year interactive growth term and the time dummy variable are statistically significant.

CHAPTER 7

7.0 Characteristics of Private R&D Contractors

The main purpose of this section is to determine the characteristics of the firms which have emerged as R&D contractors. The government's intention was that R&D contractors would be manufacturing firms with the capability of exploiting commercially the knowledge gained as a result of R&D performed under contract. The evidence of the success or failure of the make or buy policy with respect to the above intention can be determined by examining the value of contracts let to industry by each department.

The data in Table 8 shows the proportion of R&D contracts awarded to seven sectors of the economy (Service, Primary, Secondary, University, Non-profit institutions, Other government and Individual). Data was provided by the Department of Supply and Services. Information on which our calculations are based shows the dollar-value of contracts awarded by each department. It does not represent final payments to the firms. This information search was completed for the period April 1, 1978 to August 31, 1981.

TABLE VIII: (% of R&D Contracts Awarded)

Sector \ Dept.	AGR.	COMM	EMR	ENV	DND	NHW	MOT
Primary Ind.	0.2	0.1	0.2	0.6	0.6	-	4.3
Secondary Ind.	6	51	51	8.3	42.1	5	8.6
Service Ind.	38	24.5	24	64.9	31.6	58	62.6
University	43	22.2	22	9.9	21.8	30.4	21.1
Non Prof Inst.	6	1	1	4.4	0.1	-	0.5
Other Gov't.	3	1.6	0.2	2.6	0.7	-	0.5
Individual	4	0.9	0.9	8.7	0.7	-	0.3

Source: Department of Supply and Services, Science Centre

According to DSS Science Center data, the two non-complying departments (see 3.4.1) had the highest fraction of their extramural contracts with secondary (manufacturing) industry. Both Communications and Energy, Mines and Resources contracted out more than 50% of their total extramural R&D to manufacturing firms.

On the other hand, the departments which complied with the directive allocated a much higher fraction of their contracts to the service industry. Environment, Transportation, National Health and Welfare, and Agriculture allocated respectively, 65%, 63%, 58% and 38% of their total extramural contracts to the service industry. Department of National Defence is a bit of an outlier here, but otherwise the difference between complying and non-complying departments is remarkable.

As they stand, our findings seem to indicate that non-complying departments contracted out relatively more prior to the directive and tend to contract more with manufacturing industries and less with service industries than do complying departments. As a consequence, the value of R&D contracts of all departments to secondary industry, measured in constant dollars, has fallen between 1972 and 1980.

Taking all complying departments together, the weighted average of their pre-policy industrial involvement (I/R) in 1972[98] was 1.2%. Similar calculations were performed for non-complying departments and the weighted average was found to be 13%.

Based on the distribution of contract money to each sector of the economy as presented in Table VIII, the total value of R&D contracts placed with secondary sector firms (in constant 1971 dollars) for all departments for the year 1972 and 1980 was computed. During this period, the decline in contract values to secondary industry of the non-complying departments dominates the increase in the value of R&D contracts to the same sector placed by complying departments. In the eight years following the implementation of the make-or-buy directive, the value of R&D contracts to secondary industry has actually fallen. Hence, to the extent that the policy was designed to increase R&D contracts to the manufacturing sector as opposed to the service sector, it has failed.

This finding supports claims made by the Canadian Manufacturers' Association. In the MOSST 1975 report, the Association expressed the opinion that "the service sector is receiving too high a proportion of the contracts, without really contributing to the original objective of the policy". (MOSST, 1975 "Make-or-Buy", p. 20)

CHAPTER 8

CONCLUSIONS

Canada does tend to perform a greater proportion of government supported R&D within the government than do a number of similarly situated OECD countries. As a consequence it may be foregoing some benefits which can result from private performance of publically funded R&D. While it is possible that Canada has failed to exploit the potential benefits of contracting-out, it is not necessarily the case. Indeed, it is one of our principal conclusions that a universal contracting-out policy such as the make-or-buy directive is not necessarily conducive to more effective use of our research resources.

Contracting-out can be beneficial because the private contractor has an incentive to exploit the by-products or spin-offs resulting from R&D performed under contract. Contracting-out also involves additional costs in that performance of the research stiuplated in the contract must be assured within the context of an arm's length relationship between the government and the contractor.

There will be cases in which spin-offs are minimal and the costs of arm's length contracting are high. In these cases contracting out reduces the effectiveness with which research resources are used and the application of the make-or-buy directive is ill-advised.

There will also be cases in which spin-offs are large and contracting costs are relatively low. In these cases the application of the make-or-buy directive will increase the effectiveness of a given R&D effort.

There will be an incentive to engage in some contracting out in the absence of a make-or-buy directive. If contractors can exploit spin-offs, this should be reflected in the fee they are willing to accept to perform a given R&D task. The greater the value of appropriable spin-offs the lower will be the contractor's fee relative to the cost to the government of internal performance of a given R&D task. The lower is the cost of extramural relative to intramural performance, the more likely it is that a government department which has the goal of minimizing the cost of its overall research operation will choose to contract out. In this case a centralized make-or-buy directive is redundant at best.

If there are spin-offs which contractors can exploit but this is not for some reason reflected in their desired fee (or bid price) or if the government departments involved have as a major objective the maximization of internal employment there may be little contracting-out even though it is socially advantageous to do so. In this case the application of a centralized make-or-buy directive can be beneficial.

We have argued that spin-offs are most likely where the R&D contractor is an industrial firm. Where the contractor is a service firm, the effect of the make-or-buy directive is simply to duplicate government research facilities outside the government.

We have also argued that contracting costs will be higher the more basic or fundamental is the R&D task involved. Taken together, these arguments imply that the benefits of contracting-out will be greatest for applied industrial R&D and least for basic, non-industrial R&D.

Our investigation of departmental R&D mandates indicates that the R&D tasks of National Health and Welfare, Environment and Agriculture will involve little in the way of appropriable spin-offs. Although we found that these departments have responded to the make-or-buy directive, they have done so largely by contracting out to service firms (R&D specialists). We would conclude that the application of the make-or-buy directive to these departments has not, on balance, been beneficial.

The Department of Transport also complied with the make-or-buy directive and its compliance also involved extensive use of service sector R&D contractors. While the department's R&D mandate is such as to imply that contracting-out is potentially beneficial, the nature of the departmental response to the directive has been such that any benefits realized to date will have been minimal

The department which might be expected to produce the greatest benefits by contracting-out is the Department of Communications. This department ranks first in the proportion of its extramural R&D which is conducted by industrial firms. The Department of Communications also engaged in considerable R&D contracting prior to the issuance of the make-or-buy directive. This is consistent with our argument that there is a decentralized, market-style incentive for a government department to contract-out.

Our analysis of the response to the make-or-buy directive demonstrates that this department did not increase the proportion of its R&D budget contracted-out after the directive was issued. Thus, the department with the largest pre-directive involvement in contracting-out and with the greatest potential for spin-off benefits (due to the high proportion of contracts with manufacturing firms) did not respond to the directive. One possible conclusion is that, in the case of the Department of Communications, the make-or-buy directive was redundant.

A second department where contracting-out is likely to involve significant benefits is the Department of Energy, Mines and Resources. Together with the Department of Communications, this department ranks first in the proportion of its extramural R&D conducted by manufacturing firms. Energy, Mines and Resources did not contract-out extensively prior to the make-or-buy directive nor did it increase the proportion of its R&D budget contracted out in response to the directive.

The failure to respond to the make-or-buy directive may be due to relatively high contracting costs. There is, however, no reason to believe that the marginal cost of contracting should be higher for Energy, Mines and Resources than for Communications. The implication is that a positive response to the directive by EMR could have resulted in a net benefit in terms of the excess of the value of spin-offs over the cost of contracting.

This raises the possibility that the failure of EMR to respond to the make-or-buy directive was not the result of contracting cost considerations but a consequence of the priority attached by the department to assembling and maintaining an internal R&D staff. If this is the case the goals of EMR would appear to be incompatible with those of the government.

The Department of Defence ranks second (to Communications) in the proportion of its R&D activities contracted out prior to the make-or-buy directive. It also ranks second (after Communications and Energy, Mines and Resources) in the proportion of its extramural R&D contracted to manufacturing firms. The evidence on its compliance with the directive is ambiguous. There is no ambiguity, however, in the evidence that such compliance as did occur was partly at the expense of contracts with universities. In sum, this is a department in which contracting-out is potentiallly beneficial and which did, in fact, contract-out on a significant scale prior to the directive. There is some doubt as to whether the make-or-buy directive has had any impact on the proportion of its R&D performed extramurally. This may, again, be reflective of either or both: (1) a relatively high marginal cost of contracting; and (2) a difference between the goals of the government and those of the Department of Defence.

Given the lack of response to the directive on the part of the departments of Communication and Energy, Mines and Resources, and the ambiguity surrounding the response of the Department of Defence, we have the ironic result that the make-or-buy directive has not increased contracting-out in areas where there are potential benefits and has increased it in areas where there are not.

The response to the directive has been confined to departments with little or no history of industrial involvement and has generally involved additional contracts to service sector firms (R&D specialists). The net result has been that, at least as far as the contracts processed by the Science Centre are concerned, constant dollar industrial R&D contracting has actually fallen while service sector contracting has risen since the directive was issued.

The policy implication of our results is that it might be preferable to confine the application of the directive to the departments in which contracting-out can be expected to be beneficial and to investigate whether the observed non-compliance of these departments is due to the redundancy of the directive (no net benefit from additional contracting-out) or to its incompatibility with the goals of the bureaucracy. Only in the latter case would there be grounds for more vigorous enforcement of it.

APPENDIX A

UTILITY MAXIMIZING GOVERNMENT AGENCY MODEL

Let the utility function of the bureaucrat be represented by

$$u(S,P) = u(S, P^i, P^e) = u(S,P(s/k, P^e))$$

where $P = P^e + P^i$ = number of external projects + number of internal projects.

$P^i = S/k$ k = number of staff per internal project.

Bureaucrat's objective is to maximize utility subject to the departmental budget constraint.

$$B = WS + vP^e = wkP^i + vP^e$$

where w = payment per unit of staff

v = payment per external project.

Setting up the Lagrangian expression,

$$L = u(S,P(S/k,P^e)) + \lambda(B-wS-vP^e)$$

gives the following first order conditions for a maximum.

$$\frac{\partial L}{\partial S} = \frac{\partial u}{\partial S} + \frac{\partial u}{\partial P}\frac{1}{k} - \lambda w = 0$$

$$\frac{\partial L}{\partial P} = \frac{\partial u}{\partial P} - \lambda V = 0$$

$$\frac{\partial L}{\partial \lambda} = B - wS - vP^e = 0$$

Eliminating the Lagrangian multiplier we get

$$\frac{\left(\frac{\partial u}{\partial S} + \frac{\partial u}{\partial P}\frac{1}{k}\right)}{\frac{\partial u}{\partial P}} = \frac{w}{v}$$

The above condition can be rewritten as

$$MRS = \frac{\frac{\partial u}{\partial S}}{\frac{\partial u}{\partial P}} = \frac{wk-v}{wk}$$

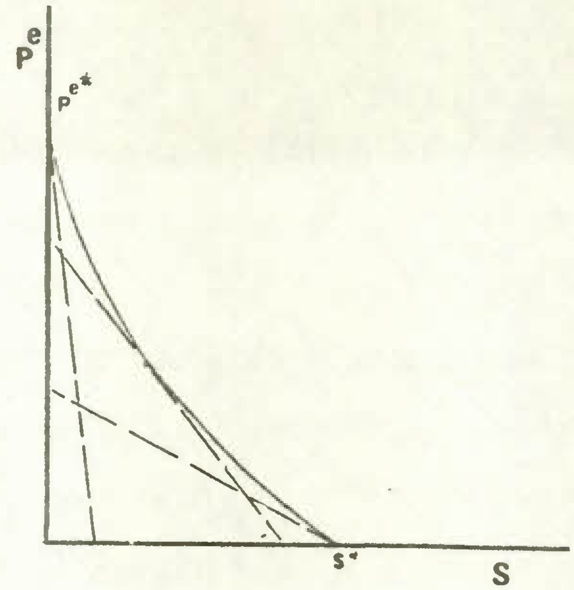
If $v \geq wk$, bureaucrat will exhaust the staff option before contracting out. The number of staff will be increased until the marginal utility derived from the last unit of staff is zero.

If $v < wk$, bureaucrat will choose a combination of staff and number of projects (extramural projects included). That is, the government agency will contract out some of its research tasks. The amount contracted out will depend upon the share of the bureaucrat's utility function.

Assuming that both staff and projects are normal goods, a change (increase) in the departmental science budget, B, will increase both the organizational staff size and the number of extramural projects.

A change in the relative cost of performing R&D will effect the optimal combination of staff and extramural projects. In general, a reduction in the cost of extramural performance will lead to a greater effort by the agency to contract out.

These relationships are presented graphically in Figure I. Staff is plotted along the horizontal line and extramural projects are similarly plotted along the vertical axis. In staff-external project space, a utility set for the bureau can be drawn.



Terms of trade can be obtained directly from the budget constraint. That is

$$B = wS + vP^e$$

$$0 = dB = wds + vdP^e$$

$$\therefore \frac{dP^e}{dS} = \frac{w}{v}$$

Similarly, along the indifference curve, there is no change in utility, hence

$$du = 0 = \left(\frac{\partial u}{\partial S} + \frac{\partial u}{\partial P}\frac{1}{k}\right)dS + \left(\frac{\partial u}{\partial P}\right)dP^e$$

$$\therefore \frac{dP^e}{dS} = \frac{\frac{\partial u}{\partial S} + \frac{\partial u}{\partial P}\frac{1}{k}}{\frac{\partial u}{\partial P}}$$

By introducing indifference curves between extramural projects and staff, the equilibrium results can be interpreted as follows.

First, the optimal combination of staff and project that will yield the highest level of utility for a given budget will be determined by the point of tangency of bureau's utility function and the terms of trade line. That is, where the marginal rate of substitution between S and P^e is equal to slope of the budget line. This in general will give us an interior solution.

Next, consider special cases where we have corner solutions. It can easily be shown that the bureau will not contract out if the terms of trade is greater than the inverse of the number of personnel required for a unit of intramural project.

$$\text{Since } \frac{dP^e}{dS} = \frac{\frac{\partial u}{\partial S} + \frac{\partial u}{\partial P}\frac{1}{k}}{\frac{\partial u}{\partial P}}$$

$$\text{then as } \frac{\partial u}{\partial S} \rightarrow 0 \quad \lim_{\frac{\partial u}{\partial S} \longrightarrow 0} \frac{dP^e}{ds} \rightarrow \quad \frac{1}{k}$$

That is, as the marginal utility of staff approaches zero, the marginal rate of substitution approaches $\frac{1}{k}$. (This is point S* in Figure I). In other words, as long as the cost of performing research intramurally is less than or equal to the cost of extramural project, the bureau will choose an all-staff option.

Our second observation is that we cannot rule out the possibility of an all extramural project option. According to our model, as the terms of trade becomes more steeply sloped (i.e., as staff becomes relatively more expensive), the tangency shifts continuously to the left of S*.

APPENDIX B

Point P^{e*} may be realized if at the vertical axis the marginal rate of sbustitution is less steeply sloped than the price line. This corner solution will persist for all price lines that are greater than or equal to the slope of the indifference curve at P^{e*}.

However, this special corner solution can be ruled out if the first unit of staff is objectively valued very highly by the bureaucrat. That is, if staff is indispensable in the utility function. In such a case, the benefits from expanding the first unit of staff are so high that the slope of the indifference curve exceeds the slope of the budget line (i.e., terms of trade)

(OLS) $(\frac{I}{R}) = \alpha_0 + \alpha_1 TD73 + \alpha_2 G + \mu_t$

Department	Constant	TD73	Growth	TD* Growth	R^2	F	D.W.	ρ
Agriculture	-.219330E-03 (-.130867)	.173301E-02 (11.4508)	-.359459E-03 (-.211631)		.9038	65.7907	1.43	
Communications	.424672 (4.01394)	-.283640E-01 (-2.08504)	.218968E-01 (.241840)		.3258	2.17483	.9301	
E.M.R.	-.711015E-01 (-1.28510)	.508772E-03 (.79777E-01)	.140996 (2.64823)		.3431	3.65559	1.2358	
Environment	.452859E-01 (2.36788)	.107437E-01 (5.53789)	-.172118E-01 (-.385860)		.7056	16.7759	1.7927	
N. Defence	.269440 (3.33239)	-.642001E-02 (-.781511)	.171062E-01 (.193677)		.0418	.305683	.4264	
N.H.W.	.152382E-02 (1.52)	.615006E-03 (4.89)	-.292914E-03 (-.315434)		.6360	12.2308	1.1309	
Transportation	.834226E-01 (.921070)	.386829E-01 (3.37358)	.116737 (1.44952)		.4888	6.63240	1.6838	

CORC $(\frac{I}{R}) = \alpha_0 + \alpha_1 TD_{73} + \alpha_2 G + \mu_t$

Department	Constant	TD73	Growth	TD* Growth	R^2	F	D.W.	ρ
Agriculture	-.271789E-02 (-546579)	.176843E-02 (8.39258)	.195014E-02 (.426112)		.9111	66.6052	1.92	0.26
Communications	.640405 (3.11843)	-.391239E-01 (-1.45951)	-.907066E-01 (-1.00230)		.5906	5.77031	1.25	0.60
E.M.R.	-.156580 (-2.24442)	-.289559E-02 (.382663)	.208440 (3.62872)		.5010	6.52484	.9178	0.29
Environment	-.194698E-01 (-.570434)	.137974E-01 (4.03112)	.346821E-01 (1.37115)		.7471	19.2013	2.1076	.483
N. Defence	.557132E-02 (.740327E-01	.177032E-01 (1.78080)	.139973 (5.17950)		.8657	41.9037	2.31	0.82
N.H.W.	.269260E-02 (1.93)	.518382E-03 (3.146)	-.106485E-02 (-.964512)		.7089	15.8270	2.1289	.34
Transportation	.129681 (.966145)	.357811E-01 (2.55492)	.801076E-01 (.732862)		.4348	5.00017	1.85	0.15

(OLS) $(\frac{I}{R}) = \alpha_0 + \alpha_1 TD73 + \alpha_2 G + \alpha_3 TD73{*}Growth + \mu_t$

Department	Constant	TD73	Growth	TD* Growth	R^2	F	D.W.	ρ
Agriculture	.264154E-03 (-.153747)	.394223E-02 (1.05159)	-.271001E-03 (-.155213)	-.228099E-02 (-.589815)	.9063	41.9334	1.5288	
Communications	.306602 (2.91735)	.391182E-01 (1.15408)	.139427 (1.47999)	-.647422E-01 (-2.13130)	.5714	3.55583	1.2451	
E.M.R.	-.723995E-01 (-1.24144)	.787325E-02 (.132430)	.142369 (2.52852)	-.683685E-02 (-124646)	.3439	2.27087	1.2306	
Environment	.432210E-01 (2.21719)	.230282E-01 (1.55066)	-.1467878E-01 (-.820166)	-.131931E-01 (-.834515)	.7206	11.1735	1.7462	
N. Defence	.275392 (3.27241)	-.4814749E-01 (-.541776)	.109613E-01 (.119389)	.425656E-01 (.471713)	.0580	.266642	.4646	
N.H.W.	.153707E-02 (1.42)	.587018E-03 (.88)	-.305865E-03 (-.30)	.301855E-04 (.04)	.6361	7.5731	1.1316	
Transportation	.116455 (1.28805)	-.375584E-01 (-.688229)	.758353E-01 (.915535)	.799002E-01 (1.42669)	.5580	5.47007	2.0071	

(CORCO) $(\frac{I}{R}) = \alpha_0 + \alpha_1 TD73 + \alpha_2 G + \alpha_3 TD73{*}G + \mu_t$

Department	Constant	TD73	Growth	TD* Growth	R^2	F	D.W.	ρ
Agriculture	-.335031E-02 (-.585661)	.307252E-02 (.778510)	.259232E-02 (.485783)	-.134403E-02 (-.329569)	.9117	41.3223	1.8960	.2127
Communications	.424517 (1.60977)	.126973E-01 (.251551)	.380959E-01 (.267246)	-.378843E-01 (-1.16739)	.6569	4.46836	1.2632	.57220
E.M.R.	-.163654 (-2.22095)	.238558E-01 (.488054)	.215539 (3.50837)	-.198805E-01 (-.435173)	.5087	4.14134	.8574	.51
Environment	-.318077E-01 (-.968203)	.330419E-01 (2.64699)	.451911E-01 (1.88314)	-.206828E-01 (-1.58424)	.7904	15.0879	1.9874	.51771
N. Defence	.607821E-02 (.775854E-01)	.150996E-01 (.566729)	.139519 (4.90278)	.279342E-02 (.105616)	.8685	25.8165	2.2965	.82061
N.H.W.	.293675E-02 (1.87)	.310608E-03 (.50)	-.128693E-02 (-1.02)	.218406E-03 (.35)	.7118	9.88080	2.1514	.32
Transportation	.171602 (1.30405)	-.522464E-01 (-.888854)	.294870E-01 (.255313)	.936973E-01 (1.57193)	.5157	4.28937	1.9377	-.04362

(OLS) $(\frac{I}{R}) = \alpha_0 + \alpha_1 TD74 + \alpha_2 G + \mu_t$

Department	α_0	α_1	α_2	α_3	R^2	F	D.W.	ρ
Agriculture	-.121802E-03 (-.907371E-01)	.205826E-02 (14.5550)	-.167996E-03 (-.123487)		.9382	106.28	2.12	
Communications	.416523 (4.01)	-.333116E-01 (-2.13)	.209078E-01 (.23)		.3356	2.273	.93	
E.M.R.	-.709830E-01 (-1.28)	.509349E-03 (.068)	.141117 (2.65)		.3430	3.654	1.24	
Environment	.475670E-01 (2.47)	.124579E-01 (5.43)	-.172605E-01 (-.976)		.6978	16.163	1.89	
N. Defence	.268738 (3.29)	-.488655E-02 (-.505)	.113977E-01 (.128)		.0179	0.128	.44	
N.H.W.	.175434E-02 (1.699)	.697936E-03 (4.569)	-.374480E-03 (-.388)		.6040	10.6776	1.01	
Transportation	.888048E-01 (.92)	.412730E-01 (2.89)	.125227 (1.46)		.4201	5.0719	1.59	

(CORC) $(\frac{I}{R}) = \alpha_0 + \alpha_1 TD74 + \alpha_2 G + \mu_t$

Department	α_0	α_1	α_2	α_3	R^2	F	D.W.	ρ
Agriculture	-.334122E-02 (-.45)	.209703E-02 (13.48)	.295910E-02 (.41)		.9381	98.5185	2.06	-.07234
Communications	.589369 (3.15)	-.387193E-01 (-1.37)	-.785107E-01 (-.87)		.5794	5.5115	1.2523	.59232
E.M.R.	-.154468 (-2.24)	.277251E-02 (.32)	.208148 (3.61)		.4993	6.48086	.92	.29257
Environment	.109661 (3.78)	.106222E-01 (5.66)	-.736228E-01 (-2.82)		.7421	18.6990	1.48	-.35753
N. Defence	-.263258E-01 (-.35)	.257091E-01 (2.43)	.139975 (5.64)		.8829	49.0190	2.30	.84336
N.H.W.	.287472E-02 (2.08)	.580122E-03 (2.91)	-.107347E-02 (-.995)		.7077	15.7391	2.16	.39242
Transportation	.160183 (1.12)	.344260E-01 (1.85)	.708389E-01 (.63)		.3759	3.91468	1.95	.2368

(OLS) $(\frac{I}{R}) = \alpha_0 + \alpha_1 TD74 + \alpha_2 G + \alpha_3 GTD74 + \mu_t$

Department	α_0	α_1	α_2	α_3	R^2	F	D.W.	ρ
Agriculture	-.133290E-03 (-.096)	.274286E-02 (.76)	-.145458E-03 (-.10)	-.708105E-02 (-.19)	.9384	65.9894	2.15	
Communications	.296567 (2.99)	.537534E-01 (1.37)	.139686 (1.57)	-.823937E-01 (-2.34)	.6059	4.09898	1.28	
E.M.R.	-.720786E-01 (-1.24)	.880441E-02 (.12)	.142352 (2.53)	-.779934E-02 (-.16)	.3437	2.26893	1.23	
Environment	.455071E-01 (2.32)	.269041E-01 (1.50)	-.148396E-01 (-.82)	-.155621E-01 (-.81)	.7124	10.7340	1.83	
N. Defence	.273565 (3.21)	-.455524E-01 (-.42)	.651642E-02 (.07)	.413876E-01 (.38)	.0287	.12786	0.46	
N.H.W.	.178562E-02 (1.61)	.608605E-03 (.70)	-.405972E-03 (-.39)	.965116E-04 (.10)	.6044	6.61918	1.01	
Transportation	.102335 (1.03)	-.141166E-01 (-.19)	.109065 (1.22)	.580794E-01 (.77)	.4452	3.47798	1.79	

(CORC) $(\frac{I}{R}) = \alpha_0 + \alpha_1 TD74 + \alpha_2 G + \alpha_3 GTD74 + \mu_t$

Department	α_0	α_1	α_2	α_3	R^2	F	D.W.	ρ
Agriculture	-.379759E-02 (-.50)	.395795E-02 (1.07)	.344095E-02 (.46)	-.191558E-02 (-.50)	.9392	61.8003	2.09	-.12369
Communications	.250265 (1.11)	.564591E-01 (1.00)	.158431 (.95)	-.784120E-01 (-1.74)	.6714	4.76659	1.23	.31380
E.M.R.	-.159839 (-2.20)	.257384E-01 (.44)	.213942 (3.49)	-.219151E-01 (-.40)	.5058	4.09331	0.87	.23655
Environment	-.213686E-01 (-.62)	.382146E-01 (2.39)	.415860E-01 (1.59)	-.255415E-01 (-1.51)	.7596	12.6397	1.97	.49419
N. Defence	-.354318E-01 (-.44)	.183403E-01 (.64)	.138181 (5.35)	.898529E-02 (.32)	.8842	30.5361	2.26	.85056
N.H.W.	.315562E-02 (2.06)	.279509E-03 (.38)	-.133799E-02 (-1.09)	.318480E-03 (.43)	.7119	9.88601	2.174	.36940
Transportation	.169901 (1.13)	-.807591E-02 (-.11)	.570342E-01 (.46)	.464511E-01 (.61)	.3911	2.56971	1.97	.15844

TOBIT ANALYSIS

Department	Constant	$TD^{73}/74$	Growth	TD# Growth	R^2	F	D.W.	ρ
Agriculture	-.46975E-02 (-.20024)	.24985E-02 (3.7311)	-.29288E-03 (-.12566E-01)		.3535		2.74	
	.12271E-02 (.74303E-01)	.25779E-02 (4.1337)	-.43278E-02 (-.24256)		.9530		2.74	
N.H.W.	.43865E-02 (1.9050)	.53819E-03 (3.3451)	-.35725E-02 (-1.6189)		.6524		1.33	
	.49913E-02 (2.0713)	.71978E-03 (3.2374)	-.40215E-02 (-1.7268)		.6321		1.28	

(OLS) $\frac{E}{R} = \beta_0 + \beta_1 TD73 + \beta_2 G + V_t$

Department	Constant	TD73	G	GTD74	R^2	F	D.W.	ρ
Agriculture	.384214E-02 (.877497)	.361613E-02 (9.14571)	.797243E-02 (1.79664)		.8653	44.9820	1.4248	
Communications	.762497E-01 (.502706)	.185590E-02 (.437283)	.132681E-01 (.479634)		.0491	.232182	1.7560	
E.M.R.	.384606E-01 (.724516)	.351794E-01 (5.74930)	-.521924E-02 (-.102171)		.7076	16.9373	1.7363	
Environment	.109972E-01 (.585436)	.477313E-02 (2.50493)	.293332E-01 (1.71061)		.3708	4.12550	.9227	
N. Defence	.668745E-01 (4.24806)	-.350259E-02 (-2.18746)	.296495E-02 (.172224)		.2585	2.44054	.6837	
N.H.W.	.598675 (16.42)	-.399216E-01 (-8.73216)	.639274E-01 (1.89863)		.8559	41.5697	1.6636	
Transportation	.848014E-01 (2.53505)	.103613E-02 (.244661)	.138075E-01 (.464202)		.0191	.136538	1.4920	

(CORC) $(\frac{E}{R}) = \beta_0 + \beta_1 TD73 + \beta_2 G + V_t$

Department	Constant	TD73	G	GTD74	R^2	F	D.W.	ρ
Agriculture	.200802E-01 (1.90343)	.339248E-02 (6.18835)	-.694744E-02 (-.731725)		.8800	47.6457	1.4973	.34
Communications	.264443E-01 (.463307)	.124911E-02 (.234274)	.682619E-02 (.160594)		.0211	.861499E-01	2.0281	.11
E.M.R.	.107283 (1.38256)	.349842E-01 (4.66600)	-.657680E-01 (-.987709)		.7165	16.4238	1.9069	.21
Environment	.396098E-01 (1.35675)	.277237E-02 (.846826)	.888161E-02 (.441154)		.4853	6.12898	2.1144	.56
N. Defence	.100222 (6.96945)	-.437866E-02 (-2.33371)	-.237658E-01 (-2.15589)		.7168	16.4494	1.6288	.54
N.H.W.	.579615 (10.6355)	-.386342E-01 (-7.22696)	.780590E-01 (1.66178)		.8614	40.4066	1.7605	.10
Transportation	.178059 (3.69579)	-.534559E-02 (-.747451)	-.515074E-01 (-1.74383)		.2527	2.19758	2.1957	.54

(OLS) $(\frac{E}{R}) = \beta_0 + \beta_1 TD73 + \beta_2 G + \beta_3 GTD73 + V_t$

Department	Constant	TD74	G	GTD74	R^2	F	D.W.	ρ
Agriculture	.369983E-02 (.829583)	.106301E-01 (1.09237)	.825327E-02 (1.82103)	-.724180E-02	.8705	29.1342	1.3401	
Communications	-.547958E-02 (-.146055)	.143856E-01 (1.18885)	.348981E-01 (1.03763)	-.119150E-01 (-1.10392)	.1748	.564764	1.8033	
E.M.R.	.409174E-01 (.732524)	.212402E-01 (.373006)	-.781623E-02 (-.144935)	.130541E-01 (.246320)	.7089	10.5542	1.6759	
Environment	.129582E-01 (.675616)	-.689334E-02 (-.471774)	.269362E-01 (1.52872)	.12529E-01 (.805500)	.4007	2.89762	.9394	
N. Defence	.656247E-01 (4.00247)	.484410E-02 (.279613)	.419330E-02 (.234424)	-.850875E-02 (-.483982)	.2716	1.61611	.7187	
N.H.W.	.614129 (16.8215)	-.72567E-01 (-3.23333)	.488172E-01 (1.44085)	.352201E-01 (1.48341)	.8767	30.8230	1.4697	
Transportation	.853117E-01 (2.37587)	-.141674E-03 (-.653667E-02)	.131756E-01 (.400511)	.123433E-02 (.554952E-01)	.0194	.85569E-01	1.4986	

(CORC $(\frac{E}{R}) = \beta_0 + \beta_1 TD73 + \beta_2 G + \beta_3 TD73 + V_t$

Department	Constant	TD74	G	GTD74	R^2	F	D.W.	ρ
Agriculture	.179368E-01 (1.97578)	.149897E-01 (1.61060)	-.434215E-02 (-551924)	-.120755E-01 (-1.24663)	.8925	33.2246	1.4204	.43
Communications	-.852476E-01 (-.85817)	.284359E-01 (1.36209)	.968017E-01 (1.23863)	-.228343E-01 (-1.34351)	.2217	.664779	1.3401	.12
E.M.R.	.122235 (1.53628)	-.222850E-02 (-.422053E-01)	-.794235E-01 (-1.18482)	.352127E-01 (.713591)	.7271	10.6585	1.7851	.27
Environment	.452507E-01	-.757987E-02	.336002E-02	.113441E-01	.5220	4.36896	2.2109	.55
N. Defence	.100031 (6.61990)	-.352679E-02 (-.376810)	-.235883E-01 (-2.02170)	-.888047E-03 (-.929588E-01)	.7170	10.7328	1.6328	.54
N.H.W.	.654550 (10.9228)	-.802870E-01 (-3.52648)	.101223E-01 (.219586)	.437102E-01 (1.94683)	.8882	31.7909	1.8861	.41
Transportation	.181091 (3.43116)	-.861715E-02 (-.476496)	-.545832E-01 (-1.58073)	.344684E-02 (.202758)	.2551	1.37019	2.1645	.54

(OLS) $(\frac{E}{R}) = \beta_0 + \beta_1 TD74 + \beta_2 G + V_t$

Department	Constant	TD73	Growth	TD* Growth	R^2	F	D.W.	ρ
Agriculture	.412132E-02 (.951138)	.422184E-02 (9.24896)	.841865E-02 (1.91709)		.8679	45.9931	1.3921	
Communications	.184088E-01 (.572462)	.123587E-02 (.255190)	.137792E-01 (.494969)		.0358	.167261	1.7223	
E.M.R.	.436242E-01 (.879826)	.420827E-01 (6.20866)	-.519792E-02 (-.108885)		.7442	20.3685	1.9512	
Environment	.137351E-01 (.700164)	.487632E-02 (2.08726)	.286695E-01 (1.59081)		.3051	3.07300	.8429	
N. Defence	.665602E-01 (4.25956)	-.416313E-02 (-2.25092)	.269209E-02 (.157932)		.2695	2.58209	.7025	
N.H.W.	.583917 (14.4673)	-.454055E-01 (-7.60319)	.691802E-01 (1.83494)		.8189	31.6448	1.2974	
Transporation	.867425E-01 (2.58267)	.170240E-03 (.343531E-01)	.137803E-01 (.461872)		.0150	.106753	1.4781	

(CORC) $(\frac{E}{R}) = \beta_0 + \beta_1 TD74 + \beta_2 G + V_t$

Department	Constant	TD73	Growth	TD* Growth	R^2	F	D.W.	ρ
Agriculture	.224129E-01 (2.29478)	.392071E-02 (6.63842)	-.845105E-02 (-.953765)		.8924	53.9015	1.5497	.34
Communications	.305525E-01 (.552586)	.580902E-03 (.972923E-01)	.559089E-02 (.132410)		.0156	.635797E-01	2.0415	.12
E.M.R.	.110777 (1.47494)	.417112E-01 (5.58638)	-.648270E-01 (-.967204)		.7494	10.4389	2.0184	.13
Environment	.438099E-01 (1.51592)	.226536E-02 (.585643)	.791346E-02 (.401614)		.4745	5.87020	2.1356	.59
N. Defence	.987114E-01 (6.91038)	-.476764E-02 (-2.25702)	-.240903E-01 (-2.13049)		.7089	15.8256	1.6622	.53
N.H.W.	.583533 (9.70992)	-.427356E-01 (-5.10344)	.620251E-01 (1.28875)		.8441	35.1846	1.7963	.36
Transportation	.172063 (3.68054)	-.488146E-02 (-.627456)	-.506656E-01 (-1.66229)		.2460	2.12076	2.1913	.51

(OLS) $(\frac{E}{R}) = \beta_0 + \beta_1 TD74 + \beta_2 G + \beta_3 GTD74 + V_t$

Department	Constant	TD74	Growth	TD*Growth	R^2	F	D.W.	ρ
Agriculture	.403687E-02 (.903430)	.925505E-02 (.800137)	.858436E-02 (1.89074)	-.520604E-02 (-.435501)	.8698	28.9506	1.3229	
Communications	-.245282E-02 (-.65918E-01)	.163774E-01 (1.10906)	.344359E-01 (1.02750)	-.143291E-01 (-1.08415)	.1593	.505475	1.7807	
E.M.R.	.451650E-01 (.868152)	.298586E-01 (.459776)	-.701859E-02 (-.139264)	.114936E-01 (.189307)	.7448	12.6558	1.8975	
Environment	.154351E-01 (.764079)	-.704595E-02 (-.382350)	.266715E-01 (1.42962)	.128432E-01 (.652456)	.3271	2.10653	.8383	
N. Defence	.656845E-01 (4.02516)	.321485E-02 (.156052)	.357770E-02 (.201295)	-.750893E-02 (-.359684)	.2767	1.65747	.7263	
N.H.W.	.596960 (14.4389)	-.826513E-01 (-2.56265)	.560498E-01 (1.44296)	.402399E-01 (1.17460)	.8362	22.1286	1.0994	
Transportation	.883395E-01 (2.50079)	-.636742E-02 (-.243944)	.118727E-01 (.373654)	.685513E-02 (.255448)	.0199	.881687E-01	1.4731	

(CORC) $(\frac{E}{R}) = \beta_0 + \beta_1 TD74 + \beta_2 G + \beta_3 G{*}TD74 + V_t$

Department	Constant	TD74	Growth	TD*Growth	R^2	F	D.W.	ρ
Agriculture	.197739E-01 (2.33017)	.154900E-01 (1.45238)	-.540741E-02 (-.728938)	-.120719E-01 (-1.08486)	.9007	36.2859	1.4445	.43
Communications	-.549842E-01 (-.595335)	.269160E-01 (1.13067)	.759300E-01 (1.02676)	-.226831E-01 (-1.14235)	.1702	.478548	1.4897	.14
E.M.R.	.125209 (1.63267)	.365339E-02 (.593210E-01)	-.785994E-01 (-1.16162)	.360111E-01 (.622957)	.7564	12.4212	1.9280	.19
Environment	.488218E-01 (1.65170)	-.934708E-02 (-.696347)	.298081E-02 (.143765)	.128471E-01 (.907189)	.5081	4.13183	2.1912	.58
N. Defence	.987429E-01 (6.58241)	-.484370E-02 (-.435407)	-.241368E-01 (-2.01838)	-.801596E-04 (.703751E-02)	.7089	9.739	1.6624	.53
N.H.W.	.645461 (9.86694)	-.937426E-01 (-3.39004)	.660246E-02 (.155261)	.542950E-01 (2.05977)	.8799	29.3113	1.8588	.60
Transportation	.182396 (3.69178)	-.199857E-01 (-.950068)	-.593532E-01 (-1.82212)	.155400E-01 (.769274)	.2814	1.56629	2.0607	.52

$$(OLS)\ \left(\frac{I}{R}\right)_{it} = \sum_{i=1}^{7} \beta_{oi} D_i + \beta_G G + \beta_9 GTD + \sum_{j=0}^{n} \beta_j X_j TD + \beta_\ell TD + U_{it}$$

	OLS 1973	OLS 1974	TOBIT 1973	TOBIT 1974
β_{01}	-.145974 (-2.85)	-.102078 (-2.87)	-.17783 (-3.44)	
β_{02}	.464408 (5.29)	.296899 (5.41)	.30768 (4.38)	
β_{03}	-.221915E-01 (-.58)	-.228E-01 (-.60)	-.41433E-01 (-.85)	
β_{04}	-.124022 (-2.24)	-.115273 (-2.22)	-.17388 (-2.69)	
β_{05}	-.434674E-02 (-.04)	.140044E-01 (.10)	-.15905 (-.96)	
β_{06}	-.941272E-01 (-2.01)	-.102658 (-2.11)	-.13914 (-2.28)	
β_{07}	.961220E-01 (2.76)	.130705 (3.05)	.13393 (2.44)	
(G) β_G	.974798E-01 * (3.29)	.989567E-01 * (3.35)	.10038 * (2.39)	
(GTD) β_9	-.244521E-01 * (-2.09)	-.353000E-01 * (-2.36)	-.36044E-01 * (-2.04)	
(E) β_1	-.709568E-03 * (-2.94)	-.797767E-03 * (-3.31)	-.95877E-03 * (-3.43)	
(K) β_2	-.211509E-03 (-.41)	-.104527E-03 (-.19)	-.84591E-03 (-1.35)	
(N) β_3	-.122284 * (-2.57)	-.136605 * (-2.85)	-.1700 * (-3.09)	
(TD) β_ℓ	.778827E-01 * (2.93)	.919984E-01 * (3.40)	.12733* (4.03)	
R^2	.7164	0.7120	.71	
(12,94) F	19.78*	19.36*		
DW	1.71	1.69	1.66	

	(OLS)		(TOBIT)	
	1973	1974	1973	1974
β_{01}	-.151392	-.104074	-.28836	-.19076
	(-2.94)	(-2.92)	(-3.66)	(-3.60)
β_{02}	.507177	.312854	.57381	.33321
	(5.28)	(5.43)	(4.72)	(4.61)
β_{03}	-.156914E-01	-.180046E-01	-.35195E-01	-.36943E-01
	(-.41)	(-.48)	(-.71)	(-.76)
β_{04}	-.100235	-.964319E-01	-.14105	-.13902
	(-1.68)	(-1.72)	(-1.96)	(-2.05)
β_{05}	.284925E-01	.485289E-01	-.88476E-01	-.90863E-01
	(.23)	(.33)	(-.62)	(-.54)
β_{06}	-.962058E-01	-.106104	-.13508	-.14855
	(2.06)	(-2.17)	(-2.32)	(-2.44)
β_{07}	.969099E-01	.130161	.10015	.13124
	(2.79)	(3.04)	(2.28)	(2.41)
G	.938795E-01*	.964918E-01*	.92464E-01*	.97919E-01*
	(3.15)	(3.25)	(2.21)	(2.35)
GTD	-.235696E-01*	-.344077E-01*	-.24231E-01	-.35036E-01*
	(-2.01)	(-2.29)	(-1.77)	(-2.00)
(E) β_1	-.255504E-03	-.358045E-03	.97384E-04	-.15495E-03
	(-0.53)	(-.67)	(.17)	(-.25)
(K) β_2	.765456E-03	.836776E-03	.12133E-02	.86555E-03
	(0.74)	(.72)	(1.01)	(.65)
(N) β_3	-.595970E-01	-.757920E-01	-.13654E-01	-.56221E-01
	(-.80)	(-.93)	(-.16)	(-.60)
(CV) β_4	-.163178	-.136915	-.36336*	-.25025
	(-1.09)	(-.92)	(-2.01)	(-1.45)
β_5				
TD	.625137E-01*	.731407E-01*	.81388E-01*	.93542E-01*
	(2.09)	(2.15)	(2.40)	(2.44)
R^2	.7200	.7146	.72	.7124
F	18.3939*	17.9113*		
DW	1.74	1.71	1.70	1.65

$$\left(\frac{I}{R}\right) = \sum_{i=1}^{7} \beta_{oi} D_i + \beta_{\ell} TD + \beta_9 G_{-1} + \beta_9 G_{-1} TD + \sum_{j=0}^{N} \beta_j X_j TD + u_{it}$$

		OLS 1973	OLS 1974
	β_{01}	-.133650 (-2.52)	-.968624E-01 (-2.67)
	β_{02}	.56803 (5.39)	.331583 (5.50)
	β_{03}	-.255656E-01 (-.65)	-.288076E-01 (-.75)
	β_{04}	-.922211E-01 (-1.47)	-.865984E-01 (-1.49)
	β_{05}	.363714E-01 (.25)	.294462E-01 (.18)
	β_{06}	-.956402E-01 (-2.03)	-.105409 (-2.14)
	β_{07}	.100188 (2.88)	.131567 (3.05)
	β_{ℓ}	-.147662 (-.87)	-.134510 (-.75)
	β_G	.906956E-01* (3.03)	.950880E-01* (3.19)
	β_9	-.243788E-01* (-2.07)	-.358479E-01* (-2.37)
(E)	β_1	-.256896E-02 (-1.52)	-.220700E-02 (-1.32)
(K)	β_2	-.947952E-03 (-.60)	-.635704E-03 (-.38)
(N)	β_3	-.185947 (-1.59)	-.177777 (-1.52)
(PE)	β_5	.100575 (1.35)	.715822E-01 (.98)
(MG)	β_6	.25440 (1.25)	.24807 (1.17)
(CV)	β_4	.214546 (.70)	.178437 (0.57)
	R^2	.7261	.7192
	F	16.0825*	15.54*
	DW	1.80	1.74

FOOTNOTES

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6. The Globe and Mail, 15 April 1981, Report on Business, np.

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9. Senate of Canada, Special Committee on Science Policy (1972), A Science Policy for Canada, Vol. 2, p. 586.

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28. Ibid., pp. 581-586.

29. Ibid.

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32. Senate of Canada, Special Committee on Science Policy, A Science Policy for Canada, Vol. 2, p. 586.

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34. Senate of Canada, Special Committee on Science Policy, A Science Policy for Canada, Vol. 1, p. 240.

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36. Ibid.

37. Ministry of State for Science and Technology (MOSST) (1976), The Make or Buy Policy 1973-1975 (Supply and Services, Ottawa), p. 4.

38. Treasury Board, Administrative Policy Branch, Guidelines for the Implementation of the Make or Buy Policy Concerning Research and Development Requirements in the Natural Sciences, January 1973, p. 2; Policy and Guidelines on Contracting out the Government's Requirements in Science and Technology, April 1977.

39. Ibid.

40. P. Meyboom (1974), op.cit., p. 579.

41. Ibid., p. 585.

42. Ministry of State for Science and Technology, op.cit., p. 25.

43. Ibid., p. 25.

44. D.G. McFetridge (1981), op.cit., pp. 266-267.

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58. Ibid., p. 16.

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60. Ibid., p. 14.

61. See Table II.

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80. M. Prince and J. Rice, "The Department of National Health and Welfare: The Attack on Social Policy", _How Ottawa Spends Your Tax Dollars_, p. 91.

81. _Ibid._, p. 92.

82. _Ibid._, p. 93.

83. _Ibid._

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85. Ibid., p. 9A:35-6, p. 9A:65-66.

86. Senate of Canada, Proceedings of the Special Committee of the Senate on Science Policy, Issue 9A, p. 9A:139-152.

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88. Transport Canada, Annual Reports 1979/80, p. 3.

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95. For more information see J. Kmenta, Elements of Econometrics (New York: MacMillan Publishing Co., Inc.), 1971, p. 509.

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98. Weighted average of prepolicy industrial involvement is calculated as follows

$$\sum_{n=1}^{N} {}^{e}w_i (I/R) \text{ for complying departments}$$

and

$$\sum_{i=1}^{N} {}^{NC}w_i (I/R) \text{ for non-complying departments}$$

(i.e., Communications and Energy Mines and Resources). I and R are the same as notation used above.

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