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SCIENCE POLICY IN CANADA: A CONJUNCTION OF PHILOSOPHY, SCIENCE AND POLITICS

by

M. W. Jackson ©

A THESIS

SUBMITTED TO THE FACULTY OF GRADUATE STUDIES AND RESEARCH IN PARTIAL FULFILMENT OF THE REQUIREMENTS OF THE DEGREE OF DOCTOR OF PHILOSOPHY

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FACULTY OF GRADUATE STUDIES AND RESEARCH

The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research, for acceptance, a thesis entitled "Science Policy in Canada: A Conjunction of Philosophy, Science and Politics" submitted by Michael Jackson in partial fulfilment of the requirements for the degree of Doctor of Philosophy.

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DEDICATION

To the Graduate Programme of the Department of Political Science at the University of Alberta, past, present and future, particularly, but not exclusively, to the Bullpen inmates.

ABSTRACT

The thesis of this essay is that science policy in Canada touches upon, and is touched by the deepest issues of public life, independence and integration. Generally science policy is treated as an ordinary case of interest group politics and public policy. However, each such case has unique features and this study focuses on those of science. Three levels of analysis are pursued. The first identifies and criticizes a technocratic tendency in contemporary Canadian politics. This tendency is to suppose that instrumental productivity and organization, to which science can uniquely contribute, will alleviate conflict-generating scarcity. For it wealth produces happiness. Level two explicates and criticizes a technocratic proclivity to see knowledge as the key to wealth. This proclivity emphasizes an inductivist methodology, the limitations of which are discussed. Together, it is argued, instrumental and inductivist conceptions give priority to big science, which was, but is not necessarily now, productive. Thirdly emphasized is industrial-developmental research. Canadian deficiencies in these areas are traced to the behaviour of the subsidiaries of multi-national corporations owned in the United States. Foreign ownership is shown to be an important economic issue which relates both to Canadian independence from the United States and integration between English and French Canada. The advocacy of science policy by some is held

to be an attempt to get around the political difficulty of the latent conflict between independence and integration by increasing productivity with science and technology, not foreign capital. Otherwise belt tightening for the purposes of Canadian independence condemns Quebec to dependency on English Canada.

PREFACE

"The weakness of all utopias is this, that they take the greatest difficulty of man and assume it to be overcome, and then give an elaborate account of the overcoming of the smaller ones. They first assume that no man will want more than his share, and then are very ingenious in explaining whether his share will be delivered by motor car or balloon."

Sam J. Lundwall, *Science Fiction* (New York: Ace, 1971), p. 50.

"Canadian public opinion has two dangerous propensities: to accept the American myth that with enough science you can reach and sustain an ideal state of society, and to accept the European myth that with enough policy of any kind you can become as rich and powerful as the United States."

Harry Johnson, "Comments on Senator Grossart's Paper", *Minerva*, IX (1971) 4, p. 547.

ACKNOWLEDGMENTS

My interest in the problems of science policy was first kindled while in the employ of the Alberta Human Resources Research Council where I was forced to confront some of them and given the opportunity to think about them. My pursuit of that interest since then has been especially aided by a legion of nameless information officers and secretaries who have quickly and kindly replied to my numberless inquiries for unpublished documents and records. Without this service nothing could have been done. The same is true of a number of librarians and libraries upon which I imposed. I am grateful for the opportunity to have read Bruce Doern's book *Science and Politics in Canada* in manuscript form before its publication. Valuable bibliographic help was received from the Social Science Information System of York University. Senator Maurice Lamontagne made available to me a complete set of the Senate Special Committee's hearings which greatly eased a fundamental part of the task. Financial support is happily acknowledged from a University of Alberta's Dissertation Fellowship and the Canada Council's Doctoral Awards. At various times funds were made available to me to travel by the Faculty of Graduate Studies and Research of the University of Alberta, the Graduate Student's Association, the Canadian Union of Students, and the Association of the Scientific, Technological and Engineering Communities of Canada (SCITEC). Whatever its defects, SCITEC provided a valuable medium in which to observe, meet and talk with a

number of scientists and politicians. Finally, I am grateful to the members of my examining committee for their care, tolerance and patience.

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INTRODUCTION

When originally conceived, this study was to be exclusively directed to the most general features of the (1) political philosophic and (2) philosophy of science issues evoked by the considerations of national science policy. Features such as then were exclusively in mind were those to be encountered in nearly any conceptual inspection of science policy. Doubtlessly, these conceptual issues are important, though they may be issues more honoured in silence than in speech. In the pages which follow these issues will have a major part to play.

While of the greatest moment, these issues do not exclusively occupy the attention of this study. As crucial as these two dimensions of conceptual concern are, it is clear that particular features of the (3) Canadian context must be taken into account. Appreciation of all three together is relevant to the task of clarifying the place of science in Canadian society and politics.

This study divided into three main parts. The first devotes itself to philosophical questions about the nature of politics. These questions arise from the use of science as an instrument of public policy. The second part turns attention to questions arising within the scientific community due to the attempt of instrumental control. These are primarily questions of the methodology of science. In the third and last part, focus shifts to political questions arising out of the Canadian historical, geographical and constitutional situation.

What follows in this the introductory chapter is a discussion consisting of five parts: Part (1) outlines the idea of national science policy. Part (2) examines the relevance of the Canadian experience with national science policy to that idea. Part (3) takes up the relevance of national science policy to Canadian public life. Next, Part (4), asks whether national science policy needs recommendations, or analysis. Lastly, Part (5) outlines the themes of this study.

1. THE IDEA OF NATIONAL SCIENCE POLICY

It is the thesis of this study that the puzzling debate over Canadian national science policy is only one symptom of a more fundamental, deeper-lying difficulty in the Canadian polity. Some students of Canadian science policy believe it to constitute a distinct and self-contained area of investigation. Accordingly, their attention is narrowly focused on matters of "science policy".(1) In contrast the argument here is that the problems of Canadian science policy cannot be understood, much less resolved, without their first being recognized as manifestations of the more general difficulties of all Canadian policies and politics. Until such time as this recognition occurs, neither the explicit nor the implicit goals of national science policy will be attained.

A national science policy is possible only when the structural faults which cause it to emerge as an issue have been confronted and resolved. The key aspects of the character of science in Canada have been generated by the society's most basic social and economic structures. Making policy for science without first changing these underlying structures is foredoomed. Were it, however, possible in some hydroponic sense, the altered configuration of science would have little influence on those more important social and economic structures. The mouse of science can have but little affect on the elephant of society.

Of course, it is widely recognized that science is related to the more pervasive aspects of our society. Indeed, it is for this reason that science policy is recurrently a cause for public concern. For those who place faith in science the hope is that by manipulating science those more pervasive features can be altered. This hope is the product of either mistaking the inescapable relationship of symptom and disease for an indentify, or attempting to cure the disease by quelling but one symptom.

As has been previewed this study proceeds from three main perspectives. First is that of philosophy. This approach consists of a political philosophic analysis of the role of the product of science, of knowledge, in public policy. A certain role is attributed to knowledge, as the product of science, by the advocates of a national science policy. We must ask, "What is the role?" Then, "Is this role desirable?"

Second is the perspective of science. From a philosophy of science point of view, an analysis is conducted of the role of the political process in ruling science. Here the question of concern is, "Is it possible to fulfill the role ascribed to politics in science?"

Finally, there is undertaken a political analysis of the aspects of national science policy particular to Canada. Asked here is the question "Can Canada achieve the benefits of science, such as they are understood to be in view of the constraints introduced by the preceding two perspectives?"

Studying national science policy from those three perspectives results in an examination of a rather different order from the mainstream of public policy investigations. Principally it is different in two main ways.

First, this study is concerned primarily with evaluating the policy under examination, not analyzing its evolution, current status or future prospects. Just as policy makers often tend to become so preoccupied with the analysis of the feasibility of policies that sight is lost of the prior questions of desirability, so too it is with policy students. The public policy literature abounds with studies of feasibility. Contributing to that literature is not the purpose at hand. The prior question of desirability will always be foremost in this study.

Naturally this evaluation proceeds with close attention to the relevant evidence. Moreover such a study as this must necessarily be philosophical as well as practical in character, a conclusion of redoubled, not diminished, importance precisely because it is not generally held in either policy making or policy studying.

Emphasis must be given to a second difference between this and more orthodox studies of public policy. This study is argumentative. I maintain that contemporary proponents of a national science policy for Canada--Senator Maurice Lamontagne and those of a similar persuasion--are fundamentally mistaken.

They are mistaken first in their conception of science in general. Specifically, their mistake concerns the expectations of the amount and impact of the technological and economic fruits science can be made to yield under even the most careful cultivation.

Furthermore, they are also mistaken in some of their central assumptions about the nature of the Canadian polity and economy. These matters constitute the indispensible underpinnings of the advocacy of national science policy in Canada. If they are brought into a reasonable doubt, then so is the idea of science policy.

At a time in the not too distant past, it would have been thought to be ridiculous to suggest that government was responsible for the control of the economy. The necessities of the Depression and the Second World War have ensured that this suggestion is no longer a laughing matter. Now throughout the world's elections political parties offer competing economic policies and the governing parties devote the vast majority of the attention of the government to this area of policy. Thus, Presidents of the United States before 1929 were judged both by their contemporaries and history in reference to such social and foreign policies as conservation and border consolidation. Consider T. R. Roosevelt and W. Wilson. After 1930 the Presidents and the years of their administrations are invariably thought of in reference to economic matters: F. D. Roosevelt's New Deal; H. Truman's Fair Deal; Eisenhower's recessions; Kennedy's deficit financing and more recently the President's name has been attached to his economic policies, Nixonometrics.

The Depression and World War II together sired another kind of policy too, science policy. Though science policy must be judged without excuse, it would be well to remember that the demand for scientific planning may be at present as naive as the first efforts at economic planning were in the 1930's, just "as in the case of economic planning we have to develop a much more sophisticated understanding of how the existing system works before we can control it"(2) or even decide that we cannot control it, although admittedly the success of economic planning may not inspire confidence.

The mobilization and control of much of science by various governments in the war is too well known to require amplification. It was adumbrated in World War I and culminated in World War II. Less well known, because it was far less successful, are the interests shown during the Depression in increasing production via science and technology. Suffice it to say for present purposes that both the French and American executive advisory bodies for science were created in this time, well before World War II.(5)

The tremendous impact of mobilized science and scientists on industrial production and product generation during the war left an indelible imprint upon the public consciousness. It became clear that economic policy could benefit immensely from a similar mobilization of science. Sooner or later, to one degree or another and in this way or that, economic policy would have to take as one of its instruments the control and the use of science. Thus, much of this initial interest in science was narrowly concentrated on military purposes. Quickly the interest grew more general, though it has misleadingly continued to be justified budgetarily by military purposes.

Prestige for some nations and survival for others now rests in large measure on the vitality of their economies, demands made particularly harsh by the greatly increased international economic interests and competition resulting from the internationalism founded in World War II's United Nations. Resources, both human and material, tapped for the War effort in allied countries became available for export, as soon as defered domestic consumer wants were fulfilled. Coincidentally, export markets presented themselves in previously ignored parts of the world, namely in Asia, Africa and Latin America, and in the resource-depleted and exhausted nations of Europe. Thus, although in the first half of this century the volume of world trade declined relative to the total world output, since 1950 world trade has expanded more rapidly than world production.(4)

Science was important because it was thought to contribute to technology and the production of highly qualified manpower which together contribute to the acceleration of productivity. Productivity in turn leads to economic growth. Economic growth was prized for two reasons: full employment and high per capita income.

In short, wartime science had shown itself capable of overcoming scarcities imposed by the war effort, for example, in creating synthetic substances to substitute for inaccessible materials or in multiplying production to meet the high war demand. It was easy to suppose that a similar mobilization of science to alleviate other scarcities was stimulated by military purposes, but not exclusively, for with the end of World War II Western industrial nations formalized a good deal of the responsibility for economic planning which had come to them in the Depression and the war. Economic planning involves technology and technology involves science. As the importance of technology in production has increased so too has the attention to science policy. With involvement of science comes an involvement of universities as the home of science.

Stimulated by the alleged connection between science and economic growth, nearly all nations have turned attention to national science policy. The more industrialized a nation is the greater that attention is. These nations first faced the challenge of science policy; they first reaped the harvest of its rewards.

Of late, with perhaps less initial probability of success but with greater desire, the middle level of industrialized nations have explicitly turned to science policy, countries from the United Kingdom to Germany to Canada. For them science policy is sought to provide a technique by which to obtain the maximum benefit from their human and natural resources.

Certainly government interest in scientific research and education is by now a stranger nowhere. In the developing nations of the Third World no less than in Rumania or Canada, governments see a considerable public service to be performed directly or indirectly by scientific research and education. To the generality of interest in science policy witness is born by the large numbers of science policy country studies carried out up to 1971, twenty by the Organization for European Cooperation and Development (O.E.C.D.) and twenty-eight by the United Nations Educational, Scientific and Cultural Organization (UNESCO).

Both as formally defined in these studies and in the day-to-day business of government, the compass of science policy is broad, very broad indeed. According to the O.E.C.D's Frascati Manual of uniform terminology in science policy, it can be understood to extend to those aspects of education that are related to the training of qualified scientists and engineers or, more generally, highly qualified manpower, the latter concept including an important range of technical personnel excluded by the former.(5) In other words a part of science policy is higher education. Naturally science policy also includes scientific research in its university and commercial settings. Precisely what these aspects are varies from one country to another, from one constitution to another. Not only does science policy reach backward to the antecedents of science in the educational function of universities, it also reaches forward to its consequences, technology. The unity of science policy from education to industry is witnessed by the fact that the Quebec cabinet committee on science policy includes, aside from the ministers for the environment and social affairs, the ministers of education and industry.(6) In the ordinary parlance in which political discussion occurs, to say "science" is to say "technology", if not instead of, then in addition to science proper. This is especially, but not exclusively, so for politicians. For them to say science is to bespeak technology and engineering, and so national science policy in Canada sweeps over education, science, technology and engineering. Thus, the full name of one science policy oriented organization is "The Association of the Scientific, Engineering and Technological Community of Canada" (for short, SCITEC). Certainly in the Canadian context the importance of technology and engineering in science policy has been in addition to and not instead of science. This is true because advocates of science policy have by-and-large taken the view that there exists a causal relation between science and technology. Seemingly, if one wishes to affect technology, then one must first affect science.

Ironically, just at the time when science, in the broad sense relevant to science policy, comes to be regarded as more and more important, it also becomes increasingly difficult to differentiate into a separate area of policy and administration. It grows in importance as its elements make contributions to agriculture, to manufacturing or transportation. As policy attention is focused, it is more and more difficult to see science as a whole across agriculture, manufacturing or communication. Its importance and hence the interest of policy-makers grows as it becomes more integrated into otherwise diverse policy areas, so that it is then difficult to distinguish it as a policy area in its own right without disrupting the very conditions which originally aroused that interest. In a way, as science becomes more publically visible through its effects, it also becomes less administratively accessible due to its deepening integration. This is cause for caution but not alarm, for it may be a sign of the same kind of immaturity which once afflicted economic policy.

2. CANADA AND NATIONAL SCIENCE POLICY

The Canadian case of national science policy is one unusually revealing of the public policy process in science policy. More than enough has been said already to establish the world-wide interest in science policy. In no state is the policy process more likely to be visible than in a liberal parliamentary democracy like Canada. Nowhere is science policy viewed as being more vital than in middle size industrial nations like Canada.

Amongst liberal-democratic, middle-sized nations Canada is in many ways distinctive. At least one of these distinctions is of relevance to science policy. It is the simple fact that science policy has been made consciously and systematically a public issue. Nowhere else has such an extensive and intensive public debate over science policy occurred.[7]

The first shot in the present generation of science policy debate was fired in 1958 when a Civil Service Commission report suggested ending the exempt status of the staff of the National Research Council (N.R.C.)[8] Until that time professional staff at the N.R.C. were not hired or promoted on Civil Service criteria of experience and tenure. It was not until 1962 that this skirmish was followed up by the first major engagement in the debate. Indeed the present debate over national science policy was rehearsed in 1962 by volume four, report twenty-three, of the report of the Royal Commission on Government Organization, chaired by industrialist J. G. Glassco.[9] Report twenty-three was devoted to the organization of government research, which in the view of the report, was exceedingly disorganized. Especially singled out by the Glassco report was the N.R.C.[10] Being quite direct in its criticisms of government science, the Glassco report elicited a public reaction of sorts, though it was a reaction pretty well confined to Ottawa. While this controversy ran its course, a group of business concerns with commercial interests in science together with the Ontario Research Council formed a consortium for industrial research at Sheridan Park near Toronto.[11]

While the immediately visible reaction to the Glassco report was not great it was important, especially so when it became clear that, apparently in response to the report, a number of wheels were being set into motion in government. In 1964, upon the personal request of Prime Minister Lester Pearson, Dr. C. J. Mackenzie, a former President of the N.R.C, submitted a personal report on the organization of government science.[12]

Both the Glassco and Mackenzie reports had recommended the establishment of a central scientific secretariat.[13] In April of 1964 this was done. As part of the Privy Council Office the Science Secretariat was created.[14] The Secretariat remained small in size, launching only a few studies and preparing the legislation that led to the creation of the Science Council of Canada in 1966.

The Science Council was created to occupy a more public role in contrast to the closed advisory role of the Secretariat within the Privy Council Office.[15] Indeed the Science Council was specifically charged with stimulating public consideration of and attention to matters of science policy. It was to be more or less analogous to the Economic Council, unlike the Secretariat's role as a confidential advisor.

While the roles of two agencies were distinct, they were nonetheless tied together at the outset. The Secretariat provided staff support to the Council. This proved to be an unsatisfactory arrangement.[16] In 1968 the two were cleaved asunder. The Council was made a crown corporation; the Secretariat was divested of its support role and wholly withdrew into the confines of the Privy Council Office.(17)

In 1967 the Senate established a Special Committee on Science Policy.(18) This committee was chaired by the Senator who introduced the motion for its creation, Maurice Lamontagne. March 1968 witnessed the first hearings of this committee. The proceedings of these hearings, when completed in 1970, ran to 12,000 pages containing information from some 243 briefs.(19) Two reports have thus far been issued. The first appeared in 1970. It is a critical review of science and science policy in Canada.(20) The second is forward looking; it sets out targets and strategies for the seventies.(21) It was published in 1972. It is not wholly clear how many reports can be expected from this committee or when they will appear. The projected number has changed several times, from one to two to three to four.(22) There is no doubt that the activities of this remarkable committee more than anything else have sparked the widespread debate over science policy occurring in Canada.(23) As well the influence of the Committee was noticeable even during the hearings. In an unusual move, the committee was singled out for mention in the speech from the Throne opening the third session of the twenty-eighth parliament.(24) This symbolic recognition has been sustained by the cleavage of the Science Council and Science Secretariat and the creation of the Ministry of State for Science and Technology (M.O.S.S.T.), both moves having been called for by the Committee in the course of its deliberations.[25]

There has been no doubt of the Committee's interest in seeing the effective utilization of science in the public realm. Perhaps indicative of this interest in the practical effects of science is the fact that the first witnesses to appear before the Committee were representatives from the sciences of man, that is, the Canada Council.[26]

There appeared in 1969 the tenth in a series of O.E.C.D. case studies on national science policy. This one was on Canada.[27] Its 453 pages contain some of the most detailed information and analysis yet undertaken on science policy in Canada. Unfortunately, this report has only received a nodding recognition from the main contributors to the debate on science policy.[28] Its impact on the policy process seems to have been exceedingly small. Even the Senate Special Committee which went around the world and across the country for information makes only a few brief references to the O.E.C.D. study.[29]

Also in 1969, appeared a special study conceived by the Science Council and executed by the Science Secretariat. Known by the name of the study group chairman, J. B. Macdonald, this report concerned the role of the Federal Government in support of research in Canadian universities.[30] This particular aspect of science policy in [illegible] was treated again in 1972 when the Association [illegible]ies and Colleges of Canada released the r[illegible]tudy group composed of L. P. Bonneau and J. A. C[illegible].[31]

So much concern and activity regarding science policy by government both reflected and stimulated similar interest outside government. In 1968 there was created a magazine devoted to matters of science and technology as relevant to society. This magazine is called *Science Forum.*(32) It still continues today and is largely focused on science policy matters.

The challenge to stop and think about science and science policy which the invitations to appear before the Senate Special Committee on Science Policy represented, occasioned the formation of one of the central actors in the science policy arena. While in Ottawa for Committee hearings, and with the preparation of their briefs freshly in mind, a group of industrial and university scientists formed the Association of the Scientific, Engineering and Technological Community of Canada (SCITEC). In the session involving these persons Senator Lamontagne expressed his exaspiration with the lack of a unified group representing and giving voice to the scientific community. Instead he saw himself faced by literally hundreds of disciplinary groups across the face of Canadian science, technology and engineering. From these evening sessions some of the witnesses retired to the Chateau Laurier, to devise and create just such an institution.(33)

Naturally all this has stimulated still further activity by all sorts of persons and groups. Thus debates in the letters columns of newspapers and learned journals alike have been filled on occasion by commentary on the Lamontagne Committee's Reports, or on the creation of the Ministry of State for Science and Technology. Further the agencies and groups created out of the debate have been active in spreading discussion still further. This study takes March 1973 as its cutoff date in examining the flow of this debate.

A great deal about science policy making may be learnt from the Canadian case that might otherwise go unnoticed in the examination of an alternative case. Not only will the study of Canadian national science policy-making offer important contributions to the understanding of science policy, but also to the general understanding of Canadian national policy making. Of course a good part of the interest which drives Canadians to consideration of science policy is that interest in common with all middle sized industrialized nations, namely political independence and economic growth.

Before elaborating on the points of specific Canadian interest in science policy, it would be well to observe a second dimension to the general interest in science policy. In a small economy large investments must be carefully calculated. Science, in the extended sense referred to in science policy, is a large investment item in most nations. Canada belongs to a stratum of nations whose economies may be classed as small compared to those of Germany, Japan, the U.K. and the superpowers of the USA and the USSR.(34) Where opportunity costs are so much greater, failure may mean tragedy not just frustration, closure not merely delay. Hence, the careful and measured control which science policy promises has a great appeal.

3. NATIONAL SCIENCE POLICY IN CANADA

As claimed before, there is a sense in which science policy is a matter of specific interest in Canada. Very simply, Canadian geography has required much technical improvisation from those who would make it their own.(35) Thus in the case of British Columbia's entry into the Confederation a specific technological feat was part of the bargain, namely the construction of a transcontinental railroad. Canadian geography has made demands satisfiable only by technologies. Foremost amongst those geographic factors would be the severity of the climate and the great distances over which the country stretches with the attendant problems and puzzles, especially the Pre-Cambrian Shield and the Rockies.

Canadian geography has not only made technological innovation a necessity in part, it has also made it a positive benefit for in many ways substantial rewards are offered to innovation. Canada has offered and continues to offer a vast store of natural resources, which when processed and transported in quantity return great profits. Throughout Canadian history, finding the means to process and transport these resources has been a great technological challenge which began with the French and English fishermen drawn by the cod fish of the Grand Banks of Newfoundland and forced to find techniques of taking and shipping cod on a large enough scale to realise a profit over and above the large fixed costs entailed in operating fishing fleets at so great a distance from home ports.(36) This challenge has continually returned in various guises, for if, as one of the most popularly disseminated and academically established interpretations of Canadian history holds, Canada has been a staple product, nature resources, economy, then science has always been a major factor in that economy.[(37)] Too often science is thought to be related to only modern sophisticated manufacturing. It is no less relevant to the production, transportation and marketing of staples on a large scale than it is to the development of secondary industry. Cutting a single tree in the forests of Northern Ontario and shipping it to the treeless plains of Nebraska is not difficult, but it is time consuming and unprofitable. Cutting and transporting a thousand trees is profitable, but it is difficult. A thousand trees requires much that a single tree does not in the way of portable saws, winches, timber slides and rafts, flat cars with heavy duty suspension and so forth.[(38)] Staples offer a profit in bulk so as to allow a margin above the high fixed costs of transportation to the metropolitan market.[(39)] Bulk production of staples is enhanced by, if not impossible without, science.[(40)]

There is another aspect of bulk staple production that needs to be born in mind. Bulk production and marketing is capital intensive relative to the capital supply indigenous to a staple economy. Building railroads is never easy and it is always expensive. Moreover, because staple production is such a large scale operation it clearly makes great demands on organizational experience and skill.[(41)] Together with their being marketed, and generally processed, elsewhere, these demands make bulk staple production pretty much the undertaking of a corporation most likely to be based in the metropolitan market for the staples.(42) For example, "to withstand the stresses of the St. Lawrence rapids, [timber] drams had to be put together very securely and they were consequently expensive to construct."(43) More generally, Canadians need but consider the numerous corporations like the Hudson Bay Company at work in our history or the colonial relationship between the eastern Metropolitan centres of Canada and the Western hinterland to appreciate this truth.(44)

No where is the joint effect of the scientific challenge and opportunity which Canadian geography offers better illustrated and its potential political consequences more plain than in the history of the Canadian railroads. As fascinating as it is, only two high points of this history can be allowed to detain use here. They are that part which eventuated in Confederation and that part related to Westward expansion to the Pacific Coast.

The effort to individually develop and jointly unify the Maritime colonies in the 1850's resulted in large debts which gave New Brunswick, Nova Scotia and Prince Edward Island an initial interest in Confederation. The debts of those provinces entering Confederation were so important that they were specifically mentioned in the British North America Act where, in sections 114 and 115 they are made the responsibility of the Confederation. It has been estimated that three-fourths of them arose from transportation endeavors.(45)

The way west of the railroad is, of course, a great story. Driven by the desire to unify the country so as to foreshorten any eventuality of incursion by the United States in the Prairies or the Coast, the Macdonald government drove ahead furiously with the railroad, encountering rather violent stops and starts along the way when money ran out or the geography presented new and seemingly insurmountable obstacles.(46) The Canadian Pacific Railroad (C.P.R.) once constructed for these political reasons, represented a greater technical capacity than could be utilized by the existing traffic. To ensure maximum profit it was granted a monopoly in the West. The construction of other railways between provinces locally or on a North-South line to the nearby United States was expressly forbidden. Very consciously the interests of the West were to be sacrificed to the interests of the nation, as interpreted by Eastern politicians, a point which caused considerable hostility in the West at the time, and since.(47) Attempting to unify the country against a potential American economic absorption led to the recruitment of European metropolitan corporate capital and management to see to the completion of the railway, thereby paving the way for the very penetration which was feared.(48) For in some years time foreign economic penetration occurred through the vehicle of the corporation. Employment of metropolitan corporate interests to see through so immense an undertaking as the railroad, proved two-edged into the long run.

There is too much truth in the well known adage that Canadians have been limited to the role of the hewers of wood and the drawrers of water for the interests of various metropolises.[49] The rich harvest of bulk staple production from Canada's vast storehouse of natural resources introduced and established a considerable foreign, corporate, influence and a receptive attitude toward those interests within the Canadian economy and society, leaving Canadians to manage but not to own.

4. ANALYSIS AND RECOMMENDATION

The pressure for movement from assumptions to analysis to recommendations to actions is great in all areas of public policy. What is true of public policy generally is true of science policy. No shortage exists of recommendations with calls for immediate action. Nor is there ever any want of diversity in these recommendations. One can be tempted by persuasive arguments which maintain that the time for analysis is past, that the time for action is upon us.[50]

It is well to withstand that temptation. The underlying assumption from which the advocates of any policy take their guidance are of greater interest than the specific recommendations made at any point in time. This is the case for several reasons. Principal amongst these reasons is the simple fact that no set of recommendations is ever enacted and implemented exactly as it is given. Policy is invariably formed by a compromise amongst a number of competing sets of recommendations. Thus volume two of the Report of the Senate Special Committee on Science Policy alone makes no less than forty-eight recommendations. Not all of the forty-eight recommendations would be implemented under even the most favourable, the most ideal circumstances. Suppose there were no competing recommendations on science policy and that the government were eager to press ahead. Even under these circumstances some of the forty-eight recommendations would conflict with other policies, for example, financial restraint or the autonomy of government departments and agencies. Inevitably such situations would occur. At that time choices would be made. Choices which would be guided, consciously or not, by priorities built into and derived from the most basic conceptions or premises of the operative understanding of science policy. Consider a specific example. The Lamontagne Report advocates high levels of government funding for basic and developmental research, offering something for everyone.(51) Yet at the same time, it is clear, in view of the realities of the Canadian economy, that the funds available for scientific research will not be adequate to meet that recommendation. Instead a choice will have to be made to favour one or the other type of research, or to treat them equally at lower levels of funding. Which ever choice is made will reflect the priorities of the policy-makers. These priorities can be revealed best by examining the assumptions and implications of the pro science policy position.

More importantly, by analogy, the recommendations are the conclusions of an inductive argument, while the assumptions are the premises. This being so, two points are clear. First, many different, even dramatically different, conclusions can be supported by the same inductive argument, depending on one's assumptions. Hence, rather than taking up each conclusion (set of recommendations) separately, there is an economy to be gained in taking up the assumptions. This first point is admittedly only a good reason for the continued study of assumptions. It is not a sufficient reason for doing so. There is a second reason. Study of the conclusions of an argument will not give us any idea what to expect were the argument to be even slightly altered. Study of the premise will equip one with the ability to form new expectations if a shift occurs in the parameters. Shifts are of course the rule, not the exception, in the political realm. Therefore, not only advantage but also necessity prompts the continued examination of the underlying assumptions of science policy.

Caught up in a current of urgency, many persons active in the consideration of science policy see the proper role of the student of science policy to lie in the production of specific studies on the state of cell biology in Canada or such like.(52) By no stretch of the imagination is this the purpose here. Such studies would of necessity be conducted by experts in each field. Certainly this sort of information will be useful at some point in the making of a science policy. Whether or not now is that point remains to be seen. If now is not that time, then such studies would be premature, growing out of date before they could be used. Before such studies should be undertaken there is need for a clear idea of what science policy is, of the degree to which it is desirable, of the degree to which it is possible, and of the effect of the particulars of the Canadian context. This is true not only of the disciplinary studies such as mentioned above, it is also true of further empirical economics research. Much excellent economics research exists on various matters encompassed by science policy. Far more than ever has been or is ever likely to be digested in the science policy-making process. What can be best provided here is an orientation, perspective or framework within which to place this and other research, a framework which will simultaneously give theoretical importance to and derive it from the economics research. This task is an important one. And it is one to which a political scientists is well suited, for undeniably the public context of science policy is very political, even though substantively science policy is to a large extent an economic issue, to say nothing of a scientific issue.

The present debate over national science policy in Canada ranges from the dollars and cents question of securing profitable return on investment in research and development to the social responsibilities of scientists in research and development. Due to its recent currency the debate is largely undifferentiated. Paradoxically, this is the case because many of the specific issues so vital to science policy have, individually, histories antecedent to that of science policy proper. Contrary to what is perhaps a common supposition, science policy did not spring full grown from the brow of the scientific-technological 1960's. Rather it assembled a collection of unresolved issues of longer standing. Thus, its parts have a past, one rich with evidence and argument, but the whole of science policy itself is new born. Accordingly, there is a good deal of evidence to be found on any component issue of it, for example, the stimulation of industrial research and development by tax abatement versus direct grants. There is, however, little to be found on the coherence of the idea of science policy. Attention to the specifics would be all to the good, if the conceptual foundations of science policy had been thoroughly investigated and found, or put, aright. Then interest rightly ought to proceed onto the relevant facts of the matters of hand. Until such time the question here always is "What are the *relevant* facts?"

The term "science policy" is very much the creation of a sloganeer who imaginatively captured, but did not intellectually integrate, a range of diverse, yet intuitively connected, issues which partake of a relationship to science. But as the scale has shifted from specific topics to the general issue of the place of science in society and the role of society in science, the measurement of dollar inputs suffices no longer.(53) At the higher levels of abstraction towards which science policy ineluctably moves, concern shifts from organization and coordination--do programmes conflict and compete?--to secondary and tertiary effects--can science be controlled to the extent science policy requires? Historically government interest in science started with agriculture and transportation, and ended with defence. Most of the vast corpus of science was left well outside of the sphere of government interest in the hands of scientists. It is precisely this science which is now brought into question by the idea of a national science policy. National science policy bespeaks an overall blueprint which would bring all such heretofore excluded science under government observation, accounting and perhaps direction. Thus, while so many aspects of science policy have been thoroughly investigated, science policy proper, combining all of those aspects, represents a difference in degree that has become a difference in kind. Or, it is at least advisible to stop and see if it is a difference in kind. Therefore, national science policy itself stands in need of analysis from a conceptual point of view.(54) Though admittedly the enterprise is made difficult by the limited relevance of the vast body of related literature.

Operating under the tremendous daily pressures of our democratic-industrial society, Government is forced to take an exceedingly short-ranged view. Results are what is expected of it and what it therefore expects of others. The urge to try something new which promises as much as science policy is almost irresistible. Conceptual analysis does not issue in results of the kind desired by and required of government and so will not be followed through by it. In the absence of the conceptual unity and clarity no such results will be possible by any means whatever. Conceptual analysis is a necessary, not a sufficient, condition for success. Attainment of sufficient conditions preoccupies the attention of government.

Similarly, a second group from whose ranks many strong advocates of a national science policy have emerged is business. Like their government associates in this advocacy, these people too are under a considerable short-run pressure, for profits, which leads them to take a short-range approach to and perspective on the matter of science policy. Accordingly, little interest in conceptual analysis is to be found amongst industrialists concerned with science policy.

Myopia is not the exclusive prerogative of those who advocate a national science policy in Canada. Being primarily scientists, the opponents of science policy cannot but feel threatened as they contemplate securing funding for a research project envisaged for the next fiscal year. There is a sense in which any change at all threatens those who have learned to get along in a given system. Changing the rules may upset one's established ways and means.

The field which national science policy covers, but does not unite, consists of issues which were never individually resolved and which in combination create new complexities. Most of the debate over science policy follows the style of the discussions of the component issues which are its predecessors. It assumes a conceptual ground and then advances over it on the basis of evidential argument and analysis along the dimensions thrown-up by those components. It uses but does not analyze presumptions which make the adduced evidence significant.(55) Slippery is the conceptual ground, though. It has not been properly prepared for the weight of the consideration of national science policy as a whole. Moreover, as with so many public policy issues, as the example of Marx shows, the available evidence pertaining to the constituent issues is voluminous.(56) Certainly the long rows of Royal Commission and Task Force Reports which stud library shelves are sufficient sign of this. The array of evidence is so voluminous, not to say diverse, that it is quite possible within it to find support for many different, often contradictory, positions. This should not surprise us for the argument must be inductive and that is how inductive arguments work. Without any ordering perspective through which to view this evidence no single order can emerge from it.

While such evidence accretes certain well known conceptual problems go unattended, for example, the measurement of scientific-technological output. Although they are part of the assumptions necessary to make science policy sensible enough to talk about, they are not examined by those hurrying to fulfill their pressing duties and interests in government and industry, or to protect their interests and our heritage, scientists. Here the buck stops, for here these assumptions will be investigated. Investigation will proceed along three dimensions of assumptions involved in the Canadian national science policy debate: (1) philosophic, (2) scientific, and (3) political. A unit of this study is devoted to each dimension. The aim is to fill the conceptual gap within the academy as it cannot be filled in the polity. Each of these dimensions is the subject of three chapters in the following pages.

5. THE THEMES

The analysis and argument of the first dimension in unit (1) will maintain that science, the technical knowledge and the consequent economic and social benefits are usually misconceived in the consideration of science policy. They are misconceived as being solutions to problems which prove, upon inspection, to be insoluble political matters. The philosophic character of the main problems to which science policy is related by its advocates is political, not scientific. This is not to deny the social utility of many products of science. It is rather to maintain that political problems do not entirely reduce to material problems and that the products of science can contribute only to the solution of material problems.

In unit (2) attention turns from the desirability of science policy in terms of its purpose to the feasibility of it in terms of its methods. Can science be controlled in the way and to the extent necessary for science policy to deliver upon its promises? The conclusion is that the levels of control claimed for science policy by its advocates are unrealistic. This is not to deny the viability of a limited measure of control. It is to deny the orchestral control envisaged by some advocates of science policy. Control extends no further than to the inputs of the activity of science, and it is not even complete at that point. Since inputs are related to scientific outputs there is in some sense control, but because the relationship of inputs to outputs is far from clear, there is also in a sense no control.

Finally, in unit (3) the aim is to show the political context which forms the backdrop against which the science policy debate is situated. In keeping with the analysis of units (1) and (2), it is demonstrated at this point that Canadian interest in science policy arises from a desire to find an indirect, non-conflictual, unpolitical way around what is essentially a political problem, namely, the Confederation of English and French Canada, and that the means for so doing--to the degree that science can be controlled and can contribute to social goals in a purposeful way--in turn founder on a second problem, namely the concentration of non-resident ownership in Canada's high technology industries, or Canada's independence of the United States.

FOOTNOTES

1. Examples of writings on science policy which show no concern for its political or philosophic aspects are numerous. Foremost amongst which is M. Lamontagne, chairman, *A Science Policy for Canada*, 2 volumes (Ottawa: Queen's Printer and Information Canada, 1970 and 1972). This report, in its very title, begs all but the most narrowly conceived question; for it assumes we are to have a science policy, leaving open only the question of what kind. A few other prominent examples are R. W. Jackson, "Major Programs in R & D", *Science Forum 8*, II (1969) 2, pp. 10-9; R. C. Quittenton, chairman, *A Canadian Policy for Research and Development* (Montreal: Engineering Institute of Canada, 1967); and Quittenton, "Can Canada Agree on a Science Policy", address to the Fourth Western Canadian Heat Transfer Conference, Winnipeg, 1972; J. Mardon *et al.*, *Analysis of Briefs submitted to the Senate Committee on Science Policy* (Gardenvale, Quebec: National Business Publications Ltd., 1970); or S. S. Grimley, "Science for What?--The Real Debate", *National Research Council Newsletter*, III (1971) 4, pp. 1-3.

2. Harvey Brooks, "Can Science Be Planned", *The Government of Science* (Cambridge: Massachusetts Institute of Technology Press, 1968), pp. 79-80.

3. Jean-Jacques Salomon, *Science and Politics*, N. Lindsay, trans. (Cambridge: Massachusetts Institute of Technology Press, 1973), p. 31.

4. Alfred Maizels, *Industrial Growth and World Trade* (Cambridge: Cambridge University Press, 1963), p. 10. Cf. Bruce Wilkinson, *Canada's International Trade* (Montreal: Private Planning Association, 1968).

5. *Proposed Standard Practice for Surveys in Research and Development* (Paris: O.E.C.D., 1962). Because it was formulated at a conference held in Frascati Italy this manual is also known by that city's name.

6. Guy-Saint-Pierre, chairman, *Les principes politique scientifiques du Québec* (Québec: Comités des politiques scientifiques du Québec, 1972), p. 1. Cf. a large number of statements made in the hearings of the Senate Special Committee on Science Policy: See for example, Senate, *Proceedings of the Senate Special Committee on Science Policy*, 1st Session, 28th Parliament, No. 2, pp. 20-1; No. 13, p. 256; No. 14, p. 277; No. 16, p 2349; No. 39, p. 4771; No. 45, p. 6158; No. 51, . 6365; or No. 55, p. 6779 for such statements from Dr. Alexander King of the O.E.C.D. division on science policy; Sir Geoffrey Vickers, formerly British Science Adviser; St. Mary's University; the Chemical Institute of Canada; the University of Saskatchewan and others.

7. Alexander King, "The Lamontagne Report", *Science Forum 26*, V (1972) 2, p. 4. Mr. King is undoubtedly in a position to know for he was then director general for scientific affairs of the O.E.C.D. He has participated in several of the O.E.C.D's country studies of science policy.

8. See, Arnold Heeny, chairman, *Personnel Administration in the Public Service* (Ottawa: Queen's Printer, 1958), especially at 141, and E. W. R. Steacie, "Science, Society and the Individual", Three C.B.C. Lectures (Ottawa: National Research Council, 1959). Cf. I. Norman Smith, "Steacie's Scientists vs. Civil Service Commission", *Ottawa Journal*, 22 September 1959, p. 6 and "Heeny Answers Steacie Re Scientists and Commission", *ibid.*, 29 September 1959, p. 6. The following description of recent events in the Canadian government's science policy machinery is based on that provided by G. Bruce Doern, *Science and Politics in Canada* (Montreal and London: McGill - Queen's University Press, 1972).

9. J. Grant Glassco, chairman, *Royal Commission on Government Organization*, Volume IV, Report No. 23, *Scientific Research and Development* (Ottawa: Queen's Printer, 1963).

10. *Ibid.*, pp. 212-4. Cf. J. D. Babbitt, "Glassco on Science", National Research Council, unpublished paper, National Research Council, Ottawa, 1963.

11. A. J. Patterson, "Sheridan Park complex has 10th Anniversary", *Edmonton Journal*, 1 December, 1972, p. 42.

12. C. J. Mackenzie, *Report to Prime Minister on Government of Science* (Ottawa: Privy Council Office, 1964).

13. *Ibid.*, p. 1 and *Royal Commission on Government Organization*, Vol. IV, Report No. 23, p. 221-2.

14. *Debates*, House of Commons, 2nd Session, 26th Parliament, Vol. III, 30 April 1964, p. 2752.

15. Science Council of Canada Act, 1966-7, c. 19, as amended by 1968-9, c. 28, *Revised Statutes of Canada* 1970, Vol. VI, pp. 6693-8.

16. G. Bruce Doern, *Science and Politics in Canada*, pp. 15-6.

17. *Debates*, House of Commons, 1st Session, 28th Parliament, Vol. VI, 19 March 1969, 6836.

18. M. Lamontagne, *Debates*, Senate, 2nd Session, 27th Parliament, 2 November 1967, pp. 364-5.

19. Debates, Senate, *Science Policy: Consideration of Volume I of Report of Special Committee*, 1971, p. 3.

20. Maurice Lamontagne, chairman, *A Science Policy for Canada*, Volume I, *A Critical Review: Past and Present* (Ottawa: Queen's Printer, 1970).

21. Volume II, *Targets and Strategies for the Seventies* (Ottawa: Information Canada, 1972).

22. In volume I only one additional volume was envisaged, *op. cit.*, p. 15. In volume two yet a third volume was indicated, *op. cit.*, p. 333. Cf. Lamontagne, *Transcription of CTV Question Period*, 22 January 1972, p. 5. Since then there have been rumors of still a fourth volume. Since these pages were written a third called *A Government Organization for the Seventies* (Ottawa: Information Canada, 1973) has appeared.

23. Speech from the Throne, *Debates*, House of Commons, 3rd Session, 28th Parliament, 8 October 1970, p. 2. Cf. Debates, Senate, *Science Policy: Consideration of Volume I of Special Committee*, p. 27.

24. *Debates*, House of Commons, 3rd Session, 28th Parliament, Vol. VII, 21 June 1971, pp. 7165-74. The Science Secretariat was absorbed by the Ministry of State for Science and Technology.

25. On the creation of the Ministry see Lamontagne, *Debates*, Senate, 4th Session, 28th Parliament, Vol. 120, No. 7, 2 March 1972, p. 68, and on the halving of the Science Council and Secretariat, see Doern, *Science and Politics in Canada*, p.212.

26. Senate, *Proceedings of the Special Committee on Science Policy*, 2nd Session, 27th Parliament, No. 1, 12 March 1968. The Committee's interest in the social sciences and especially the Canada Council is not surprising in view of the background of the chairman who was a professor of economics and an adviser to the Privy Council at various times, see his curriculum vitae in *ibid.*, p. 8. Further, Senator Lamontagne had a large hand in drafting the original legislation creating the Canada Council, see his address to SCITEC, *Proceedings of SCITEC IV* (Ottawa: SCITEC, 1972), p. 85.

27. O.E.C.D., *Review of National Science Policy: Canada* (Paris: OECD, 1969).

28. For one exception, see Harry Gunning, "Canadian Science Policy and the OECD Report", *Science Forum 12*, II (1969) 6, pp. 3-6.

29. The OECD report is referred to no more than four times in the 608 pages which comprise the first two volumes of the Committee's report. Yet the Committee literally travelled the world over in search of evidence. See Volume I, p. 9. There are other omissions from the Committee's attention too, notably N. H. Lithwick, *Canada's Science Policy and the Economy* (Toronto: Methuen, 1969).

30. John B. Macdonald, *The Role of the Federal Government in Support of Research in Canadian Universities* (Ottawa: Queen's Printer, 1969). See also, National Research Council, "A Commentary on Special Study No. 7, 'The Role of Federal Government in Support of Research in Canadian Universities'", (Ottawa: N.R.C., 1969).

31. Louis-Philippe Bonneau and J. A. Corry, *Quest for the Optimum* (Ottawa: Association of Universities and College of Canada, 1972).

32. *Science Forum* began publication in February 1968. Since its inception the editor has been David Spurgeon who was a science writer with the *Toronto Globe and Mail* and the publisher is the University of Toronto Press. Initial financing came through the Donner Canadian Foundation along with the National Research Council, the Canada Council, the Government of Ontario and the Canadian Physiological Society. See *Science Forum 1*, I (1968) 1, p. 2.

33. I Reid, "SCITEC: Canada's hope for a united science voice". *Canadian Research and Development*, III (1970), pp. 45-6.

34. See, e.g., O.E.C.D., *The Overall Level and Structure of R & D Efforts in OECD Member Countries* (Paris: OECD, 1967).

35. Amongst these are the great variety in soil dynamics which the vast space of Canada includes and upon which railways are built, the difficult east-bound grades, large snowfalls and continued sub-zero temperatures, large scale spring run-off, the difficult passage of the Rockies and so on. In addition there were special needs resulting from transporting wheat in large quantities. The rotary snowplow is only one of the inventions stimulated by challenges such as these. See, *Brief*, submitted by the Canadian Pacific Railways, Senate, *Proceedings of the Special Committee on Science Policy*, 1st Session, 28th Parliament, No. 19, pp. 2961-6; E. Nyland, chairman, *Response to the Lamontagne Report* (Edmonton: Department of Physics, University of Alberta, 1973), p. 7: Harold Innis, *A History of the Canadian Pacific Railway* (Toronto: McClelland and Stewart, 1923), p. 2[illegible] and 243; and especially J. J. Brown, *Ideas in Ex*[illegible] ([illegible]onto: McClelland and Stewart, 1967), pp. 108-18.

36. Donald Creighton, *The Story of Canada* (Toronto: Macmillan, 1959), pp. 15-6. For a detailed treatment see Innis, *The Cod Fisheries* (Toronto: University of Toronto Press, 1954) (Revised Edition).

37. Consider Creighton, *The Empire of the St. Lawrence* (Toronto: Macmillan, 1956); Innis, *The Fur Trade in Canada* (Toronto: University of Toronto Press, 1930); W. A. Mackintosk, *The Economic Background of Dominion-Provincial Relations* (Ottawa: King's Printer, 1939); and M. Watkins, "A Staple Theory of Economic Growth", *Canadian Journal of Economics and Political Science*, XXIX (1963) 2, pp. 149-58. W. H. Pope, *The Elephant and the Mouse* (Toronto: McClelland and Stewart, 1971), p.11.

38. A. Lower, "The Trade in Square Timber", *Contributions to Canadian Economics* VI (1933), pp. 40-61; reprinted in *Approaches to Canadian Economic History*, W. T. Easterbrook and Watkins, eds. (Toronto: McClelland and Stewart, 1967), p. 43.

39. The necessity of extracting staples in bulk is graphically seen in the frantic transportation of furs taken in [illegible] Alberta. So precious was space--space for fur--on Bay Company export expeditions that the traders neither carried food nor took the time to hunt. Rather food was purchased along the way from Indians until York Factory was reached. See James MacGregor, *A History of Alberta* (Edmonton: Hurtig, 1972), pp. 29-30. Cf. Innis, *The Fur Trade in Canada*, pp. 383-8.

40. See Watkins, "A Staple Theory of Economic Growth", reprinted in *Approaches to Canadian Economic History*, p. 54. In the prairies the importance of science in broad sense of science policy is unmistakable. For the Prairies are wheat and wheat capable of maturation in a short and unpredictable growing season was the product of research at the Dominion Experimental Farm in Ottawa by Charles Saunders. MacGregor, *op. cit.*, pp. 213-4. A discovery which turned land once found marginal under the reign of previous wheat strains into a land of plenty. Of course the land did not change, the wheat did. *Ibid.*, p. 214.

41. Innis, *The Fur Trade in Canada*, pp. 386-92.

42. "The frontier, far from being essentially independent and self-reliant, is in the largest sense a dependent. It constantly requires metropolitan aid and control." This is in part due to the fact that "we have had far less fertile acreage for agricultural settlement than has the United States." J. M. S. Careless, "Frontierism, Metropolitanism and Canadian History", *Canadian Historical Review*, XXXV (1954) I, reprinted in *Approaches to Canadian History*, Ramsey Cook, Craig Brown, and Carl Berger, eds., (Toronto: University of Toronto Press, 1967), p. 80-2. Cf. Innis, *Problems of Staple Production in Canada* (Toronto: Ryerson, 1933); M. Zaslow, "The Frontier Hypothesis in Canadian Historiography", *Canadian Historical Review*, XXIX (1948), pp. 53-66; S. D. Clarke, "The Frontier and Democratic Theory", *Transactions of the Royal Society of Canada*, XLVIII, Series III; and Michael Cross, *The Frontier Thesis in the Canada's* (Toronto: Copp Clarke, 1970).

43. Lower, "The Trade in Square Timber", p. 43.

44. "It was the fate of the West to become the colony of a colony which brought to its new imperial role neither imagination, liberality nor magnanamity," W. L. Morton, "CLIO in Canada", *University of Toronto Quarterly*, XV (1946) 3; reprinted in *Approaches to Canadian History*, pp. 47-8. Cf. Innis *A History of the Canadian Pacific Railway*, p. 294 and C. B. MacPherson, *Democracy in Alberta* (Toronto: University of Toronto Press, 1962) (Second Edition), pp. 6-9.

45. Donald Smiley, ed., *The Rowell/Sirois Report/Book I* (Toronto: McClelland and Stewart, 1963), p. 45. "Of the Province of Canada's net debt of $74 million, over $18 million had gone into the canal system and $33 million into loans to railways. In addition the Province had shouldered municipal obligations (which, with arrears of interest, amounted to $14 million) arising mainly out of rash municipal support of railway development. The Maritime Provinces had a direct investment in publically owned railways of $11 million. With the exception of a small amount in Nova Scotia, the capital commitments of the Maritime governments consisted exclusively of obligations contracted for roads and railways." *Ibid.*, p. 218.

46. Innis, *A History of the Canadian Pacific Railway*, pp. 44-5; Hugh G. J. Aitken, *The State and Economic Growth* (New York: Social Science Research Council, 1959), pp. 79-114; and V. C. Fowke, "National Policy and Western Development in North America", *Journal of Economic History*, XVI (1956) 4, pp. 461-79.

47. Cook, *Provincial Autonomy, Minority Rights and the Compact Theory, 1867-1921*, Study No. 4, Royal Commission on Bilingualism and Biculturalism (Ottawa: Queen's Printer, 1969), p. 36-7.

48. See McNaught, *op. cit.*, pp. 170-1.

49. Pool, *op. cit.*, pp. 11-49.

50. E.g., M. P. Bachynski, "Science policy in Canada: study and debate must now be replaced by action", *Science Forum 31*, VI (1973), 1, pp. 19-27.

51. Thus while the Committee recommends reducing Basic Research from 23% to 10% of Canada's total research and development effort it also recommends an overall doubling in the amount invested in research and development so that the absolute decline of basic research would be slight. See volume II, pp. 421 and 443. Here as in all budget matters recommendations to cut have a far greater likelihood of being heard than do recommendations to spend.

52. Bachynski, *op. cit.*

53. An example of this relating to the second largest social science research project ever undertaken is James Coleman, "The Concept of Equality of Opportunity", *Harvard Educational Review*, XXXVIII (1968) 1, pp. 16-9. The project is Coleman, *Equality of Educational Opportunity*, 2 volumes (Washington: U.S. Government Printing Office, 1966). Recalling footnote (51) above let it be noted that the Coleman Report's recommendations to stop existing programmes were accepted immediately while those to develop new programmes have been ignored. See "Educational: Delayed Impact?" *Newsweek*, 26 March 1970, pp. 113-4.

54. D. Price, *The Scientific Estate* (London: Oxford University Press, 1965), p. 5.

55. E.g., "Aspects of research management have been carefully studied throughout the years, but research policy has as yet received only scant attention. See, Editorial, *Research Policy*, I (1972-2), 1, p. 1.

56. Marx's example lies in the fact that his radical analysis and theory arose on the basis of evidence available in a public library in government reports. This lesson may be his most important one, certainly for non-Marxists.

CHAPTER TWO

KNOWING, MAKING AND DOING

INTRODUCTION

"By ensuring enough good science many of today's problems would disappear. The only question is the precise "meaning of good science'."[(1)] More recently, an editorial headline read, "It's engineers we need not more BAs."[(2)] Moreover, the early 1970's ecological reaction against the technological society of the 1960's seems to have contributed to the need of further technology, not to the restraint of it.

Delayed only slightly by the greening movement, the attempt to specify a meaning of good science and the reinforce it has led to a world wide debate on science policy. This concern is the latest form of a continual public interest in the impact of science on society since World War II and the development of the atomic bomb. With the advent of the atomic bomb science dramatically proved itself to be more than a subject matter of public policy like health, airlines or coal, but, more importantly, to be simultaneously an effective instrument of policy. Knowledge had long been figuratively spoken of as power. The operational instrumentality of science made some knowledge into power literally. Thus, the fact that science was uniquely invited into government and entered reluctantly under the pressure of the Great Depression and the Second World War distinguishes it from the range of other interests surrounding government.(3) Yet there is a persistent tendency to dismiss this unique characteristic without inquiry into its origins.(4)

This study proceeds from the conviction that the questions implicitly at stake in the science policy debate are far more than what is "good science", but also what is good politics. Anticipating what follows, it can be said that this is a result of the instrumental successes of science combined with the distastefully conflictual character of politics, and the tension reducing effect of wealth. No method lends itself equally to all goals. Each method is somewhat specialized. The introduction of scientific and scientific-like means in government and politics has led to a change in the ends pursued by government. The more successful a means, the greater the tendency to choose goals susceptible to it. Science has been enormously successful, providing an irresistible temptation.

The processes which symbolically culminated in the atomic bomb reach far back into Western culture. The increasing presence of scientific products and processes in our culture is a consequence of much of our history. Identifiable tendencies in our thoughtways have brought us to this point, perhaps not inevitably, but certainly not accidentally. So pervasive are these tendencies that it is difficult to find an untouched perspective from which to analyze them. As long as the principal cause for concern with science and the policy was nuclear weapons or anti-ballistic missiles, the details of perspective could be sacrificed to the study of the more apparent and larger issues.

Today the most visible issues arising at the intersection of science and politics may not be the most important ones, especially outside the United States. The geometric growth in density of both science and society has matured each. Just as each is more sophisticated and subtle, so too are their interactions. No longer is the interaction only the threat of destroying life with nuclear weapon. Now there is also the prospect of unreflectively changing life in a short time. Detection, inspection and judgement of these more gradual and more subtle impacts on public life requires a perspective.

This chapter attempts to survey such a perspective on knowledge and power. This is the perspective from which the remainder of this study proceeds. In activity, in product and in practitioners there is little common ground between science and politics. Lawyers, but not scientists, may become Members of Parliament, and Members of Parliament may become lawyers, but not scientists. That the two dimensions of this interface have so little in common makes the need for a perspective on them all the more important. Absence of a common dimension will force the search for a perspective back upon some of the fundamentals of behaviour. Hence, there will of necessity be some old wine in new bottles. This old wine will consist of an analytic perspective drawn from Plato and T. D. Weldon.

What follows is divided into three parts. (1) The first sets an analytic differentiation of social activity and production as a heuristic perspective. This is the major part of this chapter. It is followed by two shorter parts. (2) Part two impressionistically discusses the relationship amongst the analytic distinctions of part (1). (3) The third and concluding part indicates some difficulties that arise out of the present state of the relationships described in part two.

1. ANALYTIC DISTINCTIONS OF SCIENCE, TECHNOLOGY AND POLITICS

By extending a distinction suggested by Plato in passing, social activity and its products can be differentiated into three classes.[5] The three classes are making, knowing and doing.

Making is bringing something into being, usually from inanimate material. Illustrations of making would be sculpture or carpentry. To bring an idea into being in materials is the role of the maker.

Unlike making, knowing is seen to be neither creative nor active. Rather it is passive, receiving that which is given. It occurs within the intellect, having no effect on the world, but affected by it. One who knows is a savant.

Doing is the final class of social activity and production to be distinguished for the purposes at hand. It is impermanent and unpredictable for it is composed of the unmediated relationship of person to person. Mediations are understood as social roles and institutions. Unmediated relationships are those which seek to destroy or recreate those very roles and institutions of mediation. This is a political task.

Each of these three classes is distinguished by an exemplary form of activity which yields a distinctive product. The activity of making is puzzle-solving, knowing is problem-solving and doing, difficulty-solving. The distinction of puzzle, problem and difficulty is borrowed from T. D. Weldon, and bears explanation.[6]

Puzzles are man-make and have correct solutions. Puzzles may be said to range from following a blueprint in a piece of construction to a mechanical task.

In contrast, problems are not man-make, but do have correct solutions. Forecasting the weather or correctly stating the structure of a chemical compound: these are problems.

Difficulties are neither man-made nor have correct solutions. Within the ambit of difficulties would be both the definition of a word and the formulation of a moral principal.

Each activity in turn can be related to a particular product. As before each class is composed of a type of activity and a type of product. If the activity is thought of as a question, then the product is its solution.

A puzzle is solved by an innovation. An innovation is a

> ". . . prescription for a producible product or operational so new as not to have been obvious to one skilled in the art at the time the idea was put forward, or we may add to the requirements of novelty the additional one of prospective utility."[7]

Puzzles have certain general features in common. For the purposes at hand foremost amongst these features is that they can be dealt with on the basis of previous experience, knowledge. Making a solution of the challenge of constructing a building according to a blueprint draws upon, but does not expand the current body of knowledge after a certain threshold has been reached.

Innovation is socially institutionalized in the laws surrounding invention. The Canadian Patent Act defines invention as:

> ". . . any new and useful art, process, machine, manufacture or composition of matter, or any new and useful improvement in any art, process machine, manufacture, or composition of matter."(8)

It is not enough for an investion to be new, it must also be useful.

On the basis of the importance of this criterion of utility it can be seen that puzzle solving is what can be called technology. Technology is composed of:

> ". . . our current knowledge and experience about how to use scientific knowledge for practical purposes and about the way in which other things may be made to 'work'."(9)

"Le savoir-faire technologique comprend notament l'aptitude pour la conception des moyens de sa production."(10) If it works, then the puzzle has been solved. Technology is know-how. It is "the organization of knowledge for the achievement of practical purposes."(11) Combined with the technical criterion of practicability--can it be done?--there is an additional one of marketability--is it worth doing?(12)

The latter question can be understood as a more precise formulation of the former. Instead of asking generally, can it be done? It asks, under certain market and production conditions can it be done? Enumerated amongst the production conditions would be (1) the present state of knowledge, (2) the available know-how and (3) the intensity of the commitment to the project. It was not possible to build the atomic bomb in 1940. It was not possible because no one was interested in undertaking the commitment it entailed so that the state of atomic energy relevant know-how was small. The state of knowledge--know why--was, however, adequate. In 1945 it was possible to build and detonate an atomic bomb. Nothing in the structure of the physical world and theoretical physics changed between 1940 and 1945. What changed was the willingness and resources devoted to developing atomic technology.

Discovery is the means of solving problems. It is "the formulations of a new idea or concept of reality."(13)

Prediction of the emergence of a new chemical compound cannot be conducted on the basis of existing logical or cognitive principles, although the solution of one such problem does provide principles that can contribute to the solution of similar problems. Hence, one of the first and most important tasks in problem-solving is determining the similarities and differences between the matter at hand and previous experience.

Discovery reconceptualizes that part of nature's domain at hand and hypothesizes empirical relationships amongst the freshly created concepts. The hypotheses are then tested against observations to ascertain their truth. To the extent that an hypothesis is true, a part of the structure of nature has been laid open for a time. Encapsulated in principles, what is revealed of the structure becomes knowledge. Revelation is never complete and problems always remain.

Occasionally an unresolved problem becomes exceedingly troublesome because of its central location in a theory and its seeming disagreement with the theory. Such a nagging anomaly can become intolerable when the knowledge developed by the normal process of problem-solving isolates it and is thereafter stymied by it. Normal science is the work which gradually [illegible]tes an anomaly. Abnormal science is the work which overcomes an anomaly.(14)

Abnormal science occurs when an anomaly can no longer be tolerated. Up to that point the theory has been used successfully to order and account for facts. ~~Now that~~ is no longer possible. Either the theory cannot account for the anomaly or it cannot account for anything else until the anomaly is dissolved. When the facts no longer yield to the theory, then the theory must yield to the facts. A new theory is needed, one which accounts for all that the previous one did and at least for the anomaly in addition, if not more. The invention of a new theory does not proceed by the attempt to extend the present theory for it is this failure which has led to the need for a change in theory. Existing knowledge will not do. Knowledge needs to be extended. This means that the foundation of knowledge must be broadened to permit an extension. The search for a new theory must begin with a reconceptualization of its subject matter. Only in this way will it avoid the unsatisfactory course of its predecessor.

The variety of nature is infinite in human terms. The logical and analogical fertility of any theory will tap only a part, not the whole, of that variety. Any theory can be exhausted.

The activity of problem-solving is science. The product of problem solving is (scientific) knowledge. It is knowledge "of the physical and living elements in the world around us." As opposed to the know-how of technology, science is know-why.(15)

This is a distinction largely ignored, or at best given lip-service, in the polemics of science policy.(16) Failure to understand this analytic distinction will be shown throughout to contribute to a failure to differentiate goals appropriate to science from those appropriate to politics and a failure to differentiate the means of science from those of politics.

Difficulties have no correct solution. This is the case because for them there is not an external standard which can be erected and taken for granted, in contrast to know-how and know-why. Words suffer no limit as to what they may be defined to mean. So too it is with the strings of words composing statements which do not refer to the world for evidence of one kind or another. Denuded of reference to or reliance upon verification, falsification or corroberation, these sorts of words force us back to our opinions about what should be, past our beliefs about what is. Unbounded by the constraints of utility or truth, opinions may conflict often and without self-evident means of conclusion.

When the issue is the meaning of a term, the risk is low. Definition can be and are generally expected to be generally derived from existing and related primitive and defined terms. However, when the issue concerns the moral or political prescriptions of the norms of conduct, then a non-conflictual resolution is not to be assumed.

In the realm of the normative there is not knowledge available as there is in technological or scientific disputes.

If difficulties were a part of a body of knowledge, then they would not have normative force. They would not have normative force since empirical statements alone do not imply action.

To be taken as sound, an empirical conclusion must be the issue of empirical arguments. The correctness of each argument must be left to the facts. In this, as in any argument, there is no warrant for anything in the conclusion which is not in the premises. Normative premises in an empirical argument are at best superfluous and at worst distorting. Difficulties do not occur in empirically describing the world, they occur in prescribing our conduct.

Standard illustrations of this point are numerous, of course. One will suffice for present purposes. It is the contrast between relating ends to means and choosing ends. Relating a means to an end is simply an empirical matter. Logic combines with evidence to yield an implication of means to ends. Before this can proceed there must be an end. The selection of an end is not unquestionable.

> "For instance, we may be able to prove the implication: if stealing were permitted, there would be no prosperous human society. In order to service the conclusion that stealing should be forbidden, we must first decide that we want a prosperous human society."(17)

Afterall, we might rather have decided on a freewheeling, individualistic society which would tolerate stealing, just as we might value smoking before health.

Each of the three classes which have been differentiated is composed of an activity and a product. In the following table these various components are classified.

TABLE 2.0

KNOWING, MAKING AND DOING

	Knowing	Making	Doing
Activity	Problem	Puzzle	Difficulty
Product	Science	Technology	Politics

This constellation of analytic distinctions is only meant to be taken as heuristic. Certainly, any particular activity or product may prove to be exceedingly difficult to place into one and only one of these classes. Indeed, it may even be difficult to distinguish an activity from its product. All that is claimed for this system of classification is that bearing it in mind will prove useful in reconstructing and analysing the issues and events of science policy.

2. INTERRELATIONS AMONGST DISTINCTIONS

The temptation to rely on a single factor approach to puzzles, problems and difficulties is only too well known. Whether it be the anti-communist who sees communism as the source of all evil, the chemist who would reduce all biology to its elements, or the engineer who responds to design problems with more of the same. Whatever the merits of individual cases of single factor explanation, the syndrome of applying to one context the knowledge successfully developed and employed in another context is well known. To use what one knows is a perfectly natural wish.

What is true of us as individuals is also true of groups and societies. When a group of people find success in one domain, then there is a tendency to apply both the instruments and the goals of that success elsewhere. A transference of means and ends is undertaken in the interest of psychological orientation and practical return. Orientation comes from the use of a previously established and coherent set of concepts which order the features of a new domain of attention. Equally important is the belief that the perspective will be as tangibly rewarding in the new context as it was in the old.

Once people felt possessed of a great and certain knowledge of spiritual matters through knowledge of the gods. It was felt that people knew the rituals by which to appease the gods and could divine the nature of good life. What was unknown to them was when storms would occur and the consequences of erosion. The spiritual world was clear, but the physical world was not. Quite naturally people attempted to bring order to the physical world. This was easily done because an order was at hand, that of the spiritual world. If the physical world were viewed as a consequence of the spiritual world, then a grasp could be got on it indirectly. Securing favourable weather for a sea voyage then meant securing favour from the appropriate deity. The skills and results developed in one domain were transfered to another.

Psychologically comforting, such a method of ordering the world was not as useful practically. Practical failure seldom leads to rejection of such a transference. There is no ready alternative because the transference is complete, the weltanschuung is total. It offers no criteria of adequacy. Any contradiction can be reconciled under the will of the gods. An erratic god is one who tests our conviction. To admit of failure would be to fall back on nothing.

The growth of modern science has led to a reversal of the direction of this transference. Expanding geometrically science has undermined the idea of spiritual certainty and advanced material certainty.

Science has desmystified the world. The veil of mystery in which the enigma of nature had been slumbering was unwrapped. Certainty of nature was gained and no location of spiritual certainty was left. This clash of competing truths is exemplified in the trials of Galileo and Bruno. Which was cause and which was effect? Did god bring order to the universe, or did the order of the universe inspire the idea of a god. Now physical certainty seems plausible, but spiritual certainty does not.

Science has brought an extraordinary knowledge of the world. Eventuating from this knowledge is a great sense of control over nature, something that satelite communication or moon shots consciously or unconsciously inspire in us all. A sense of control based solely on human capabilities. So strong is this conviction that the lasting reaction to the question of the ~~limits to~~ growth seems to be to place even more, not less, faith in a scientifically based technological fix.

Coincident with this rising sense of mastery there occurred a decreasing confidence in spiritual matters. The revelations of science eroded the established bastions of spiritual authority whether by estimates of the age of the earth or by the discovery of cultural differentiation of norms. The association of moral relativism and subjectivism with the rise of science and the scientific outlook has been well documented by its critics. In these industrialized countries where the progress of science has been greatest, the crises of normlessness has been greatest too.

Nor was the development of scientific knowledge without material consequences, most notably in making the Industrial Revolution possible. There have been other revolutions too, including that of the transistor, the computer and the release of atomic energy. These developments made wealth more than the dream of a life after death. They made it a reality. As more and more goods and services were made available, their distribution and acquisition became more and more preoccupying.

Advances in scientific knowledge led to the development of highly productive technologies. At the same time they substantially removed the basis of previous norms. Whereas in earlier times a lack of knowledge of the physical world and knowledge of the spiritual world invited the latter to order the domain of the former, now the obverse is true. The flow of transference is reversed. Now mastery of nature seeks to resolve and order spiritual problems. From enough wealth will come happiness and much wealth will come from science through technology.

Moral uncertainty came to be sublimated by the wonders of material certainty. As George Grant has said, "in the last several centuries most human beings have come to believe with growing certainty that all human problems can be settled by technical skill."(18) Thus, he continued, "the pursuit of technological advance constitutes human excellance in our age and therefore is our morality."(19) And science is commonly taken to be the vessel of technological advance, especially, but not exclusively, by those who do not distinguish it from technology. Hence, national science policy can be understood to join issues of great moment.

The first Minister of State for Science and Technology used the occasion of his first nationwide audience to state that "one of the major functions of my brand new ministry . . . is to . . . create more jobs and higher incomes for Canadians." And to:

> ". . . help guide the economy towards the greatest possible expansion of production, employment and real incomes and more time has been spent on this item than any other in Cabinet."(20)

While the Quebec Cabinet Committee on Science Policy sees "la satisfaction des besoins de l'economie et de la société en general" to be the purpose of science policy, "les besoins de la société en general" are not again discussed in the report's thirty-four pages, but "les besoins de l'economie" certainly are.(21) The narrow confinement of science policy to economics seems only to have been recently recognized for what it is, with an accompanying aura of outraged innocence, by what in fact is one of the prime advocates of such confinement, namely the O.E.C.D.(22) And Senator Lamontagne says that:

> ". . . the major interest that society has, and therefore what the government should have in science and technology centres . . . around the innovation process. It is through this process that society either benefits or suffers from the applications of science."

So science is, for the purposes of science policy, innovation. And what then is innovation? It is "the introduction for the first time in the world of a product, a service, a method of production or a policy." In the immediately previous paragraph lip-service is specifically, quickly and vaguely paid to the exceptional cultural contributions of science, but about these contributions nothing more is said.(23) All of this emphasis is predicated on the view that because our material wants are a necessary condition to all further wants they are more important than all other wants, and finally that there just are no other wants.

When knowing and doing are not differentiated there is a reversal of Gresham's law.(24) Hard knowledge drives out soft opinion. The activity of knowing seems to be possessed of the qualities of objectivity, incrementalism and control, so also do the products. Wherever possible any government and any politician would rather work with fact than opinion. The sense of legitimacy is greater and personal responsibility is lessened. I am responsible for my opinions because I create them, but I am not responsible for what I know, that lies in the world not in me.

This is a long way around saying that a class of means comes to be permitted to determine the class of ends. The designation of ends by means occurs for several reasons on this analysis. First and most general is the diminishment of personal responsibility of the politician. Instead the responsibility of the bureaucratic technologist increases, but that responsibility is not personal. It is based on facts and rationality. Second, there is the equally understandable desire to concentrate on th[e] ends where the prospect of success seems greatest and [illegible] where there is the greatest confidence in ends. It takes no argument here to show that Western industrialized societies excel in science and technology more than in the development of sophisticated and intense ideologies. Our ideologies have not changed greatly since the 19th Century, but our technology has.[25] Accordingly, scientific and technological approaches to public policy receive emphasis. When this happens the society becomes increasingly committed to the linear progression of existing states of affairs and disaffected from the consideration of alternatives.

Alternatives cannot be considered for the very good reason that bureaucrats will not allow themselves to set political goals. Precisely because they are not electorally accountable to the citizen body, the ideal bureaucrats studiously avoid attempting to lead public opinion. Instead they try to divine public opinion and follow it, taking as given ends those prevalent in society. Once this is done, then vast policies are planned and put into operation. These policies reinforce those given ends. Contemporary politicians become like bureaucrats in seeking only to administer given ends, not trying to develop an interest in different ends. Naturally enough the existing ends which prima facie seem to have the greatest claim to prevalence are material onces, the lowest common denominator. There is a neat concurrence between what we are good at and what seems to be of the widest interest. The political emphasis on economic growth results. Since science and technology can expand available wealth, existing wealth need not be redistributed.

This emphasis on growth has not gone unchallenged. Even now the benefits of growth are under attack. This time from the standpoint of ecological balance. However, the critique is likely to allow itself to be satisfied by placing an even greater emphasis in science and technology. Admittedly it may be a science and technology which is not (so much) oriented to growth, but it will be science and technology all the same.

3. ISSUES IN INTERRELATIONS

As science and technology grow in importance as instruments and subjects of public policy the arena of politics is moved. If the subject matter of key policies are technical and scientific questions and if the approach to these and other questions is to be as scientific and technological as possible, then the range of issues publicly considered is reduced and the number of potential participants decreases. If public policy tries to entertain only issues with a knowledge component, then many significant issues must be put aside. If public policy tries to deal with all issues in as technical a way as possible, then the pool of participants decreases towards expertise. The signs of reliance on technical expertise are rife in public life.

It is commonly said in the United States that because of the size of the country and the complexity of issues that government is no longer by the people, but rather for the people. This message apparently is well understood judging by the from low voting turnouts and limited dissemination of ideology. Government serves our need, not our wants. Our needs can be determined technically and are unchanging. Our wants only we can determine, and we can change them. A government dedicated to our needs can pay little attention to our wants. And governments, and their science policy, are dedicated to our needs. Madame Jeanne Sauvé, second Minister of State for Science and Technology, said upon coming to office, that the task of science and science policy is "adapter la technologie aux besions du peuple."(26)

Without the leadership of political parties, public awareness of this phenomenon is transitory. It is easily taught to accept the substitution of needs for wants. Our opinions remain inchoate if given nothing to form about. Governments too can get entrapped in this syndrome as the handling of the 1973-4 oil crisis shows. What began as an explicitly political action--the Arab embargo--was quickly transformed into technical puzzles and scientific problems about sources of energy and cost of access. In short, failure to distinguish science, technology and politics in public life gradually transfers attention from politics to technology and science.

While science for policy and policies for science interact strongly, it is clear that most of the debate on national science policy in Canada has concerned itself with policy for science. Even the work of the foremost student of Canadian science policy, Professor G. Bruce Doern, follows this emphasis. Doern does so despite his specific claim that the emphasis of his book, *Science and Politics in Canada*, which sums up an impressive body of work contributed by Doern to the study of science policy making in Canada, places "the emphasis on the science in policy" dimension.(27) What is meant here by "science in policy" and what Doern means by it are obviously different. Our understanding of "policy for science" are similar.(28) This is the area of research management. And our understanding of "science for policy" appears to be similar, for it is the policy stage which involves "the utilization of science as a means for solving problems in other substantive public policy areas."(29) So far so good. However, in the course of his work, Doern's notion of science in policy becomes limited to quite specific established government policies, such as the Intense Neutron Generator affair and the general policy orientation behind science in policy.(30) Thus Doern's book mentions agricultural research once;(31) economic policy once;(32) industrial research six times only;(33) and does not mention at all, productivity; balance of payments; license fees; multinational corporations; or the like. The book is an excellent study of the main features of the hodgepodge of Ottawa's science policy-making apparatus, but it, like that ensemble, seems a little distant from the political questions toward which policy is directed. In short:

> "Doern ne fait pas justice au titre de son livre. Faire l'analyse des décisions a l'intérieur des organismes gouvernementaux, n'est pas la même chose que faire l'analyse de la situation de la science au Canada en rélation avec la politique canadienne. En éffet, le développement de la science au Canada ne saurait être limité aux prises de décisions des organismes gouvernementaux."(34)

Doern's study excludes politics and political theory from examination because he treats administrative apparatus and policies as though they, and they alone, constituted the policy questions concerning the use of science. And while it is doubtlessly true that administration is more political than was once widely realized, it most certainly is not and should not be treated as the whole of policy. To take the administrative point of view is to forego or to beg the overriding questions about science policy, namely whether or not one is desirable, or whether it should be for all science or only a part. Being so close to the administrative apparatus in his thorough research, Doern seems to have mistaken a few of the most important trees for the entirety of the forest forever. Certainly Doern is aware of the differences between the administrative and policy aspects of science policy, for he offers a policy analysis of the Senate Committee Report.(35) But it is placed in an appendix, indicating that the concern with policy is to distinguished from the administrative and organizational focus of the text. All of which is only to say that Doern has not done what this study aims to do.

Now even the most casual reader of the foregoing pages will realize that the concerns of science policy do not fit nearly into our tabular display of the concepts involved. This should not lead us to doubt the coherence and utility of the schema, but rather of science policy, for it is precisely because of this incongruence that science policy is problematic. It focuses on only one type of activity, science, yet is undertaken with the intention of achieving ends under all three headings.

Some critics of industrial society have feared the subvention of human values to the rationality of science and technology, notably Weber, Marcuse and Ellul. Others have drawn attention to the prospect of the subvention of the capability of science and technology to human values like greed. Both criticisms have merit, for what seems to be happening unintentionally is a change in the emphasis of public life from the clash of opinions to technological solution of puzzles in the disguise of bringing social control over science.

Some indication of the pervasiveness of this process is gained by realizing that nearly all ideologies native to Western industrialized societies are uncritical of the movement of science and technology into public life as means. Left, centre and right use the very means of science and technology to offer criticisms and blueprints of each other and the future. Their objections are to the introduction of science and technology into the realm of ends, for each would serve different constellations of the populace at different priorities. The possibility is largely ignored that the use of scientific and technological means, even for critical purposes, continues to narrow the issue and participation ranges of public life.

FOOTNOTES

1. R. G. Ward, "The Role and Function of Science in the Modern Community", *Public Administration*, XXVII (1968) 2, p.106.

2. *The Australian*, 21 February 1974, p.1.

3. H. L. Nieburg, *In the Name of Science* (New York: Quadrangle, 1970) (Rev. ed.), p. 114 and Daniel Greenberg, *The Politics of Pure Science* (New York: New American Library, 1967), p. xvii.

4. Greenberg, *The Politics of Pure Science*, p. xi.

5. Plato, *The Republic of Plato*, trans. F. M. Cornford (New York: Oxford University Press, 1945), pp.331-337.

6. T. D. Weldon, *The Vocabulary of Politics* (Middlesex: Penguin, 1953), pp. 75-81. An additional category to Weldon's three could be Alvin Weinberg's idea of transscience. It is comprised of questions which may be intelligently asked on the basis of present scientific knowledge, but which cannot (ever) be answered. Within the reaches of transscience Weinberg places matters pertaining to the probability of extremely improbable events, as a catastrophic reactor accident; the behaviour of a particular individual; or the biological effects of low-level radiation insults. The common feature of these is that their solution must be found experimentally, not by theoretical deduction, and that for varying reasons the necessary experiment is impossible. Specifically, to the last of the three he says, "to determine by a direct experiment whether 150 mrem will increase the mutation rate by one-half percent requires around eight billion mice!" It is Weinberg's guess that most trans-science questions would concern the side effects of technology. See his "Science and Trans-science", Paper read at the Fourth International Conference on Science and Society, Herceg-Novi, Yugoslavia, 1971, pp. 2 ff.

7. Joseph Schmookler, *Invention and Economic Growth* (Cambridge: Harvard University Press, 1966), p. 6.

8. Patent Act, *Revised Statutes of Canada* (Ottawa: Queen's Printer, 1970), VI, p. 5693.

9. Andrew Wilson, *Science, Technology and Innovation* (Ottawa: Queen's Printer, 1968), p. 5.

10. Guy Saint-Pierre, *Les principles de la politique scientifique du Québec* (Québec: Comité des politiques scientifiques du Québec, 1972), p. 7.

11. Eugene Mesthene, *Technological Change* (New York: New American Library, 1970), p. 25.

12. Schmookler, "Technological Change and Economic Theory", *American Economic Association Papers and Proceedings*, LV (1965), pp. 335 and 338.

13. Wilson, *Science, Technology and Innovation*, p. 8.

14. See Thomas Kuhn, *The Structure of Scientific Revolutions* (Chicago: University of Chicago Press, 1969) (2nd ed.), pp. 35-42.

15. Wilson, *Science, Technology and Innovation*, p. 5.

16. See, e.g., Nieburg, *In the Name of Science*, p. 113 and Leslie Sklair, *Organized Knowledge* (London: Paladin, 1973), p. 66.

17. Hans Reichenbach, *The Rise of Scientific Philosophy* (Berkeley: University of California Press, 1964), p. 279.

18. George Grant, *Philosophy in the Mass Age* (Vancouver: Copp Clark, 1960), p. iii.

19. *Ibid.*, p. iv.

20. Alastair Gillespie, *Transcript of "The Nation's Business" Broadcast*, C.B.C., 24 October 1971, pp. 1 and 2. Cf. Edward Wenk, formerly of the Executive Office of U.S. Government, "The Interaction of Science, Technology and Social Needs" and Richard Carpenter, Chief of the Environment Policy Division of the Legislative Reference Service of the U.S. Government, "Trends in the Development of a Federal Science Policy", *Symposium on Science, Technology and Public Policy in the 1970's* (Columbus: Ohio State University Press, 1971), pp. 3-5.

21. Saint-Pierre, *Les principles de la politique scientifique du Québec*, pp. 2 ff.

22. Harvey Brooks, *Science, Growth and Society* (Paris: O.E.C.D., 1971), pp. 14-16.

23. Maurice Lamontagne, "The General Goals of Science Policy", Address to the Round Table on the Social Aspects of Science Policy, University of Toronto, 1969; reprinted in Senate, *Proceedings of the Special Committee on Science Policy*, 1st Session, 28th Parliament, No. 34, 29 March 1969, p. 4839. Cf. the remarks of the former director of the Allied Atomic Project at Chalk River, Sir John Cockeroft, who speaks of science as the "'goose' which sooner or later 'lays the golden egg'," in his "Science Policy", Address to the Round Table on the Social Aspects of Science Policy, University of Toronto, 1966, p. 3.

24. Alan Davies, "Politics in a Knowledgeable Society", *Essays in Political Sociology* (Melbourne: Cheshire, 1972), p. 3.

25. Claus Mueller, *The Politics of Communication* (New York: Oxford University Press, 1973), pp. 101-112.

26. *Le Devoir*, 13 December 1972, p. 3.

27. Doern, *Science and Politics in Canada* (Montreal: McGill and Queen's Universities Press, 1972), p. xii.

28. *Ibid.*, p. xi.

29. *Ibid.*, p. xii.

30. *Ibid.*, pp. 101-122.

31. *Ibid.*, p. 87.

32. *Ibid.*, p. 221.

33. *Ibid.*, pp. 22, 49, 58, 128, 175 and 214.

34. Philippe Garigue, Book Review of *Science and Politics in Canada* by G. B. Boern, *Science Forum 27*, V (1972) 3, p. 19.

35. Doern, "The Senate Report on Science Policy", *Journal of Canadian Studies*, VI (1971) 2, pp. 42-50; reprinted in *Science and Politics in Canada*, pp. 211-224. Cf. D. Spurgeon, "The Political Realities of Science Policy", *Toronto Globe and Mail*, 31 March 1971, p. 7 and Doern, *Political Policy-Making* (Montreal: Private Planning Association, 1972).

CHAPTER THREE

INSTRUMENTALISM AND DEPOLITIZATION THROUGH SCIENCE

INTRODUCTION

Throughout its history various official and self-appointed spokespeople for industrialization have claimed that one of its long term benefits would lie in the creation of the necessary conditions of a public life open to all. In its general features this argument held that existing restrictions on civic interest and participation to certain classes of the populace were the artifacts of current economic conditions. When, through progress, these barriers fall away there would be created the necessary conditions for the stimulation and admission of all citizens to the public life. At times the barriers in question have been understood to be degrading working conditions, the poll tax, a substandard wage and exposure to mind-robbing television. Those who have argued such include an endless number of Chamber of Commerce-like persons who have faded into the merciful obscurity of history, and such popular writers as Saint-Simon, Bellamy and Ferry, who both summed up and spurred on ideas current in their times.(1)

Noteworthy here is recognition of the goal of a more active civic life and the means of removing economic limitations which were thought to impede its attainment. Once the restricting limitations were thrown off, then public life could go on, but until then all must work together to bring about that happy day. Liberalism in a sense brought Augustine's City of God to earth while retaining its linear chronology.(2) Recently, those who see leisure to be the one important result of increasing industrialization and increased public activity to be the one important result of leisure, have had a resurgence.(3) Yet somehow the leisure which industrialization undeniably proffers is equally undeniably absorbed in private activities which result from that industrialization. Leisure is thus contested for and absorbed by radio, then television, then colour television, or the latest hardware with which to cook an egg or mow a lawn. The rather compulsive side-effects of industrial society have been widely discussed to good effect in both academic and popular writings. Further commentary along these lines is not necessary here. Brief reminder of these aspects need only serve to point out that civic participation is not one of the central characteristics of our liberal tradition. The democratic-participatory element is present in this tradition, but it occupies what can be no more than a second place. Far in the lead in importance is the properly liberal element, which is tolerance.

The following pages in this chapter divide into six parts. (1) The first part reminds us of liberalism's belief that individual well being is the foundation of the good life and the main priority of government. (2) The second highlights the politicization of administration and the corollary depolitization of policy. (3) The third part suggests that the conditions of rule have changed thanks to this depolitization. (4) The fourth examines the reduction of political issues and participation to economic issues and participation which is affected by depoliticization. (5) The fifth part proceeds to examine the further reduction of these economic issues to scientific issues through the mediation of productivity and technology. (6) The last part summarizes this chapter.

1. LIBERALISM AND WELL BEING

What then is the liberal tradition of the Western industrialized nations? Of course, it is like all traditions in being a tapestry too diverse and too richly detailed to be done full justice in these pages. The liberal tradition at which we have so long drunk has been truly ecumenical, all things to all people. Unfortunately, the rich complexity and variability of the liberal democratic tradition in Western industrialized society has almost driven it beyond the scope of social criticism, both for citizens and academics. Our history is too long, our culture too diverse, our economy too complicated, our politics too invisible to be made the subject of criticism and analysis. Instead we analyze, not technocratic society, but rather health care, auto insurance or the National Research Council. We lower our focus to more limited topics, hoping that these will be manageable and relevant. Curiously enough this reduction of scope is consistent both with traditional academic structures which were developed before the complexification of society and the conventions of social activism which have been developed more recently. Whether such more limited topics are more manageable and/or relev nt are empirical questions. More manageable they may be logically, but this does not prove that they are manageable. So too it is for relevance.

Now of course scope is reduced with a second hope in mind, namely that the larger social issues will be mirrored in the more precise issues, and that the catalogue of limited range issues adds up to the social whole. But again, these are empirical claims which have yet to be substantiated.

If there is one academic truism it is that the questions which one asks determine to a great degree the answers at which one arrives. This study proceeds from the conviction that some issues do not arise within the spectrum of the more limited, micro-critiques, some questions fall between stools. This is after all why they are advocated by their proponents and what it means to say that they are marginalized. And these unasked macro-questions are of the greatest importance, for they relate to the overall shape and direction of our society.

Rich and diverse though the Western culture is as it is manifested in Canada, it is like any culture in having identifiable, main features. It is in terms of these features that this discussion may proceed. Before proceeding however, a further note of caution needs to be sounded. A portrayal of tendencies in technocratic society will dominate this chapter. There are, of course, contrary directions within that set of tendencies and antithetical sets of tendencies. It is by no means the case that our society is in a final, existential sense technocratic now or that inevitably that it will be. Rather it is maintained that (i) it is consistent with some of the main streams of the Western tradition to aspire to technocracy and (ii) that some of these aspirations have been fulfilled while others are now under active consideration in Canada in both elite and mass.

Essentially, liberalism is a most optimistic doctrine. It believes simultaneously in the increasing perfectability of people and in their increasing mastery over the social and natural environment. The idea of human effort correcting social and natural tendencies, fate, had its beginnings in Machiavelli's individualistic representation of what the Prince could do. Machiavelli's prince was neither mysteriously born to, nor would he mysteriously lose, authority. The achievement and retention of princely authority were analyzable phenomena, which could be controlled, once understood. From the shoulders of Machiavelli, Hobbes extended this attack on quiescent fatalism to a more collectivist level. Hobbes argued that a people can mould their environment and hence their fate, within certain parameters. These two are the thin end of a wedge in European political culture from which emerges the more general, implicit idea that people may consciously and decisively seize control of their environment and re-order it. Only unreconstructed conservatives have hung back.(4)

Everything cannot be re-ordered at once and everything should not be re-ordered at once, for some things are more important than others. Identified as foremost amongst the difficulties in need of re-ordering is the scarcity of material goods and services. Thus from the earliest to the most recent times, variants of liberalism alike give distribution pride of place both in their analysis of the causes of social conflict and in their recommendations for the cures of social conflict, though, of course, the variants place emphasis differently and often portend different solutions. Nor was this preoccupation with scarcity the monopoly of liberalism. It arose and matured concurrently with the European Industrial Revolution which directed the attention of all to the economic basis of society which had earlier concerned Aristotle. In this sense, the preoccupation of liberalism with economics is only one mirror of a wider social concern stimulated by the Industrial Revolution. This sensitivity to the material basis of society is most clearly manifested in Marxism, lying to the left of liberalism, but it is a feature of both, a monopoly of neither. Indeed it may be that these two characteristics--the belief that scarcity underlies politics and that it may be alleviated--that distinguish the left from the right in most cases.

If politics arises from a conflict over scarce material resources, as both liberalism and Marxism hold, then by ending scarcity, such conflicts will be ended. Hence, politics, too, will be ended. If the goal of liberalism and Marxism is to diminish and to end scarcity, then their goal is the end of politics, as they understand it. To replace "the government of persons" which scarcity necessitates with the "administration of things" which affluence permits, this is the goal.(5) In short: in scarcity the distribution of goods and services is a zero-sum game. Being a zero-sum game, authority is required to make distributions stick. Affluence destroys the zero-sum idea and introduces a positive-sum game, removing the stimulus of conflict and thereby the need for politics.

At the time of the advent of the industrial revolution in England the main obstacle to the realization of the liberal vision were those remaining vestiges of feudal regulation of trade and commerce. These became the first practical subjects of the theoretical development of philosophic liberalism.(6) Specifically, the first liberal solution to the difficulty of scarcity was the Whig idea of the free market. If demand and supply were permitted unfettered interaction, then a natural balance between the two would ensue.

According to the idea of the free market, public harmony would issue from the interplay of the private interests of individuals. When mixed together our private demands for goods and services would stimulate others and ourselves to make profit by supplying those demands. While no theorists would have seen this as either a perfect or wholly elastic mechanism, few, if any, successfully concentrated attention on its imperfections or inelasticities. Dismal economics donned the smile of liberalism.

Aiming at the alleviation of scarcity provides liberalism with a standard of judgement. It is in terms of the effectiveness of a means to that end that a policy decision is made or not made. The standard of decision is utility, the method is instrumentality. In these things, and in much else, the watch-word of liberalism becomes efficiency. And it is efficiency in terms of economic growth to end scarcity.

So important is the desire for growth that a certain necessity to permit economic planning is accepted. By treating commercial organizations in the same way as individual citizens, liberalism at once departs from socialism and allows the attainment of a unified organization having a sufficient size--horizontally and/or vertically--to permit planning. If growth really is as important as we say it is, then it cannot be left to the chance of the market, a feeling doubtlessly accentuated by the persistence of casualties in the free market. It is at this point that liberalism conceives of introducing specialization in government. The first introduction of specialization can be said to be Plato's differentiation of the rulers and the ruled. This distinction continued for some time. Somewhat coterminous with the rise of liberalism, democracy challenged even this differentiation. However, in a brilliant manoeuvre liberalism managed at once to give into the democratic sentiment while outflanking it in the long-run. The outflanking manoeuvre came as a result of the additional levels of differentiation and specialization which liberalism introduced as it became liberal democracy. These specializations were sought to increase the efficiency of government in taking on the complex challenges of efficiency and growth in industrialization. First, it divided rule into three: rule-making by a legislature, rule-enforcement by an executive and rule-interpretation by a judiciary. Within the executive itself a further specialization developed between policy and administration, between making and maintaining policy. Administration has become nearly a fourth branch of government. Meanwhile, arguments about size and mass instability led to a system of representation for rule-making. The legislature was placed at one remove from the populace and liberal theorists were unremittingly hostile to the idea of parties and factions filling the gap. Gradually political parties did develop their own institutional character, enhancing even more the specialization of rule. Consequently, while the institution of democratic elections brought citizens closer to government, political differentiation within government deprived that proximity of much of its meaning. Government was spatially closer, but because it was more complex due to its goal and its organization psychological distance increased.

Now this exposition has not taken up directly the classical liberal concern with the protection of a litany of rights and freedoms. Nor will it do so. As important as these ideas are to liberalism as a whole, and as exclusively preoccupying as they may be to some liberals, it is sufficient for the purposes at hand to see these freedoms as being granted to the citizens "not in order that they may govern, but in order that they may not be misgoverned."(7) In the tradition of limited government, universal adult suffrage and other rights of citizenship exist as checks on governmental excess, not as a means of direction and control. The ballot cannot be effectively used to say yes, because of certain structural characteristics it is never clear what a yes vote is for in a mass democracy, but a no vote is effective. In the 1964 United States Presidential election a no vote for Goldwater because of the Vietnamese War was clear, but the yet votes for Johnson were not. The aim of a theorist like John Stuart Mill was to prevent bad government, not to insure government according to the wants of the people. Where the planning required for good government conflicts with the theoretical extension of citizens' rights, Mill's system would break down. It is his assumption that the free market of ideas will be efficient. Were the free market to prove to be inefficient, then it would have to be reconsidered.(8)

While the corpus of liberal doctrine has grown enormously beyond its narrow base in the assumption of scarcity and the idea of the market, these things are still at its root. And the idea of scarcity still is the engine of the non-liberal left as well.

That the assumption of scarcity and the idea of the market still lie alone at the heart of liberalism is proven mostly by virtue of the fact that liberalism's concept of public life and citizenship is nothing more than the concatenation of private interests. The public domain of liberalism contains only the private interests of individual citizens. Nothing is added by way of issues in the public domain. Everything that is there is traceable back to individual interests. Public life has no issues of its own. It has only those issues brought to it by private lives and these are only material economic interests. Private interests are thereby restricted to economic motivations for three overlapping reasons. First, material well-being is seen to underlie all of life. Hence, it has first, if not exclusive, priority over public life. It only comes to take on an exclusivity for the two other reasons. Second, the idea of efficiency of freedom stresses the need for a minimal role for the public life so that it interferes as little as possible with private creativity. Third, the idea of what citizens seek in the state is one which is left at the pre-conditions necessary for life and the privacy and freedom to enjoy them. The assumption is that the values which primarily motivate people are those values which can be enjoyed, but not necessarily met, in an individualistic and solitary fashion. This rules out social and political values such as self-expression or awareness of others. Economic values can be consumed individually. They are brute and physical, but social values depend for their conception on interaction with others.

And in the thinking of liberalism, individuals precede groups. Values which stem from individuals have a priority. Social and political values, instead of being ends, are means to the end of economic consumption.

For these reasons in textbook presentations of liberal democracy, once the assertion and protection of one's interests are accomplished, no other content is ascribed to citizenship. And the whole public domain of the state is nothing but a collection of these private interests.(9) It is surely not coincidence that inclusion of the idea of a public interest has plagued liberal theory, no matter how odd it seems for a public body to need to justify having public issues, for a community to wonder if it had community issues.

Even more interestingly, radical critiques of liberal democracy charge it most often with having failed in this transformation of private interest to public interests, not with having attempted it in the first place. Apparently, these critics too give priority to material well-being. This is no surprise for this idea is pervasive in our culture. Conceiving of an alternative to it is difficult for us all. Even revolutionaries like Marx and Engels could say little about the nature of a society once it was freed from its materialist condition by communism. Instead we learn little more than that the state as we know it would wither away. Politics will end.

2. DEPOLITICIZATION

To make the world anew, to make a world without scarcity which would be a world without conflict, these are the desires of liberalism. Understanding conflict to arise out of scarcity, it is not sur rising that liberal politics often pursues economic growth at breakneck speeds. These were the arguments of the preceding section.

In any particular case, ends always determine means to some extent. So it is in this case. Elimination of scarcity depends principally on the creation of new resources from which additional goods and services may be produced. Additionally, scarcity would be assuaged by the creation of new and more efficient techniques of production from both previously existing and newly identified resources, and of distribution.

Knowledge has become the end of politics. That knowledge is the end of politics is true in a double sense, each of which is discernible, though the two are inseparable. In the first sense, knowledge has become the goal of political activity. It is the goal of political activity in the sense that the material wealth sought by liberalism is to be produced by and from creative scientific knowledge, which will stretch and/or substitute for otherwise limited resources. Once our private, individual economic interests are guaranteed, then the liberal concept of public life is empty. Happiness results from wealth.

In the second sense, knowledge is the end of politics in the sense of terminating the need for public activity. Under the conditions of scarcity the distribution of resources makes public life a zero-sum game. Not all demands can be met by the limited supply, so priorities must be established. To be sure to receive needed resources, individuals and groups must contest for them by justifying different priority schedules. This is political activity and it is ended under the conditions of affluence. There all demands will be met. Economic growth's:

> ". . . appeal exceeds that of the brotherhood of man, indeed it comprehends it. For as we become richer, surely we shall remedy all social evils: heal the sick, comfort the aged and exhilarate the young."(10)

Hence, the main imperative of modern society is "to produce as much as possible through mastery of the forces of nature."(11) This ethos has naturally taken root in Canada and was evident in the hearings of the Lamontagne Committee, including the testimony of O. M. Solandt, then head of the Science Council.(12) Some years ago Senator Lamontagne himself concluded that the only business of politics was economics.

> "En effet, le autorité publique cloit faciliter et stimuler progres économique mais, au besoin, le freiner et l'oreinter afin d'assurer une utilisation rationalle des ressources qui sort en même temp a l'avantage général de la population."(13)

And all demands will be met faster if all involved cooperate and rationalize their efforts. So, for example, we learn to delay gratification. In the sense of rationality and efficiency, knowledge becomes the means of ordering society. It becomes the mechanism by which public life is conducted.

Rationality replaces partisanship; cooperation replaces conflict. Wealth results from knowledge.

To summarize: (i) As happiness is seen to be derived from wealth, doing is replaced by making. The forms of the activities of making become the dominant forms of public life. (ii) As wealth is seen to be derived from knowledge, making is based on knowing. The products of knowing become the dominant products of public life. (i) and (ii) are discussed further in parts (4) and (5) of this chapter. Before that can be done the theoretical background of these phenomena must be further elucidated.

The world of the endless frontier which liberalism seeks is one:

> ". . . with certain epistemological characteristics among which are the development of more fruitful categories of thought, increased differentiation of ego from inner and outer worlds, an imagination of structures contrary to fact, reflective abstraction, changing truth criteria, and a changed philosophy of knowledge. This increase in knowledge and change in thoughtways leads to changes in policy-making procedures. There is increased application of scientific criteria for policy determination at the expense of the usual short-term political criteria and ideological thinking as well."(14)

It was in this way that the end of ideology was foreseen in the affluent days of the 1950's in the United States. Like most things American, the syndrome spread easily to Canada. Generally:

> "Canadian Liberalism as it emerged from the Mackenzie King Era . . . is an undiluted variant of the end-of-ideology premises which dominated the thought and practice of domestic politics during the 1950's."[15]

It is far more than a coincidence that liberalism's tolerance of freedom has allowed it to offer a territory into which the roots of science have been deeply sunk. The goal of scientific knowing is truth, and liberalism, believing as it does in the utility of truth, strives to place no obstacle in the path of truth. Instead of attempting to remake science in its own image, as various conservative and communist ideological variants have done, liberalism remakes itself in the perceived image of science. Academic freedom is thus a hallmark of liberal society and knowledge is at once neutral and ideological. Liberalism fulfills what is the essential injunction of the scientific method: Do not block the way of inquiry.[16] Each, liberalism and science, grew together out of the hothouse of 19th Century European culture. It is no wonder that they interact and share characteristics. Not only does this affinity have hold at the macro level, it holds on the micro level as well. More than one widely known representative of liberalism has also been a widely known representative of science; examples include Benjamin Franklin, Bertrand Russell, John Dewey and John Stuart Mill.[17]

Knowledge adduced by respect for truth provides the main fuel to liberal rationality. It is a fuel neither equally available to all nor equally efficiently burned by all. It is at this point that liberal democracy meets in one form its perennial theoretical difficulty, namely reconciling the conflicting demands of authority and liberty. The pure liberal impulse believes that there is knowledge and that it should be used as the b.sis of rule. Knowledge becomes a principal of authority. To the reformist liberal, priority attaches itself to what is needed and this is a problem of knowledge. Meanwhile, the pure democrat has no such confidence in immaculate knowledge and celebrates individual liberty, which itself imposes authority through the decision making rule of majoritarianism. To the populist democrat priority adheres to what is wanted, and this is not a problem of knowledge; it is difficulty. Clearly, the distinction traced in the foregoing sentences would be difficult to maintain strictly. Indeed, any differentiation of liberalism and democratism becomes difficult to maintain. Because the two have many common assumptions, desires and implications they came together into liberal democracy and once together they have shaped each other.

Liberal democracy attempts to partially satisfy both schools of thought, and therefore certainly satisfies neither fully. Primarily, the method of reconciliation is the division of government and its ensuing specialization. The effects of this manoeuvre have tended, however, to enhance the liberal-knowledge strand at the expense of the democratic one.

As was claimed earlier, the effect is a reverse of

Gresham's law, hard knowledge of needs seems to drive out soft opinions about wants, as technical, rather than ideological, issues are seen to dominate public life, a conviction expressed to the Senate Special Committee on Science Policy.(18)

Four commonly known indicators of this phenomenon can be cited, though admittedly the status of each is more complex than their use here as examples indicates. First and foremost is the idea of professional self-regulation which has arisen in the industrialized liberal democracies.(19) In a number of socially sensitive services it has been decided that there is a knowledge base such that, if not disturbed by external interference, it should and will direct its practitioners to maximize their social benefit. The fields cannot be legislated from the outside. They rest on knowledge. This knowledge must be the exclusive basis upon which decisions about the field are made. The knowledge can only be fully appreciated by practitioners and not by outsiders. So far this picture would include mystics as well as medicos, but if the assumption of the social importance of the service is added, then we have professional self-regulation. Certain social services have the foregoing characteristics and are socially important, for example law, engineering, medicine and accounting. Not because these domains of activity are deemed unimportant, but rather because they are deemed important they are, partly, set outside the range of political conflict.

Second and following from the first, it is precisely the occupants of these professions that generally score highest in social ratings, while politicians score much lower. Doubtlessly, part of the image of professional occupations which makes them attractive is their higher income and freedom from supervision. The freedom from supervision relates to the knowledge-base and community and self-discipline which is understood to arise from that base. The income levels are themselves [illegible] signs of the esteem held for these occupation. A small, but important, indication of this esteem is the distinctive success enjoyed by the professional in public life, especially in seeking elected office. Doctors and lawyers usually form a considerable block in any legislature.

Third, the manoeuver of dividing the authority of government may work to limit its exercise, thereby to protect citizens, but it does not work to make government more subject to control of citizens. The restraints of limited government in liberal democracy are meant to apply against both elite and mass. If willingness and interest in government and politics can be taken as some sign of the specialized character of modern government, then the mass of the electorate may be understood as having realized it. The mass electorate shows only a passing interest in political information and an erratic turnout at non-compulsory elections. These facts have been well documented over the years in numerous studies. Various interpretations of this lack of interest have been offered. The two main poles of interpretation are (1) a contented complacency generated by the present efficiency distribution system of liberal democracy and (2) a resignation arising from the frustration of being unable to alter that manner of distribution. At least superficially compatible with both of these line is thinking is that which is relevant here. It is that citizen inattention results from a feeling that government is too complex to be understood, regardless of whether according to Robert Dahl one sees that as tolerable or according to Jack Walker as frustrating.[20]

One of the traditional roles of political parties in mediating between individual interests and the collective of the state is normally described in first year university textbooks as simplifying and clarifying otherwise complex issues. Though conceptualizing empirical indicators of this process is difficult and so neither commonplace nor distinctive evidence can be referred to, the low levels of citizenship response in elections would seem to indicate the degree of failure of simplification and clarification. What can be safely said is that it is widely agreed amongst politicians and other opinion leaders that government has grown more complex. This belief cannot but help influence their direction of parties. Though they might react to this belief in at least one of two different ways. The first would be to attack it by further simplification. The second would be to become more complex. Because partisan strategies are never unidimensional and are highly interactive, the dominant reaction cannot be specified. It is important to notice, at this point, that political parties have altered their structures in some ways which reflect an emphasis on growing complexity. Principally, they have become research conscious. Normally one would have found a policy section in a national party headquarters, now one finds in addition, a research section. A research orientation to policy has marked the New Democratic Party for sometime. The Progressive Conservatives recently created such a division, in response to the creation of a pool of funds for Opposition Research.(21)

One of the major mechanisms by which political parties simplified public issues was by focusing conflicts in terms of leaders and personalities. But even that mechanism is no longer automatically invoked and may not carry if invoked. The 1973 Oil Crisis for example was treated mainly as a highly complex technical-scientific issue about the availability of oil and rather than as a political issue about its distribution, not only by governing parties but also be oppositions as well. For whatever reason, politicians were either unable or unwilling to politicize the issue.

A fourth indicator of the reverse Gresham's law regarding political knowledge is the centralization of legal and popular authority in the executive of government which has resulted from the earlier simplifications of political parties.(22) The tendency toward Executive Government which has been witnessed in recent years in Canada has boomeranged. Instead of moving government closer to the people, it has moved it further away psychologically. The executive itself becomes a hotbed of research. It does not act until the facts are in. Controversial issues like drugs or inflation are farmed out for research to Royal Commissions, Task Forces, Senate Committees or Crown Corporations.[23] The emphasis on research is amplified further in several ways. Royal Commissions were once used primarily as sounding boards of public opinion on broad policy issues. There is some evidence now that this has changed. According to one observer, there has been a relative decline in the use of public hearings by Royal Commissions and a relative increase in the use of research staffs.[24] On the other hand, citizen participation must be discouraged by the requirements for submission of briefs set by, for example, the Senate Special Committee on Science Policy.[25]

In turning to these sorts of methods Prime Minister Trudeau has gone outside normal channels, but for the purposes at hand, the effect is the same. Thus, while he may reject the advice of the bureaucracy, he has created his own bureaucracy in the Prime Minister's Office and the Privy Council Office to which he does listen.[26] The Prime Minister has long had a desire to find rational solutions to political conflicts.[27] Meanwhile, Programming Planning Budgetting Systems are considered for departmental adoption.[28]

Really controversial issues may go to Cabinet groups which work entirely in confidence--read secret, like the Gray study of non-resident capital. The knowledge becomes so complex, it is believed, that the greatest danger lies not in not having it, but in its being misinterpreted, hence secrecy.

Of course, this can and perhaps has become a reflexive prediction. If one grows out of the habit of simplifying situations, alternatives and policies they might doubtlessly come to be too complex to explain.

As admitted earlie , designating indicators of the failure of parties and now leaders to simplify and clarify is not possible. Still in sum one may say that Canadian parties would seem likely to score fairly high on the complexity scale, when it is developed. For reasons which will be discussed later two explosive issues underlie much of Canadian public life and they are avoided wherever, whenever and however possible, at least by the most successful of the national parties, the Liberals. They may be hence, as Gad Horowitz has argued, a centrist party.(29) The Canadian Liberal Party is perhaps a centrist party that is using research to find the centre.

In its most basic form, knowledge-based rule is bureaucratized rule by expert. This is what Michel Crozier called the bureaucratic phenomena.(30) Reliance of government policy-making on administrative policy-maintenance in this way causes the two to blend together. At least initially this blending was probably salutory. It would have introduced a bracing bit of rigor to politicians and an equally bracing bit of reality to administrators. Over time, when the distinction between policy and administration is not made by either leaders, elected or appointed, critics and citizens, then it is lost. It is likely that the loss occurs sooner and easier where there is one party electoral dominance in government. By entirely natural and non-conspiratorial means politicians and administrators who work and live in extended contact come to think alike. And one party electoral dominance is the norm of liberal democracies. Like any long married couple, they come to look alike, as J. E. Hodgetts once said.(31) But as in some marriages, this blending may not be a mixture of equals, but rather a devolution to a lowest common denominator. In short, administration is politicized. So far so good. This is a realization which was long overdue and one which is now commonplace. What is perhaps not commonplace is that politics becomes depoliticized due to the same blending. As the two grow more alike policy-maintaining takes on more of a partisan-conflictual character while policy-making loses some of this character and takes on more of a character of objectivity. The lowest common denominator is one which avoids conflict and for promises of conflict avoidance nothing can surpass technocratic liberalism. With the wedding of administration and politics, the conditions of rule change.

3. CONDITIONS OF RULE

Following the technocratic liberal injunction of restraint until all the facts are in often serves the traditionally political function of delay. But there is an additional, more important effect as well. It is the achievement of a non-conflict solution. The hope is that, given mutually shared cultural values, the facts will eventually make possible an unambiguous balance of values. Without our values changing, the facts will change such as to allow all (or most) of our existing values to be realized and maintained. The world but not we will change, this rather than our changing our values to fit the facts, or our coming into conflict to thwart the competing values of others. So long as the facts do not permit the satisfaction of all values, the conclusion is that all facts are not yet in. Policy changes can be then no faster than the expansion of the relevant knowledge. Major changes slide into an infinite regress, mortgaged to an indefinite future, and are carried along by technocratic liberalism's incremental changes.

When public questions become questions of knowledge two important, inter-related changes occur. The identity of the questioner changes, and so does the question put. First, the questions come to be directed at the relevant group of experts and not at the lay public. The range of persons who can participate in the solution is narrowed. Second, the nature of the questions changes. Questions of difficulty tend to be replaced by questions of fact. It is in terms of this second point that most of the foregoing discussion has been conducted. The discussion will continue in these terms, for four reasons. The first reason is simply consistency with what has preceded. Second and more important, the result of the shrinkage of citizen participation is either definitional or obvious. Third, the processes of that shrinkage, which is neither obvious nor definitional, can be incorporated within a discussion focusing primarily on the character of public issues when addressed to experts. Fourth, the two effects exist in a dialectic without a discernible logical or chronological sequence.

Qualification and tactics aside, when public questions are oriented to (or asked of) experts, not only is the process of question-asking changed at the day to day level, but also the very nature of the questions is changed. This is obviously true in two uninteresting ways. (i) Neither can one expect busmen to be able to answer the same questions that botanists do. It would be beyond their capabilities. (ii) Nor should one expect botanists to answer only the same questions that busmen do. It would be an underutilization of their talent. These obvious levels need not detain us any longer. More interesting is the effect upon values of a shifting emphasis to facts in public life. The immediate effects on people are visible. The effects on values are less visible and more long term.

When public questions are asked of citizens they may be either puzzles, problems or difficulties. When asked of experts they may be only puzzles or problems, but not difficulties. It is only on the condition that experts judge objectively that we turn matters over to them. Instead of introducing their own values, instead of creating new values, experts are supposed to take the values of the community as given. Leaving aside the intriguing questions of whose values the community values are, the evaluative restraint of experts is initially an important protection against expert usurpation of the prerogatives of the citizenry.

> "The emphasis on research as a preliminary to government action comes, of course, from an unwillingness to permit the government to answer a question arbitrarily, but even to define the issue, present its views, and manage the administrative machinery. This unwillingness to take the answers from established authority leads to a tremendous use of research as a basis of decisions at all levels."(32)

The evaluative neutrality of experts is zealously honoured on all sides.

Questions addressed to the public may be difficulties because the public, but not its agents, can change its mind. It can change the values. When asked of the populace a question can ultimately be, "What do we want?" The answer of the populace to this question is irrefutably correct, no more information is required. When asked of the experts a question cannot ultimately be a difficulty--these are off limits to experts and left to the public--but only a puzzle or a problem. As more and more of our political leaders become sectional experts, fewer and fewer of them remain to raise the questions of the left over difficulties. Moreover, the public would prefer to avoid many of the difficulties, like language or race. Failure to raise these questions serves a mutual convenience of elite and mass.

Difficulties are questions that concern the basic principles of a social life. These principles are normative in that they rest on choice, not evidence. They rest not on evidence because as basic, first principles there are no existing, logically prior principles or conclusions to sustain them or from which they may be derived. Basic principles are the rules of the game and as such they cannot be defended by reference to the game or anything produced by the game.

In pursuing its puzzles and problems expertise asks: "What is possible, in view of given basic principles?"(33) Experts answer with what is most easily possible which conforms to given values. The devotion of experts to perceived values reifies those values. The analytical procedures of expertise so reinforces our values by objectifying them that we who create them lose our will to alter them. We come to stand in awe of public opinion polls, forgetting that we are the public. Reification of opinion in this way is a complicated business, but something of it is shown in polling. A subject of a poll may have no opinion on a question about emission control, but when asked in a survey the respondent will formulate an opinion on the spot. Later when we whom that subject represents statistically read the poll results we can be stimulated to take on an opinion we, like the subject, did not have before.(34)

The medium and long term effects of evaluative neutrality may be counter productive. Instead of being neutral, decision-making is predicated on existing, dominant, visible values. As shifts in society occur, the value structure will change too, and it will change before decision-making can catch-up, and neutrality condemns decision-making to playing catch-up, to maintaining not making values, for it is not permitted to lead, but only to follow. Thus public opinion polls are used to reveal a consensus, which presumably exists, if the poll is properly timed and worded. This replaces the pre-technocratic emphasis on making a consensus, which involved direct contact between leaders and followers and amongst followers. The idea of revealing a consensus manifests itself not only in the current reality of polling and the use of polls, but also in our aspirations for the future too where technology is to replace political mediations, relating every citizen directly to government by computer terminals.(35) There is some reason to believe that these ideas have struck a receptive cord in the Canadian elite. Some have celebrated the treatment of politics as information.(36) Others have seen a plebiscitary, ad hoc approach in the conduct of Prime Minister Trudeau, who seeks public approval after the fact.(37)

The conditions of rule have changed. The development of science and technology has always changed the basis of production. First labour, then land, then capital have formed the basis of wealth. And now that basis is shifting once again, to information (about this more in Chapter Eight). To the extent that politics is like economics, its basis too has changed in the same direction. Knowledge is power, economic and political, in a more direct and pure sense than before.

At first to inform, but gradually to replace the will of the statesman, expert knowledge entered public life.(38) The encroachment of knowledge and knowing on public policy has not been the result either of a conspiracy or of an imperialist impulse. It arises as a latent unintended consequence. Hence it is diffuse and less than entirely consistent. The encroachment consists largely in knowledge and knowing filling a vacuum in public life. A vacuum in public life created by and creating changes in the conditions of rule following the mobilization of science in World War II and after. Once put underway by the war effort, where values were given and clear, the hard glittering armour of rationality, knowledge and expertise signalled by quantification and symbolization drove out the clothes of opinion, belief and conviction, a suit badly stained by the irrational excesses to which it had been a party in World War II. This war simultaneously presented the worst excesses of unreason in fascism and the highest achievement of reason in mobilized science in the eyes of many.

4. REDUCTION I: POLITICS TO ECONOMICS

In part (2) of this chapter, knowledge was spoken of as being the goal of politics in two senses in technocratic liberalism, as the end and as the means to that end. This section takes up that first sense, that of an end. Section (5) will be concerned with the means aspect and will lead into Chapter Four and Unit II.

Tenure-wise it is much safer for elected officials to depolitize their activities so as to be able to claim to have been inadequately informed or misinformed. Responsibility is thence shifted from accountable politicians to responsible mandarins. Within this embrace the Minister's decision to build a Mackenzie Valley pipeline would be as correct as the available information allowed. If the information dictated otherwise she would have decided otherwise, for liberalism, technocratic, reformist or whig is pragmatic, that is determined by known conditions. Moreover, the Minister can also escape from the responsibility of interpreting information as it becomes more technical.(39) In short:

> "If it really is the case that the forecast I have been given is the best available analysis and project of the evidence, I cannot really be blamed if I accept the implications of that forecast and I am (or rather the forecast) is proved wrong."(40)

In the way of public tolerance and electoral longevity there is much to be said for having decision seem to be based on knowledge.(41)

Liberalism "has come more and more to see politics simply as a technical activity like any other."(42) And another critic has defined this technology as the "institutionalization of utilitarian norms."(43) Consequently, it is not surprising to read that:

> ". . . in a recent volume of *Daedalus* on A New Europe the recurring theme is the increasing relegation of questions which used to be matters of political debate to professional cadres of technicians and experts which function almost independently of the democratic political process."(44)

Generally, "the broader face of this trend is the increasing use of experts of *all* sorts in the process of government."[45] Signs of the appeal of technocratic politics bound. The last occupant of the office of Science Adviser to U.S. President Nixon remarked while in office, "I look on science as the antidote to politics."[46] Meanwhile, a scholarly book is dedicated to "Gary in the hope that he will grow up in a society more interested in psychology than politics."[47]

The ideal worlds of utopian and like-minded science fiction writers is a world free from material need and therefore free from politics. A world, like our own, in which people frequently worship science as a religion, not merely because:

> ". . . it was through science that men had gained some insight into the nature of the physical world, but rather because the application of scientific principles had revolutionized their material circumstances."[48]

Paradigmatic of this vision is Francis Bacon's New Atlantis with a House of Science at its literal core. And it is worth remembering that Bacon was not a scientist; he was a politician.

Recently some of the basic aspects of liberal society and liberalism which have been the focus of the foregoing discussion in this chapter have been crystallized into the notion of a "technological fix."[49] A technological fix is the introduction of technology into a zero-sum socio-political conflict such that the dispute becomes positive sum. It was in this spirit that one of world's most respected scientific leaders suggested in 1966 that U.S. ghetto residences be air conditioned to abate urban disturbances.[50] The fix does not solve the difficulty, it just keeps it below the surface. Instead of a race relations difficulty, we have a shortage of air conditioners with which to deal. Meanwhile, the supposition is that all would get busy and work out the difficulty while it is abated, though with the difficulty submerged it is hard to agree that it would be attended to, for it was submerged before it exploded and went unattended.

Like all liberalism, technocratic liberalism comes in all shapes and sizes. Common to most varieties is a causal analysis of human behaviour that sees it as primarily motivated by material concerns. One extension of this belief, which generates the idea of a technological fix, is to be found in one recent, widely acclaimed science fiction novel. Concluding a 600+ page story one reads: "'I feel a bit stunned,' Gideon said. 'You seem to be claiming that wars could be cured, like a disease, with a dose of the proper medicine.' 'Yes,' Chad agreed."[51]

Technological liberal rule has not yet reached Chad's state and it may never be able to, but it is willing to and has made progress in that direction. The analysis it offers of socio-political phenomena will inevitably find causation in economic materialist influences. Revolutions will be explained by reference to the push of material conditions rather than by the pull of an ideology. For example, it was fashionable in the early 1960's to assume that due to a common technological impetus the United States and the U.S.S.R. would grow more and more alike institutionally.(52) Political phenomena are reduced to social ones. Social phenomena are reduced to economic ones, ideas are replaced by objects as the perceived motivations. People are no longer responsible for their actions. ~~They~~ are seen as driven, if not determined, by material conditions. A classic account of this process of reduction is to be found in Daniel Moynihan's account of changing interpretations of juvenile delinquency. At one time juvenile delinquency was understood as inventive rebellion which was enjoyed by its participants. To liberal reformers juvenile delinquents come to be interpreted as desperate, mechanically determined individuals.(53) In the visions of Western politics, says Sheldon Wolin:

> ". . . we are so accustomed to having political problems reduced to economic causes, or the influences of class structure, social relations, or cultural conditions, that we turn impatiently from a writer who fails to follow form."(54)

Technocratic reduction of political difficulties to technical puzzles and scientific problems is by no means the exclusive property of liberal political cultures. Further to the left, in socialist states the impulse flourishes in similar variety. According to Polish intellectual Leszek Kolakowski:

> ". . . thousands of people fondly imagine that the inhabitants of other planets will one day solve the problems from which humans cannot extricate themselves. For others the word 'cybernetics' embodies the hope of resolving all social conflicts."(55)

So long as our public priorities are above all else economic, then science is linked to politics through the mediation of economics.

It is not merely a slip of the tongue that we find it easy in moments of frustration to say "I wish I knew what was right." What is for us individually nothing more than a convenient figure of speech may be much more when it is writ large. And it is writ large for our leaders speak our language.

Leaders speak of the difficulty "'not to do what is right,' Lyndon Johnson declared in characterizing the national choices of the White House, 'our problem is to *know* what is right.'"(56) The quest for certainty in the correctness of ends in addition to means is even more clearly illustrated nearer to hand.

In his inaugural press conference the first head of the Australian Liberal Party's Federal Policy Support Unit contrasted the purposes of his organization with those of a group in the Labour government by saying that:

> ". . . they are there to see how progress is going in relation to stated objectives We are here to make sure the objectives are right in the first place."(57)

Seasoned observers would say that there two statements are merely political, and not to be taken as cause for analysis. No doubt they are political, but profoundly so, not merely so. Because they are so common all the more profound. It is surely no accident that the introduction of Program Planning Budgeting Systems and Cost Analytic schemes follow in the wake of such pronouncements. Certainly making issues of public decision seem to be based on objective results of knowledge eases the politician's load of responsibility. And does this not change the character of politics, all the more so if unconsciously the politician comes to believe what she says, as does happen? And even if the politician is too sophisticated to come to believe what he says, however often it is repeated and enacted, we the lay public may come to believe it. Thus a longitudinal content analysis of party platforms in the United States found that there was a substantial decline in attention to questions of morality and legitimacy. Concommitantly, there was found to be a great increase in concern about matters of exclusively material import.(58)

Unlike conservatism, when it comes to policy-making technocratic liberalism focuses on the issue of the distribution of resources. It will choose to deal with the situation in the way that conforms most with given values. Since redistribution of wealth is not a given value in Western societies, technocratic liberalism will not turn to it directly. All other things being equal, it will attempt to redress inadequate distribution by either increasing the aggregate available for distribution or by improving the efficiency of the existing process of distribution, relaying on an incremental trickle down effect. Of course, all other things are never equal and technocratic liberalism contains divergent strains, so it has been associated with redistributive endeavours, and it has never given up belief in the material basis of social and political life. It continues to see happiness deriving from wealth. Hence, it aims to convert difficulties to puzzles and problems. It aims to replace doing with making and knowing.

5. REDUCTION II: ECONOMICS TO SCIENCE

Thanks to the emphasis on economic wellbeing as the end of political activity, science, as a means to that end, is introduced into public life. The first clear point at which this introduction became apparent and undeniable would have been in World War II. The successes of applied science during the war and the impression that these successes made on the consciousness of both the public and the leadership of Western nations is well known and needs no further discussion here. Many saw the Cold War period which succeeded the Second World War as requiring the continued mobilization of science, arguing that the distinction between war and peace was mooted by science itself in the development of modern weaponry.(59) Based on successes in World War II the ability of science to solve, first, the difficulties of the Cold War and then peace were overestimated. The experience of World War II, however, set the pattern for science in public life as we now see it. It was then that science entered public life.(60) Key political figures were keen to heighten the collaboration of government and science in the post-war era.(61) Scientists were not entirely unwilling to accept this responsibility. In reading American Congressional hearings one:

". . . may get the impression that scientists now think that science may some day, even if it cannot now, provide the answer to any question of policy."(62)

For example, in 1967 the dean of the M.I.T. College of Engineering, Gordon Brown, said:

"I doubt if there is such a thing as an urban crisis, but if there were, M.I.T. would lick it in the same way we handled the Second World War."(63)

Scientists were so eager to accept this added responsibility that some complained when it was limited. The British astronomer Fred Hoyle in his science fiction novel *The Black Cloud* had a character remark that the scientists were the "real brains" of society and yet they were "at the bottom".(64) Meanwhile, again using the medium of science fiction atomic physicist Leo Szilard maintained that:

". . . political issues were often complex, but they were rarely anywhere as deep as the scientific problems which had been solved . . . thus it appeared reasonable to expect that the solution of political problems would be greatly speeded up also if they were subjected to . . ."

scientific treatment.(65) As late as 1970, Alvin Toffler, a prophet of the popular culture declared that:

". . . the super-industrial revolution can erase hunger, disease, ignorance and brutality . . . finding non-zero sum solutions to our social problems . . ."(66)

Even critics of technocracy accept the principal of science being a means to material well being, just as critics of liberalism accept material well being as the proper end of politics. For example, Leslie Sklair writes impassively, "the aim and ideal of technocracy is to arrange social life in terms of technically solvable problems."(67)

"What makes the drive to technology so strong", according to George Grant, "is that it is carried on by men who still identify what they are doing with the liberation of mankind." So pervasive is this view, continues Grant, that "however libertarian the notions of the new left they are always thought within the control of nature achieved by modern techniques."(68) Hence, Pierre Vallieres admits to having once aspired to be scientist and takes as part of his revolutionary programme the direction of science to the service of the people.(69) At the root, in Grant's analysis, is:

> ". . . the belief that human excellance is promoted by the homogeneity and universalizing power of technology is the dominant doctrine of modern liberalism."

Continues Grant, the:

> ". . . questions of human good are to be solved by technology . . . the most important human activity is the pursuit of those sciences which issue in the conquest of human and non-human nature."(70)

We are to enjoy the world and ourselves by dominating it. This is our purpose. In the words of Charles Taylor:

> "Modern society singled itself out in that its paradigm justifying self-image was that of a productive association bent on transforming the surrounding natural world to meet the need and fulfill the ends of man."(71)

This is our recrudescent Promethean ambition. An ambition which is carried to so great an extreme that "all along the line, human society had become as accessory of the economic system," and not vice versa.[72]

It is hardly surprising then to note that:

> "Canada's science policy has long been based on the premise that 'a few millions spent on research will yield untold millions and prestige beyond our dreams.'"[73]

Or, as put more abstractly by Madame Sauvé, "knowledge always frees you . . ."[74] A good part of this impetus to put science to work made itself felt in an emphasis on education and training in science during the 1960's.

> "A cult of education began to permeate the world. This cult took on the nature of a religious faith, a faith that believed educational systems could and would solve all the social and economic problems of the world."[75]

It is a cult still in evidence, as shown by some of the presentations to the Senate Special Committee on Science Policy.[76] Prime Minister Trudeau seems to have summed up much of this general feeling for the importance of science in Canada by saying that "nowadays there are very few problems which do not involve technology."[77] More dramatically these rising expectations for science were voiced by U.S. President Kennedy:

> "We move toward a new era in which science can fulfill its creative promise and help bring into existence the happiest society the world has ever known . . ."[78]

At one time, lest we forget, the status of science had been thought well settled. The conclusion was that science was a luxury, which rather pleasantly had or at least tended to have beneficient effects. That view has been altered only in the last three decades. Writing at the turning point Michael Polanyi, chemist cum philosopher, observed the change so acutely that his remarks merit a lengthy reproduction here.

> "The popular scientific books which I used to read as a child were mainly concerned with displaying the wonders of nature and the glorious achievements of science. They dwelt on the enormous distances between the stars and on the laws governing their motion; on the crowd of living creatures made visible in a drop of water under the microscope. Among the best sellers of the time was Darwin's *Origin of Species* and every new discovery throwing light on the process of evolution raised intense and general attention. Such were the topics and interests that came first to the mind in connection with science some twenty years ago.
>
> It was not forgotten, of course, even at that time that science also provides a store of most useful knowledge; but this was not considered as its principal justification. New practical inventions like the electromotor or the wireless telegraph were thought to be merely occasional offshoots of advancing scientific knowledge.
>
> To-day boys and girls who are interested in science are given a very different idea of it. They read books which profess that the primary function of science is to promote human welfare. The best seller in the field has been for the last seven years Hogbin's *Science for the Citizen*, which is closely rivalled in its success by J. G. Crowther's books, particularly *The Social Relations of Science*, and the famous *Social Functions of Science* by J. D. Bernal. All these books emphatically oppose the view, generally accepted before, that science should be pursued for the sake of enlightenment regardless of its practical use. They have exercised a powerful popular influence which has been consolidated lately by the support of important organisations. The Association of Scientific Workers, which now counts 16,000 members, has risen to prominence largely in response to the new doctrine. It has in fact become rare to find any public statement to-day roundly declaring that the main purpose of science is the acquisition

> of knowledge for its own sake. Such a conception of science is still generally maintained by the academic profession; but it is no exaggeration to say that it is already beginning to be forgotten by the broader public, even though it was universally accepted by it only fifteen years before.
> The new radically utilitarian valuation of science rests on a consistent philosophical background mainly from Marxism . . .
> Such a revaluation of science necessarily leads to a demand for the Planning of Science."(79)

6. SUMMARY AND CONCLUSION

Before proceeding onward to the planning of science let us pause a bit longer here. It is the contention in these pages that in revaluing science we have implicitly revalued ourselves. We have revalued ourselves in a way that is neither becoming nor accurate. In reifying our interest in material goods as irresistible, unquestionable needs, not only has our assessment of available means changed, but also that of the end has changed. To have changed the end is to have changed ourselves.

Perhaps the best illustration of the dangerous inadequacy of the "knowledge is wealth, wealth is utopia" syndrome can be seen in the simplest case, namely the United States. The most productive economy with concerted and effective efforts at the distribution of wealth and an open social mobility structure stagnates at high levels and intensifies, rather than allays, social cleavages. The technocratic, management drive in the United States has been singularly unsuccessful. As might be measured quantitatively, Canada would rank a close second to the United States on many economic indicators of wealth, and exceed it on the unabated and even increased intensity of social cleavages.

When we put off till tomorrow social and aesthetic values in preference to "necessary" economic values, it seems to be the lesson of history, not to say psychology, that tomorrow never comes.

> "Scarcity is not material but psychological in point of origin, even if men achieve a world of abundance the notion of scarcity will remain, and with it conflict."(80)

As we act so we come to think. If we act on an exclusively materialist orientation indefinitely, then we come to think in an exclusively materialist way. We teach ourselves and our children to think in this way. We then pass on into the endless future our world-view of short-term necessity. Thus liberalism's optimistic assessment of people's ability to control their fate comes to this, instead of to the 18th Century dream so well enunciated by John Adams:

> "I must study politics and war that my sons may have like liberty to study mathematics and philosophy, geography and natural history, and naval architecture, navigation, commerce, and agriculture in order to give their children a right to study painting, poetry, music, architecture, statuary, taspestry and porcelain."(81)

In sum, politics, because it is potentially redistributive, is explosive. By reducing it to economics the intensity of the public realm is lowered. A zero-sum game is changed to a positive-sum game. We are so inured to the reduction we hardly even notice it. The lack of material goods is to be abated by increased production and productivity. Technology provided these, based in turn on science and education. Technology remains in the private realm, in accord with liberal economic theory. Science and education go into the public realm as social overheads. After all, the goals of national science policy in Canada is pretty clearly economic. Reducing politics to economic to technology to science, difficulties are reduced to puzzles to problems. Left are the least intense questions and ~~activity,~~ problems and problem-solving. Only the most seemingly controllable, manageable question is allowed to remain. This is technocratic politics.

FOOTNOTES

1. For a detailed survey consult W. H.Armytage, *Yesterday's Tomorrows: A Historical Survey of Future Societies* (London: Routledge, 1968).

2. For discussion of the idea of linearity see Carl Becker, *The Heavenly City of the Eighteenth Century Philosophers* (New Haven: Yale University Press, 1932).

3. See Alvin Toffler, *Future Shock* (London: Pan, 1970).

4. Compare and contrast the conservatism of Michael Oakeshott, "Political Education", *Rationalism in Politics* (London: Methuen, 1962), pp. 111-136 with the liberalism of Christian Bay, "Thoughts on the Purpose of Political Science Education?" *The Post-Behavioral Era*, George Carey and George Graham, eds., (New York: McKay, 1972), pp. 88-99.

5. Frederick Engels, *Anti-During* (Moscow: Foreign Languages Publishing House, 1959 [1894]), p. 387. See also Vernon Venable, "Agencies: Science", *Human Nature: The Marxian View* (Cleveland: New World, 1961), pp. 171-214. Cf. the similar sentiments expressed in a contemporary liberal interpretation of Rousseau by Anthony Downs, *An Economic Theory of Democracy* (New York: Harper, 1957), pp. 285-6.

6. Carleton J. Hayes, *A Generation of Materialism* (New York: Harper, 1941), pp. 46-7.

7. John S. Mill, *Representative Government* (New York: Liberal Arts Press, 1958), p. 391.

8. Giovani Sartori, *Democratic Theory* (New York: Praeger, 1962), p. 406.

9. Robert Dahl, *Who Governs* (New Haven: Yale University Press, 1961), pp. 223-8.

10. E. J. Mishan, *The Costs of Economic Growth* (Harmondsworth: Penguin, 1969), p. 28.

11. Raymond Aron, *Progress and Disillusion* (London: Pall Mall, 1968), p. 3.

12. R. G. Johnson, President of the Canadian Institute of Steel Construction, *Proceedings of the Senate Special Committee on Science Policy*, 28th Parliament, 1st Session, No. 59, p. 7151. Cf. Engineering Research Council, Brief, *ibid.*, No. 56, p. 6906.

13. Maurice Lamontagne, *La Fédéralisme Canadien* (Québec: Les Presses Universitaries Laval, 1954), p. 164.

14. R. Lane, "The Decline of Politics and Ideology in a Knowledgeable Society", *American Sociological Review*, XXXI (1966), p. 644. Cf. his "The Politics of Consensus in an Age of Affluence", *American Political Science Review*, LIX (1965) 4, pp. 874-95 and "Open Letter to Members of the Association", *P.S.*, IV (1971) 1, p. 40 with my Communication to the Editor, *P.S.*, IV (1971) 2, pp. 256-7. Lane's point of view is a continuation of the end of ideology view of the 1950's in the United States.

15. Donald Smiley, *The Canadian Political Nationality* (Toronto: Methuen, 1967), p. xxi.

16. Charles Pierce, *The Principles of Philosophy, The Collected Papers of C. Pierce*, Volume I, C. Hartshorne and P. Weiss, eds. (Cambridge: Harvard University Press, 1931), p. 56.

17. See R. D. Cumming, *Human Nature and History*, Volume I (Chicago: University of Chicago Press, 1969), p. 76.

18. D. Lukasiewicz, Statement, *Proceedings of the Senate Special Committee on Science Policy*, 28th Parliament, 1st Session, No. 75, 26 June 1969, p. 8777.

19. Alan Davies, "Politics in a Knowledgeable Society", *Essays in Political Sociology* (Melbourne: Cheshire, 1972), p. 7.

20. Dahl, "The American Hybrid", *Preface to Democratic Theory* (Chicago: University of Chicago Press, 1956), p. 151 and Jack Walker, "A Critique of the Elitist Theory of Democracy", *American Political Science Review*, LX (1966) 2, pp. 285-95.

21. Edwin Black, "Opposition Research", *Canadian Public Administration*, XV (1972) 1, pp. 24-41.

22. Walter Stewart, *Trudeau in Power* (New York: Outerbridge and Dienstfrey, 1971), pp. 145-60.

23. For a catalogue see George Henderson, *Federal Royal Commissions in Canada* (Toronto: University of Toronto Press, 1967). The major critical pieces include J. E. Hodgetts, "Should Canada Be De-Commissioned?" *Queen's Quarterly*, LXX (1963-4) 4, pp. 475-90; John Courtney, "In Defence of Royal Commissions", *Canadian Public Administration*, XII (1969) [illegible], pp. 198-212; G. Bruce Doern, "The Role of Royal Commissions in the General Policy Process and in Federal-Provincial Relations", *ibid.*, X (1967) 4, pp. 417-33; and V. Seymour Wilson, "The Role of Royal Commissions and Task Forces", *The Structure of Policy-Making in Canada*, Doern and Peter Aucoin, eds. (Toronto: Macmillan, 1971), pp. 113-29.

24. Doern, "The Role of Royal Commissions in the General Policy Process and in Federal Provincial Relations", p. 24.

25. "The Committee requires fifty (50) copies of each brief. It is suggested that copies in French be provided." For distribution to the press an additional 95 English and 35 French copies are called for, all copies to be filed two weeks ahead. *A Science Policy for Canada*, Vol. 1 (Ottawa: Queen's Printer, 1970), p. 290.

26. See Gordan Robertson, "The Changing Role of the Privy Council Office", *Canadian Public Administration*, XIX (1971) 4, pp. 487-508 and Marc Lalonde, "The Changing Role of the Prime Minister's Office", Address to the Twenty-third Annual Meeting of the Institute of Public Administration, Regina, 1971.

27. Pierre E. Trudeau, "Introduction", *La Grève de l'amiante* (Montréal: Les editions Cité Libre, 1956), pp. 13-4. Cf. Bruce Thordson, "The Political Philosophy of Pierre Elliot Trudeau", *Trudeau and Foreign Policy* (Toronto: Oxford University Press, 1972), pp. 54-104.

28. See Alice Rivlin, *New Approaches to Public Decision-Making* (Ottawa: Information Canada, 1972). Cf. "Red Tape", *MacLean's*, 1 August 1972, p. 27.

29. Gad Horowitz, "Conservatism, Liberalism and Socialism in Canada", *Party Politics in Canada*, H. Thorburn, ed. (Toronto: Prentice-Hall, 1968), p. 67.

30. Michel Crozier, *The Bureaucratic Phenomena* (Chicago: University of Chicago Press, 1964).

31. Hodgetts, "The Civil Service and Policy Formation", *Canadian Journal of Economics and Political Science*, XXIII (1957) 4, pp. 438-52; reprinted in *Canadian Public Administration*, Hodgetts and D. C. Corbett, eds., (Toronto: Macmillan, 1960), p. 445. Cf. his "Public Power and Ivory Power", *Agenda 1970*, T. Lloyd and J. McLead, eds. (Toronto: University of Toronto Press, 1968), pp. 256-80. See also Pauline Jewett, "Political and Administrative Aspects of Policy Formation", *Canadian Economic Policy*, T. N. Brewis, ed. (Toronto: Macmillan, 1965) (2nd ed.), pp. 336-56; Eric Hehner, "The Growth of Discretion--Decline of Accountability", Address to the Ottawa Regional Group of the Institute of Public Administration, 1965; M. R. Gordan, "Civil Servants, Politicians and Parties", *Comparative Politics*, IV (1971) 1, pp. 29-58; Denis Smith, "The Transformation of Parliamentary Government in Canada", *Politics: Canada*, Paul Fox, ed. (Toronto: Macmillan, 1970), pp. 365-71; and J. R. Mallory, "The Administrative Machinery", *The Structure of Canadian Government* (Toronto: Macmillan, 1971), pp. 110-16.

32. Donald Price, *Government and Science* (New York: Oxford University Press, 1954), p. 27.

33. On basic or first principles see especially Herbert Feigl, "De Principiis Non Disputandum . . .?" *Philosophical Analysis*, M. Black, ed. (Ithaca: Cornell University Press, 1950), pp. 119-56; A. J. Ayer, "Basic Propositions", *ibid.*, pp. 60-74; and Ch. Perelman, *The Idea of Justice and the Problem of Argument* (London: Routledge, 1963).

34. This effect touches even the most important of issues. See e.g., M. Rosenberg, P. Converse and S. Verba, *Vietnam and the Silent Majority* (New York: Harper, 1970).

35. See, e.g., Amaiti Etzioni, "Minerva: An Electronic Town Hall", *Policy Sciences*, III (1972) 4, pp. 457-74.

36. Fred Schindler and C. M. Lanphier, "Social Research and Participatory Democracy in Canada", *Canadian Public Administration*, XII (1969) 4, pp. 481-98.

37. Donald Smiley, Address on Panel on the War Measures Act, Canadian Political Science Association, 43rd Annual Meeting, St. John's, 1971.

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39. Ferdinand Mount, "The Chancellor's Mistake", *Political Quarterly*, XLIII (1972) 2, p. 146.

40. *Ibid.*, p. 148.

41. Philip Melanson and L. King, "Legitimacy, Competence and Knowledge", Paper read at the Annual Meeting of the New England Political Science Association, Storrs, Connecticut, 1971, p. 10. Cf. Don Price, *The Scientific Estate* (New York: Oxford University Press, 1968), p. v.

42. Kenneth Minogue, *The Liberal Mind* (London: Methuen, 1963), p. 5.

43. Victor Ferkiss, "Man's Tools and Man's Choices", *American Political Science Review*, LXVII (1973) 3, p. 873.

44. Harvey Brooks, "Scientific Concepts and Cultural Change", *Science and Culture*, G. Holton, ed. (Boston: Beacon, 1967), pp. 71-2.

45. Emmanuel Mesthene, *Technological Change* (New York: Mentor, 1970), p. 77.

46. Quoted in Daniel Greenberg, "David and Indifference", *Saturday Review*, 30 September 1972, p. 43.

47. H. J. Eyesenk, *Psychology of Politics* (New York: Praeger, 1955), "Dedication".

48. Olaf Stapledon, *The Last and the First Man* (London: 1930), p. 296.

49. For a critical analysis of the idea of technological fix see Wallace Sayre and Bruce Smith, "Government, Technology and Social Problems", Occasional Paper, Institute for the Study of Science in Human Affairs, Columbia University, 1969.

50. Alvin Weinberg, "Can Technology Replace Social Engineering?" *Scientific Research*, I (1966), pp. 32-3. Cf. his "Science Simply Can't be Scrapped", *Washington Post*, 1 February 1970, p. B1.

51. John Brunner, *Stand on Zanzibar* (New York: Ballantine, 1969), p. 643.

52. Gertrude Schroeder, "Soviet Technology", *Problems of Communism*, XIX (1970), pp. 19-21.

53. Daniel Moynihan, *Maximum Feasible Misunderstanding* (New York: Free Press, 1964), pp. 45-7.

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69. Pierre Vallieres, *White Niggers of America*, J. Pinkham, trans. (Toronto: McClelland and Stewart, 1971), pp.121-2, see also pp. 249 and 250-1. Cf. Fidel Castro, "The Universal Conscience", *The New Left Reader*, Carl Oglesby, ed. (New York: Grove Press, 1969), p. 197 and Frantz Fanon, *The Wretched of the Earth* (New York: Grove Press, 1961), p. 82.

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CHAPTER FOUR

SCIENCE IN POLITICS

INTRODUCTION

It is the products of the activity of science that are supposed to make politics obsolete. Difficulty-solving, an activity whose only products is politics, is interpreted so as to be problem-solving. Problems yield only to science. Increasingly, alleviating scarcity by the production of wealth removes the necessity of politics and, it is assumed, once people are no longer driven by necessity, they will no longer engage in politics, in conflict. Instead we will hunt in the morning, fish in the afternoon, rear stock in the evening, and play critic at night, all the whole being neither hunter, fisherman, shepherd nor critic, but rather ourselves, always free to choose any other set of activities. Such is the widely shared ideal of Kail Marx.(1)

Beautiful though the ideal may seem to most, it is strangely naive. Not even wealth would signal the end of politics quite to the extent that Marx's apolitical citizen aspires. Would not this socialist citizen, "before hunting in the morning . . . attend a meeting of the Council of Animal Life?" asks Michael Walzer.(2) Walzer continues, important votes on the stocking of the forests would be necessarily undertaken so that the meeting would not end before noon. After all, Walzer notes, "among the many-sided citizens there will always be a lively interest even in highly technical problems." An extraordinary session of the Fisherman's Council will then occur at 1:00 p.m., postponing a previously scheduled discussion of techniques of cattle rearing. Walzer concludes that this specifically Marxist, and generally materialist, citizen may come to "love argument far better than hunting, fishing or rearing cattle."(3)

Not all potential for involvement and disagreement and uncertainty would be absorbed in even a world of material plenty it seems. Nonetheless this is the materialist presupposition, one which is the corollary of the materialist principle that all social and hence political ideas originate in, or are shaped by, the established manner of production and distribution. It is concluded that if there were no property, then there would be no politics. Or equally, if there were unlimited property, then there would be no politics.

The external utility of science, or rather the knowledge which is its product, thrust upon it an external justification. This justification was originally to the financial and prestige advantage of science and hence was accepted and developed by scientists. The prestige from utility was a heady mead, and subscription to the thesis of social utility became something of a duty. What scientist during the Cold War would have dared to refuse the attention and funds offered by the representatives of the public in the name of freedom? To have done so would have been to invite a charge of treason. Hence authoritative representatives of science found it easy to argue that even, or rather, especially, basic research makes considerable positive impacts on the economic well being of the society. This impact occurs over a lengthy period of time and is unpredictable, they argue.(4) Leading students of science policy in turn explicitly link science to the idea of social utility, even invoking the name of John Stuart Mill.(5) Unfortunately, this argument cannot be properly evaluated. It relies on escaping confrontation with evidence by appeals to a still longer run, or unpredictability. Being incontestable is an advantage of some order so long as the principle is not questioned. When doubt sets in, then there is no way to marshall evidence for the claim.(6) The conclusions reached by different methods of accounting can vary greatly. For example, it is reported that the Hindsight Project in 1965 attributed little importance to basic research in the attainment of practical outcomes. "Conclusion très pessimiste sur le role de la recherche fondamentale, dont la part est evaluée a 0.3%." On the other hand the Traces Project "Conclut a une responsibilité a 70% de la recherche fondamentale."(7) Here as in all correlational analysis, it is difficult to determine which of two related events causes the other, if either does. As in medicine, does the patient recover because of, or in spite the drugs prescribed:

> "Determinar la incidencia real de las leyes fiscales dirigidas a animar la investigación equivale a decider si un enfermo ha recobrado la salud gracia a las medicamentos que le fueron prescritos o a pesar de ellos."(8)

Hence, in summarizing a number of studies of various aspects of industrial research and development, Schmookler and Brownlee write:

> ". . . the earlier papers have shown, contrary to common expectations, that taking one industry at a time, inventive activity pertaining to an industry's capital goods appears to follow rather than lead investment."(9)

In other words:

> ". . . the evidence presented here suggests that . . . progress in technical knowledge in an industry can be an effect *as well as* a cause of the rate of industrial growth."(10)

What follows in this chapter divides into four parts. Part (1) distinguishes between the Athenian or Cartesian concept of science and the Alexandrian or Baconian concept with an eye to the consequences of each. Part (2) takes up one of those consequences under the idea of a dominant institution. Briefly, part (3) relates the rationale for external justification for science, which both scientists and politicians originally favoured, to external control which scientists do not favour. The largest part, (4), examines in an international context the soundness of the major external justification, namely that wealth demonstrably accrues from knowledge. (5) the last part summarizes the chapter.

1. ALEXANDRIAN SCIENCE

At one time there had existed two distinct traditions within science in the Western culture. The one may be called the Athenian-Cartesian tradition which focuses on the products of science; the other may be called the Alexandrian-Baconian tradition which focuses on the activities of science.[11] The war swung emphasis clearly to the Alexandrian-Baconian tradition of applied science away from the Athenian-Cartesian tradition of pure science. Science came to be judged by what it (says it) does contribute to the nation, and for a time science seemed an unalloyed good so that a favourable evaluation by this criterion was won easily.

We may today have the opportunity to witness the same sort of process as certain cultural resources are enlisted in the interests of Canadian nationalism. The Province of Ontario's Royal Commission on Book Publishing, for example, asks that writers be judged by what they do for the nation.[12] In its own words the Commission tells us that the purpose of writers, especially now, is that they unite us in the weave of our common culture.

This is all very disconcerting because writers may also divide us: indeed, perhaps this is what some of the best writers do. Disconcerting or not, it certainly is a marked change from the spirit of the last Canadian foray into the place of letters in society. In the Massey report, it was the feeling that a nation is judged by what it does for its writers. Thus we read on the opening pages of the Massey report that:

> "All civilized societies strive for a common goal, including not only material but intellectual and moral elements. If the Federal Government is to renounce its right to associate itself with other social groups, public and private, in the general education of Canadian citizens, it denies its

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> intellectural and moral purpose, the complete conception of the common good is lost and Canada as such becomes a materialistic society."(13)

Indeed, well into the report the Commissioners saw fit to warn against:

> ". . . the danger that the scholar [for our purposes, the scientist] will turn from serious fundamental investigations to the relatively simple accumulation of facts which may have some immediate practical application."(14)

It may be of passing interest here to note that Senator Lamontagne played a great part in the drafting of this report, and still later in the development of the Canada Council which was one of the major results of the Commission.(15)

Just as the Massey report also dealt with science, the increasingly widespread view that the talents and interests of the populace are natural resources has already extended elsewhere. The executive director of the Science Council of Canada has criticized social science in words which anticipated those which the Ontario report used in connection with literature. McTaggart-Cowan has argued that the proper function of the social sciences is to aid the development of social unity and harmony.(16) Needless to say, the whole of the debate over national science policy is emblematic of this process of extension of the Alexandarian concept of science, an extension which by emphasizing the materialist aspects distorts the products. First it absorbed physical science, now it reaches out to social science and literature.

The products of science were in this way brought into the political arena, first in weaponry for defence, then for space exploration for prestige and finally, in permanent agencies such as the Rand Corporation or the proposed Institute for Research on Public Policy in Canada.(17)

2. A DOMINANT INSTITUTION

The products of science became politicized. Conversely, much of the traditional realm of politics became de-politicized.

Science grew to be a big business. It grew to be a big business especially because it is the result of a lengthy process of education which requires the elaborate structure of a university. It may be that in order for science to grow arithmetically it was necessary for the House of Higher Education, of which it was only one wing, to grow geometrically. Partly, this is necessary in the labour market of a liberal society where only market regulators of low efficiency can be used to channel labour.

What would happen today if all science ceased and all scientists disappeared? Much, if not most, of our complex, urban and industrial society would grind to a halt. Most highly organized and hence centralized societies have leading institutions. Amongst these leading institutions there may be said to be one which is allowed to dominate all else.(18)

The dominant institution of Ancient Egypt or the Middle Ages was religion; the military in Prussia; politics in Greece; corporations in Canada; and today, everywhere in the

Western industrialized nations the science complex, by which is meant science, technology and engineering and the universities and schools which feed them. It is a dominant institution in the senses of (i) perceived, diffuse social impact and (ii) share in the public purse.

Whether or not science does in fact dominate modern industrial society, it is certainly widely perceived as doing so. Hence the institution of science was allocated an ever-expanded share of public revenues while expanded enrollment and training were actively encouraged. It has been estimated that as early as 1958 the knowledge industries--research and development, education and communications--constituted 28 per cent of the Gross National Product of the United States.[19] Presumably, today's figure is even higher in the United States, and perhaps in Canada too.

The startling growth of science in recent years is a phenomenon to which there will be occasion to return in later pages. Suffice it to note here that, as measured by the number of articles and scientists, science is doubling every ten years. This is a rate faster than the population's increases. 90% of all the scientists who have ever lived are living today, and 60% of them have 10 or less years of experience.[20] The corpus of science grows ever larger physically, and yet with improved communication there is a sense in which it grows ever smaller intellectually, more disciplined but less imaginative.

These improved communications combined with the difficulty of gainsaying the success of science served to tighten the already tight discipline and commensurate uniformity of scientific communication. Pockets of eccentricity seem, paradoxically, less likely today in the midst of, for example, thousands of physicists than years ago in the midst of only hundreds of physicists.

A two-person physics department at Brandon University today is probably more closely linked to and tuned in with the mainstream of physics than the thirty person department at the University of Toronto was in 1910. The economies of scale that result from these efficiencies are considerable. There is, however, a danger that the uniformity and discipline admittedly necessary for the effective conduct of the activity of science may go too far. Scientific growth, as will be argued later, requires a balance between community discipline and individual creativity. The new, post-World War II largesse of science has served in some part to underwrite the mechanisms of discipline. The main mechanism of discipline in science is the ideas of others sharing the same interest. Now the ideas of scientists are communicated sooner and more widely than ever before in articles, notes, reviews, essay reviews, abstracts, conferences, manuscripts, consultations and assessments. No longer can inchoate unconventional ideas be gradually exposed and developed. All the while the creator will be deluged by the mainstream literature, as will all of the potential critics at hand. Because everyone will know just what the latest conventions are in any field, these conventions are applied quickly to any new work, especially in terms of heightening inhibiting self-discipline by individual scientists. Admittedly, this discipline has enabled many disciplines to map out and to follow a coherent and successful programme of normal research. If it were to go too far, then it would stifle the equally necessary creative aspect of science. One of the conditions of creativity is often freedom, a lack of discipline. There may be thresholds of discipline at which diminishing returns eventuate. It is worth asking whether the highly organized scientific disciplines of today may be approaching that limit. This is a question to be taken up later, in Chapter Seven.

3. EXTERNAL JUSTIFICATION AND EXTERNAL CONTROL

Under the patronage offered by the external justification of social utility, science is viewed as a resource. A resource which is to be used as an instrument according to the wishes of the public, as interpreted by its authorities. To have thrust upon and to accept external justification is to raise the question of external control. And more than the question of external control is raised if, as part of the external justification public monies are offered and accepted. Where public money goes, there follows public control. The status of external control will be the subject of the next section of this study.

It was argued in the previous chapter that happiness does not derive from wealth, and hence that politics neither begins nor ends in economics. All politics does not reduce to economics. All political issues, all social conflicts cannot be reformulated as soluble economic problems. In an economic paradise, in an economic Shangri-La, conflict and therefore politics would continue. It would continue because people have ideas and opinions, different, competitive and conflicting ideas and opinions. Yet, it must be readily admitted that a material Shangri-La is a most worthy goal, the achievement of which would alter much of the everyday conduct of our politics and improve the lives of us all, directly and indirectly. Scarcity and its attendant anxiety just does occupy the attention of most people most of the time. But it is too often perceived as the only political issue, which it is not, or as the most fundamental political issue, which it is not. What it is, is the most common, and therefore the most significant political problem in present circumstances. Its significance arises from present circumstances and not from anything intrinsic in human nature.

4. WEALTH FROM KNOWLEDGE

The most significant political problem is also one to which the problems of science have very little to contribute. Just as wealth does not automatically yield happiness, it is the argument of this chapter that knowledge does not automatically yield wealth. The relationship between knowledge and wealth is much less clear than admitted by advocates of a national science policy.

The research literature produced by economists serves only to highlight this lack of clarity. While the purpose at hand is not to review exhaustively that research literature, portions of it provide invaluable instruction. There exists already an empirical case study of the economic aspects of national science policy in Canada.[21]

It is with that case study that this review of the present understandings of the connection between knowledge and wealth can begin best. However, first it is important to understand that the connection in question may be sought on any one of three different levels. The three levels are those of the research and development effort of a discrete firm,[22] throughout an industry,[23] or nationally across all industries. Research exists at all three levels, but because the levels are different, the resulting picture of the connection of knowledge to wealth is different. The whole is a complicated picture indeed. Principally, what emerges is the absence of an established association between the indicators of research and development input activity and gains in material output or productivity at the level of individual firms and between nations across all industrial fields. Within an industrial field correlations have been observed, with the strongest correlation being noted in the higher technology industries including aviation and chemicals.

The literature produced in studying these three levels is voluminous and complex. Only some portions of these findings that seem particularly pertinent are presented here.

The first limitation imposed on the research data reported here is the most important. It is that both the firm and industrial levels will be set aside with exclusive attention going to the third, the national level. This is done with several purposes in mind. The advocates of science policy in the Canadian debate mak little or no explicit reference to the more particular levels of firm and industry. Rather their claims are made in respect of the larger and comparative national level. To serve as an analytic treatment of the debate the national level must be treated, and it must be treated in a manner not obscured by other matters.

That is so, but alone it is hardly cause for eliding the firm and industry levels. For this there must be other justifications. There are two. First, science policy is a matter of national public policy. As such the best comparisons between policies is to compare between the effects of policies at the national level. This necessity is especially keen if part of the issue is whether or not to have a science policy in the first place. If one's question is which sort of science policy to have, and not whether to have a science policy at all, then focus may go directly to the industrial level. If, however, part of the question is, as it is here, whether or not to have a science policy, then there is need to first examine the national level to see, not which science policy is most effective, but rather to see whether there operates a knowledge-to-wealth connection at all. This is the prior question for if none are very effective, it matters not which is the more effective. The remaining pages of this chapter are focused on this prior question.

There remains one more reason for concentrating on the national and not the firm or industrial level, a most practical one. It is that the na ional level provides the context in which the firm and the industry are ultimately situated, for example, the education levels, productivity and tariffs. To concentrate at a level lower than the national level is to risk overlooking signs of national difference that would make or break any policy adopted. If the purpose of national science policy investigation is science policy then the "national" aspect needs initial attention.

As was stated, prior to the rather lengthy preceding aside, the first place we shall look for illustration of the existing evidence of the association of wealth and knowledge, of research and development and economic growth, is a Canadian case study. N. H. Lithwick's *Canada's Science Policy* carefully presents a considerable body of evidence and argument. Only a part of it needs to be repeated here, by way of introduction. While Lithwick's study is well presented it does require a partial repetition, not for the purposes of improving or criticizing its exposition, but to simply bring it to attention. It is a study that is almost entirely overlooked in science policy deliberations in Canada. Specifically, it is not cited in the report of the Senate Special Committee on Science Policy, nor in reports of the Science Council of Canada.

Lithwick begins his analysis with the connection between research activity and wealth at the national level. Table 4.1 is reproduced from Lithwick's study.(24) These data lend no support whatever to the claim that a positive relationship exists between knowledge and wealth. Table 4.2 shows only a negative relationship.

There is a second indicator of wealth widely employed in the context of science policy. It is the economic level, per capita income. Once again there exists a neglected study produced in Canada. It is J. L. Orr's *Statistical Data on Industrial Research and Development in Canada*.(25)

Before going further to analyze Orr's data as presented in Table 4.3, certain data assumptions need to be made explicit. There are two assumptions of moment. First, the national level data from the Western countries will be treated as the universe, not the sample, for the research to wealth relationship. Hence, no tests of statistical significance will be discussed, though they will be reported.(26) Since the issue here is not whether any country once it reaches a certain level will manifest a wealth to knowledge connection, but rather whether those countries that have already reached that level demonstrate such a connection, significance tests are not necessary.

The assumption that the nations for which data are available and which are referred to in science policy discussions constitute the universe and not simply a population means that there is no need to try to generalize from the findings. There is nothing to which to generalize because all relevant cases are in the universe, and the sample is universal. This

TABLE 4.1

RESEARCH INTENSITY AND GROWTH RATES, SELECTED COUNTRIES

	Share of GNP Devoted to Total R&D			Growth Rates 1955-65 GNP		GNP per Worker	
	Year	%	Rank	%	Rank	%	Rank
Japan	[illegible]	[illegible]	4	9.6	9	8.1	9
France	1962	[illegible]	6	4.9	7	4.6	8
Germany	[illegible]	[illegible]	3	5.6	8	4.3	7
Norway	[illegible]	0.7	1	4.2	3	3.9	6
Sweden	1961-2	[illegible]	7	4.4	5	3.6	5
Netherlands	1959	1.4	5	4.5	6	3.3	4
UK	1961-2	2.4	8	3.1	1	2.6	3
U[illegible]	1961-2	2.8	9	3.4	2	2.1	2
Canada	1961	0.9	2	4.4	5	2.0	1

SOURCE: N. H. Lithwick, *Canada's Science Policy* (Toronto: Methuen, 1969), p. 5.

TABLE 4.2

STATISTICAL RELATIONSHIP BETWEEN RESEARCH AND DEVELOPMENT INTENSITY AND GROWTH IN SELECTED COUNTRIES

Growth Indicator	Correlation Coefficients	
	Spearman	Pearson
G.N.P.	-0.39	-0.39
G.N.P. per Worker	-0.25	-0.33

Note: No statistical significance.

SOURCE: Lithwick, *Canada's Science Policy*, p. 6.

TABLE 4.3

GROSS EXPENDITURES ON RESEARCH AND DEVELOPMENT AS A PERCENTAGE OF GROSS NATIONAL PRODUCT AND PER CAPITA GROSS NATIONAL PRODUCT IN UNITED STATES DOLLARS

Country	Year	R&D as % GNP	Per Capita
1. United States	1963/4	3.4	3243
2. United Kingdom	1964	2.3	1700
3. Netherlands	1964	1.9	1385
4. France	1963	1.6	1674
5. Japan	1963	1.5	622
6. Sweden	1964	1.5	2281
7. Germany	1964	1.4	1774
8. Canada	1965	1.3	[illegible]1
9. Belgium	1963	0.9	1502
10. Norway	1963	0.8	1537
11. Italy	1963	0.6	897
12. Ireland	1963	0.5	805
13. Austria	1964	0.3	1172

SOURCE: J. L. Orr, *Statistical Data on Industrial Research and Development in Canada* (Ottawa: Department of Industry, 1967), unpaginated (table one).

assumption is warranted by the simple fact that from the point of view of Canada, the only relevant points of comparison are other Western industrial urban nations and which keep data on research and development. All of these nations are part of the universe.

Second, a lesser amount of faith will be placed in administrative economic data than is common. To be more precise: the national accounts in terms of which the relationships between knowledge and wealth is being examined will be assumed to be faulty, error-ridden. This is an assumption which it seems safe to make about any data set gathered universally and aggregated across the whole of a nation. When carefully and imaginatively detailed the sources of error in the routine data that constitutes economic indicators are startling.(27) It is a fine line between throwing away information by assuming the data to be doubtful and compounding error by supposing it to be unproblematic. Here caution is taken, as it must be when "even the first digit is in grave doubt."(28) Research and development data seem particularly susceptible to the pitfalls described by Oscar Morgenstern, in three particular ways.

(i) Much of it has long been collected for no other reason than curiosity and through voluntary cooperation. Hence its collection may have been less than careful and complete.

(ii) It is especially difficult to classify parts of research and development. Hence there are few common classifications across nations,[29] or even within a nation, since different departments use different definitions. Thus, estimates of United States military research and development have varied by 300% for one year.[30]

(iii) National indicators of research and development represent small figures the usefulness of which may be destroyed by large error margins. This problem applies not only to research and development figures but also to one of the dependent variables linked to it, namely growth rates. British growth rate data are among the best in the world and yet there is an error margin of ± 3% attached to rates like 4%.[31]

Therefore data representing gross national product and the growth and per capita income levels and all indicators drawn from them, which are in principle interval data, are treated as ordinal data here, as a precaution. It is possible to assume that such data convey enough information to rank order, and indeed even a bit more information than that, but not enough more for the cases to be located along an equal interval scale. The same assumption will be made about the data representing research and development efforts. Accordingly, attention will hence forth go to Spearman rank order correlation coefficients, though the Pearson product moment coefficients will also be reported.

The nonparametric Spearman statistic is distribution free, it does not assume a normal distribution in the population or universe. It is especially useful for numerical information that is not exact.(32) Yet "when used on data to which the Pearson r is properly applicable, both r and rho have efficiency of 91 percent" in detecting an association's existence, strength and direction.(33) Such a procedure does not preclude further analysis.(34)

Now that some of the methodological underbrush has been raked aside and put into place, the findings of the Orr study set forth in Table 4.3 may be examined more carefully. It can be seen from Table 4.4 that there exists a strong relationship between Orr's two variables, expenditure on research and development as a percent of the gross national product and per capita gross national product. But since this fact does not tell us which is cause and which is effect it does not necessarily give aummunition to the advocates of a Canadian national science policy. There is no danger of curvilinearity, as Figure 4.1 shows. The relationship, whatever its direction, is linear. Presenting these data in a figure allows for the consideration of another point, one not taken up by Orr. It is that there are important differences amongst the Western industrialized nations so that their bivariate array may be, indeed should be, partitioned. Because of their differences, they do not all come from the same universe. Hence in Figure 4.2 we see Orr's data partitioned into three groups. There is warrant for placing the United States in a class by itself. It exceeds the values of other countries on the two variables by an impressive distance. The division between groups two

TABLE 4.4

STATISTICAL RELATIONSHIP BETWEEN GROSS EXPENDITURE ON RESEARCH AND DEVELOPMENT AND PER CAPITA GNP

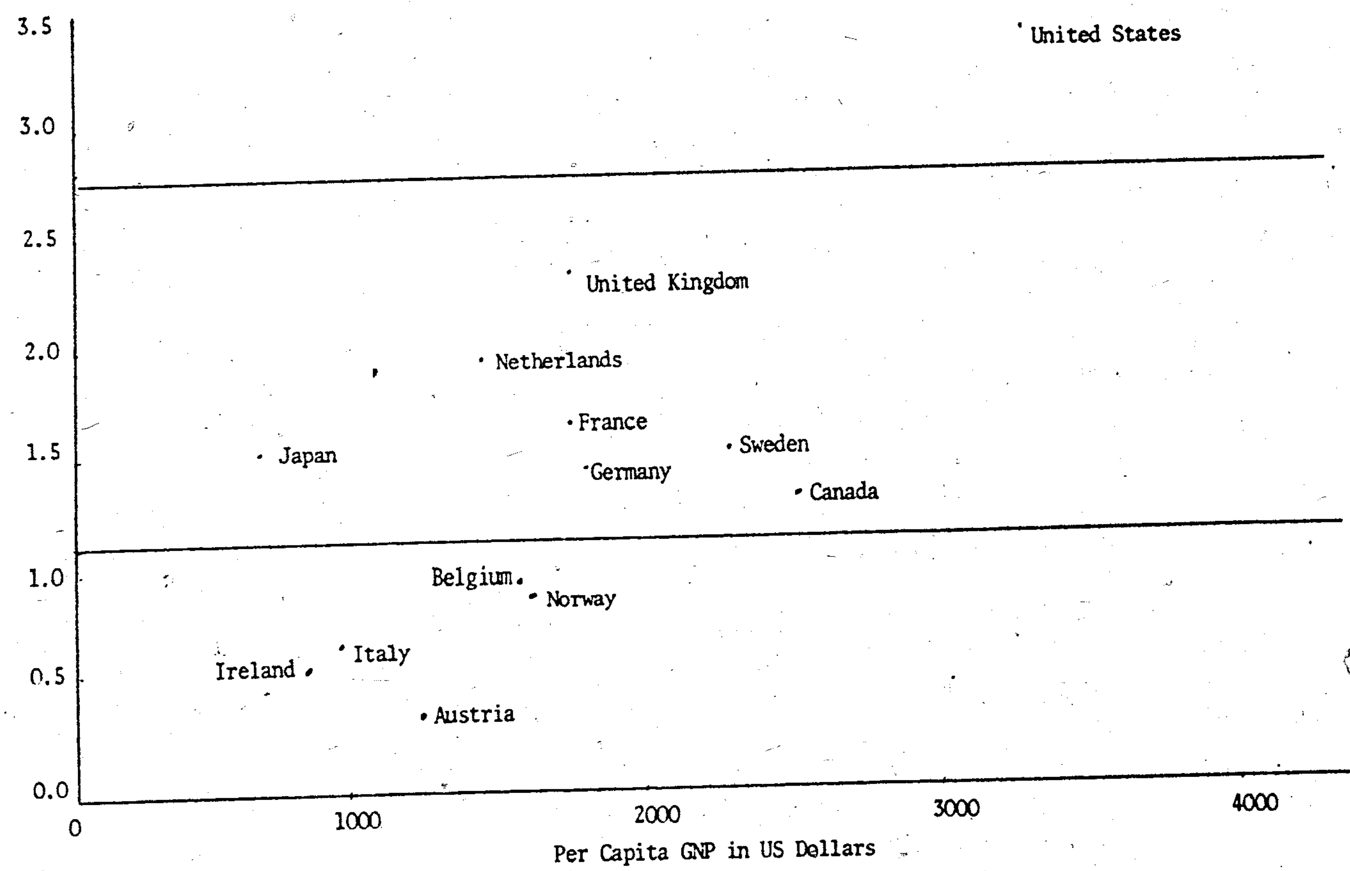
Correlation Coefficients	
Spearman	Pearson
.7662	.8302

Note: Both coefficients are significant at .001.

SOURCE: Table 4.3.

Figure 4.2

Gross National Expenditures on Research and Development as a Percentage of GNP
Per Capita GNP in US Dollars - Partitioned by Size of GNP



Source: Orr, <u>Statistical Data on Industrial Research and Development in Canada</u>. U.P. (Chart 1) and three are partly vindicated by their reflecting at least one important system of classification, namely, that used by the Organization for Economic Cooperation and Development to sort countries by the size of their gross national product. Of course, the implicit suggestion here is that the absolute number of dollars involved is more important to the effects of research and development than the percent of the gross national product. This is not an unreasonable view, since the market for scientific personnel and apparatus is largely a tariff free international one, and the price levels of the market are international too. The result is that 0.2% of billions of dollars is more effective than 10% of thousands of dollars. Hence, a rank order listing of the cases in Orr's data set by the gross expenditure for research and development in absolute United States dollars, rather than as percentage of their respective gross national products, conforms to the partition's grouping in all save one case. As can be seen, the only exception to the partition is Italy. In the partition Sweden falls into group two, but Italy does not, yet according to the absolute dollars involved, Italy exceeds Sweden and hence should be in group two as well. Otherwise the partition is warranted.

Now that Orr's data have been reconstituted, correlation coefficients may be recomputed for each of the two groups with plural membership, recalling that Canada is in group two. Here it can be seen that for nations reaching the threshold of group two, research and development investment is not

TABLE 4.5

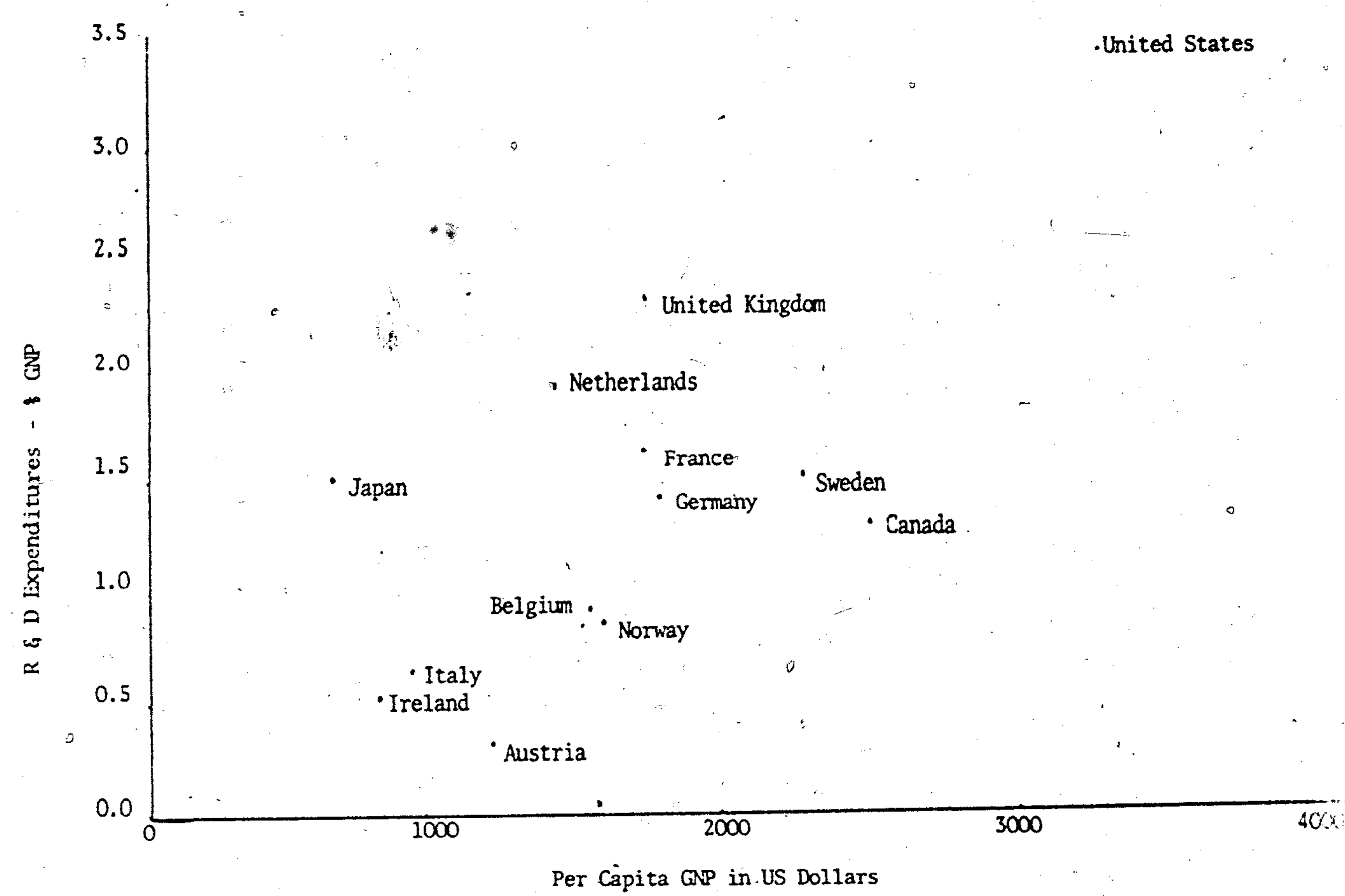
RESEARCH AND DEVELOPMENT AS PERCENT OF GNP AND IN U.S. DOLLARS

Country	% GNP to R&D	Rank	R&D in U.S. Dollars (in thousands)	Rank
Group I				
U.S.A.	3.4	1	21,035,100	1
Group II				
U.K.	2.3	2	2,159,814	2
W. Germany	1.4	6	1,436,275	3
France	1.6	4	1,299,129	4
Japan	1.5	5	892,025	5
Canada	1.3	7	425,079	6
Netherlands	1.9	3	330,385	7
Sweden	1.5	5	257,423	8
Group III				
Italy	0.6	10	290,766	9
Belgium	0.9	8	136,828	10
Norway	0.8	9	42,440	11
Austria	0.3	12	23,189	12
Ireland	0.5	11	10,446	13

SOURCE: Table 4.3, O.E.C.D., *International Statistical Year for Research and Development, Vol. 2, Statistical Tables and Notes* (Paris: O.E.C.D., 1969) pp. 42-3; and International Monetary Fund, *International Financial Statistics*, various.

Figure 4.1

Gross National Expenditures on Research and Development as a Percentage of G N P
Per Capita G N P in US Dollars



Source: Orr, Statistical Data on Industrial Research and Development in Canada, U.P. (Chart 1).

positively related to the size of the gross national product. Indeed it is negatively related and considerably so. There is reason to believe then that for group two, a dollar in research and development is dollar which does not go to further the level of the gross national product.

The opposite seems true for group three. For group three there is an unmistakably positive relationship, one of fairly considerable strength.

Analysis of these partitions can be carried one step further with edifying effect. That step is to associate gross expenditure on research and development and gross national product with expenditures for military research, within each group.(35)

In Table 4.8 it can be seen that gross expenditure for research and development and military research are closely related in both cells.(36) But because gross expenditure on research and development and per capita gross national product are inversely related in group two, as shown in Table 4.7, military research and per capita gross national product are positively related in group three and negatively in group two. Where research and development is positively related to the level of the gross national product, there military research is positively related to the level of the gross national product too. Where research and development are negatively related to the gross national product so is military research. This finding is consistent with the view that the level of the Gross National Product causes the level of research and

TABLE 4.6

STATISTICAL RELATIONSHIP BETWEEN GROSS EXPENDITURE ON RESEARCH AND DEVELOPMENT AND GROSS NATIONAL PRODUCT WITHIN GROUPS II AND III

Group	Correlation Coefficients	
	Spearman	Pearson
II	-0.5586	-0.2240
III	+0.6000	0.6469

Note: No statistical significant.

SOURCE: Table 4.3.

TABLE 4.7

STATISTICAL RELATIONSHIPS BETWEEN GROSS EXPENDITURE ON RESEARCH AND DEVELOPMENT AND EXPENDITURE ON MILITARY RESEARCH AND PER CAPITA INCOME

Group	Gross Expenditure on Research and Development	Expenditure on Military Research	Per Capita Income	Expenditure on Military Research
	Correlation Coefficients		Correlation Coefficients	
	Spearman	Pearson	Spearman	Pearson
II	0.6000	0.8535	-0.6000	-0.5243
III	1.000	0.9972	0.5000	0.4027

Note: Cell 2, 1 is statistically significant, providing some credence to the use of the Spearman assumptions for it attains unity where Pearson does not.

SOURCE: Table 4.3 and O.E.C.D. *International Statistical Year for Research and Development*, Vol. 1, *The Overall Level and Structure of R & D Efforts in O.E.C.D. Member Countries* (Paris: O.E.C.D., 1967), p. 58.

development rather than vice versa.

On the basis of these data and their analysis, it would be difficult to conclude that research and development is positively related to wealth universally. At best one could say this is so of the smaller nations of group three (and perhaps of the nation of group one). For the middle powers of group two, which includes Canada, research and development appears to be as much an economic luxury devoted to the political purpose of defence, through military research, and not an economic necessity. This is an especially appealing view when it is recalled that the correlations with the growth measures of Lithwick were uniformly negative. Only some correlation slices with gross national product were positive, raising the possibility that research and development intensity is a luxury of the more highly placed economies. Once growth has attained a high level of income then research and development intensity increase: it follows, it does not precede economic advances. On such a view all the correlational associations established or assumed in the consideration of national science policy could be retained, but with the implicit causal arrows reversed.

Correlation alone never proves cause and effect. This old adage is especially telling in the case of national science policy. The strongest correlation between knowledge and wealth we have seen is .7662 rho. But besides dollar investments there are other indicators of research and development efforts. One possibility would be to use an

TABLE 4.8

INVENTION AND GROWTH

	Country	Patent Applications by Residents per Capita (10,000)	Annual Growth Rate in GNP
1.	Japan	7.03	10.7
2.	U.S.A.	3.34	3.6
3.	W. Germany	5.86	3.1
4.	U.K.	4.83	0.9
5.	France	3.52	3.9
6.	Italy	1.44	4.9
7.	Canada	0.77	4.3
8.	Switzerland	9.64	2.9
9.	Netherlands	1.94	4.4
10.	Sweden	5.93	3.3
11.	Belgium	1.52	3.0
12.	Australia	3.49	5.0
13.	Mexico	0.63	5.9
14.	Spain	1.17	-0.9
15.	Austria	3.38	3.1
16.	Czechoslavakia	4.09	-
17.	South Africa	1.25	5.0
18.	Brazil	0.31	-97.7
19.	E. Germany	3.40	-
20.	Argentina	1.05	-35.7
21.	Poland	1.42	-
22.	Denmark	1.08	-0.5
23.	India	0.02	-
24.	Norway	2.58	3.6
25.	New Zealand	3.77	-1.1

SOURCE: Robert Koruna, "The Output and Sources of Invention in Canada as Measured by Patents", (Edmonton: Department of Economics, University of Alberta, unpublished Masters Thesis, 1971), pp. 65, 68-69.

TABLE 4.9

STATISTICAL RELATIONSHIPS BETWEEN INDICATORS OF INVENTION, GROWTH, PER CAPITAL PATENT APPLICATIONS PER 10,000 POPULATION AND MEAN GNP GROWTH, 1965-8

Correlation Coefficients	
Spearman	Pearson
.2063	.3364

Note: No statistical significance.

SOURCE: Table 4.9.

indicator quite apart from research and development expenditures.

Alternatives to knowledge indicators are not far to seek. Two may be briefly considered. They are inventiveness and scientific output. These two branch from research and development expenditures in oppositive directions. One, patented inventions, succeeds from the research and development stage to the applications stage. The other, scientific papers precedes research and development expenditures, in a sense.(37)

It is a simple matter to give a cursory check to the first possibility. On the face of it, this is not a promising avenue, at least, it is not promising enough to warrant attention in this exploration. Between per capita patent applications by residents for every ten thousand citizens and the average annual growth in real gross national product from 1965 to 1968 there exists only a marginal Spearman rho of .2063. This relationship is not as strong as that of .7662 between gross expenditure on research and development and per capital gross national product in the Orr data set. Though .2063 is a relationship, it gives little heart to vast policy changes.

5. CONCLUSION

"Is truth barren?" asked Francis Bacon.(38) His answer was no, but perhaps since then things have changed so that the answer is yes. At the very least the answer is unclear.

It may be that nowadays technology builds, not on science, as it may have done in the past, but on itself, for it has absorbed all there is or all it can absorb from science. Meanwhile, science builds on science.(39)

In the preceding pages of this chapter attention has been focused upon the external justification of Alexandrian science. It has been argued that this justification is that wealth results from knowledge. This claim, it was maintained, serves to direct external resources to science with the double effect of enlarging and vitalizing science while heightening external control, and simultaneously perhaps internal discipline as to be considered in light of Chapter Seven. Thus the scientific community becomes a dominant institution in our society, partly by influencing society and partly by permitting society to influence it. Moreover, it was argued that it is not clear that wealth does unquestionably result from knowledge. Scientific investments are neither empirically nor theoretically connected to the indicators of wealth in an obvious way. It is to be concluded from the foregoing that at the very least, an adequate basis for policy decisions does not yet exist. Nor is more or newer evidence likely to produce it, nor make us forget this evidence. The two are not unconnected, it is true, but in what way they are connected in the Canadian context is not clear. Would wealth to Canada come from more knowledge in Canada, that is the question. Until that is understood, the social impact of science policy in Canada cannot be fully appreciated. The following three chapters which comprise Unit II turn away from the social aspects of science policy to the aspects related to the scientific community, shifting focus from the products to the activity of science, from the effects of knowing on doing to the effects of doing on knowing.

FOOTNOTES

1. Karl Marx and Frederick Engels, *The German Ideology* (New York: International Publishers, 1947 [1846]), ed. R. Pascal, p. 22.

2. Michael Walzer, "A Day in the Life of a Socialist Critizen", *Dissent* (May-June, 1968); reprinted in Walzer, *Obligations* (Cambridge: Harvard University Press, 1970), pp. 229-30.

3. *Ibid.*

4. See, for example Gerhard Herzburg, "Pure Science and Government", Address at Opening of Queen's University Physics Building, Kingston, 1965, p. 1; A. Flexner, "The Usefulness of Useless Knowledge", *Bryn Mawr Alumnae Bulletin*, July 1937; reprinted in the *Journal of Chronic Medicine*, II (1955), pp. 241-6; Brian Hocking, "Science Policy" (Letter to the Editor), *Edmonton Journal*, 1 March 1972, p. 4; Henry Pabst, "Research" (Letter to the Editor), *Edmonton Journal*, 11 November 1971, p. 34.

5. See, for example, Jean-Jacques Salomon, "L'allocation des resources à la science", *Social Science Information*, IX (1970), 4, pp. 73-4; Salomon, "La résponsabilité sociale des scientifiques", *L'engagement social du scientifiques*, J.-J. Salomon, André DesMarais, and Jean Dorot (Montréal: Les Presses de l'Université de Montréal, 1971), p. 18; and DesMarais, "Evolution recénte et perspectives de l'éducation et de la récherche universités au Canada", *ibid.*, p. 62.

6. This point is also discussed in M. W. Jackson, "What is Rational and What is Research", Brief to the Commission to Study the Rationalization of University Research, Association of Canadian Colleges and Universities, 1972.

7. Hubert Curien, "Pour une nouvelle politique de la récherche", *Le Monde*, 6-12 January 1972, p. 5.

8. Manuel Lora-Tamoyo, *Un Clima Para la Ciencia* (Madrid: Biblioteca Universitaria Gredos, 1969), p. 120.

9. Jacob Schmookler and O. Brownlee, "The Economics of Research and Development", *American Economic Review*, LII (1962), p.165.

10. *Ibid.*, p. 176. Emphasis added. This finding is not inconsistent with the view that technological results can be produced to order. That technological advancement followed was a result of a demand for solutions to problems created by growth. It does indicate however that the "ordering" process may be a complicated market mechanism and not simply a matter of issuing policy directives.

11. Stephen Toulmin, "Science and Our Intellectual Tradition", *Advancement of Science*, II (May 1963) 83, pp. 29-30.

12. Ontario, *Report of the Royal Commission on Book Publishing* (Toronto: Queen's Printer, 1973).

13. Vincent Massey, chairman, *Report of the Royal Commission on National Development in the Arts and Letters and Sciences* (Ottawa: King's Printer, 1951), p. 8.

14. *Ibid.*, p. 180, and see also 365.

15. Lamontagne, Address, *Proceedings of SCITEC IV* (Ottawa: SCITEC, 1972), p. 85.

16. P. T. McTaggart-Cowan and Brigitte Schroeder, "Progress in the Social Sciences: What Prospects for Investment", *Science Forum 27*, V (1972) 3, inside cover and p. 32; with subsequent comments, M. W. Jackson, "Let's not compare the social and physical sciences," *Science Forum 29*, V (1972) 5, pp. 30-1 and J. Banks, "The Social Sciences: A language of discourse", *ibid.*, pp. 31-2.

17. Ronald S. Ritchie, *An Institute for Research on Public Policy* (Ottawa: Information Canada, 1971).

18. An elaboration of the notion of a leading institution, see James Feibleman, *The Institutions of Society* (London: George Allen and Unwin, 1956), pp. 228-41 and, implicitly, Aristotle, *Politics*, ed. with trans. by E. Barker (New York: Oxford University Press, 1946), pp. 1-38.

19. Fritz Machlup, *The Production and Distribution of Knowledge in the United States* (Princeton: Princeton University Press, 1962).

20. D. J. de Solla Price, "Policies for Science?" *Melbourne Journal of Politics*, II (1969), pp. 61-8.

21. N. Lithwick, *Canada's Science Policy and the Economy* (Toronto: Methuen, 1969).

22. Illustrative findings are discussed in D. Hamburg, "Size of Firm, Oligarchy and Research: The Evidence", *Canadian Journal of Economics and Political Science*, XXX (1964) 1, pp. 62-75; Ira Horowitze, "Firm Size and Research Activity", *Southern Economics Journal* (January 1962), and A Gustafson, "Research and Development, New Products and Productivity Change", *American Economic Review* (May, 1962), especially at p. 174.

23. On research at the industrial level especially worthwhile are Henry Grabowski, "The Determinants and Effects of Industrial Research and Development" (Princeton, N.J.: Econometric Research Program, Research Memorandum No. 82, September 1966; published in the *Journal of Political Economy*, LXXVI (1968) 2, pp. 292-306, and W. N. Leonard, "Research and Development in Industrial Growth", *Journal of Political Economy*, LXXIX (1972) 2, pp. 232-86.

24. Recomputations on these data were undertaken as a part of this study with results departing slightly from those reported by Lithwick. The different results were in cells 1,1 for the Pearson coefficient and 1,2 for the Spearman coefficient. The values attained for these cells are -0.3732, not -0.39, and -0.3096, not -0.39, respectively. No change in statistical significance accompanies these changes in values.

25. (Ottawa: Department of Industry, Trade and Commerce, 1967), n.p. Cf. the more well known B. R. Williams, "Research and Economic Growth", *Criteria for Scientific Development*, E. Shils, ed. (Cambridge: Massachusetts Institute of Technology, 1968), at p. 98 where it is written that "internationally there is no sign of a high correlation between rates of growth in output per head and the percentage of G.N.P. devoted to research and development".

26. Stefan Valavnis, *Econometrics: an introduction to maximum likelihood methods* (New York: McGraw-Hill, 1959), pp. 11-3.

27. Oskar Morgenstern, *On the Accuracy of Economic Observations* (2nd ed.) (Princeton, N.J.: Princeton University Press, 1963).

28. *Ibid.*, p. 286.

29. S. Dedijer, "Measuring the Growth of Science", *Science* CXXXVIII (16 November 1962) 3542, p. 782.

30. Willis Shapley, "Problems of Definition, Concept and Interpretation of Research and Development Statistics", *Methodological Aspects of Statistics in Research and Development Costs and Manpower* (Washington, D.C.: The National Science Foundation and the American Statistical Association, 1959), p. 7. Cf. C. Kidd, "Basic Research--Description versus Definition", *Science*, CXXIX (1959) 368, pp. 368-71.

31. Morgenstern, *On the Accuracy of Economic Observations*, p. 289.

32. Sidney Siegel, *Nonparametric Statistics* (New York: McGraw-Hill, 1956), p. vii.

33. *Ibid.*, p. 233. Cf. Fred Kerlinger, *Foundations of Behavioral Research* (New York: Holt, 1964), p. 258.

34. Specifically, the use of Spearman correlation coefficients does not foreshorten the prospect of regression analysis. The data assumptions upon which the Spearman correlation coefficient is based do not conflict with those of regression analysis. Spearman assumes that the distribution is not necessarily normal. The regression equation makes no assumption regarding the form of the distribution or the true level of measurement. See W. Hayes, *Statistics for Psychologists* (New York: Holt, 1963), p. 510. Cf. Norman Nie, Dale Bent and C. Hadlao Hull, *Statistical Package for the Social Sciences* (New York: McGraw-Hill, 1970), p. 184.

35. No attempt has been made to consider lag time. To do so would be an exercise in econometric modelling beyond present purposes.

36. All Spearman coefficients reported were produced via the Statistical Package for the Social Sciences Subroutine for nonparametric statistics. All Pearson coefficients were produced by a stand-alone Fortran programme, using double precision to ensure the retention of all the information in such bulky aggregates as gross national products.

37. The assumption here is that most science papers are in the realm of basic research and that most research and development is not, or more specifically, that few research and development dollars are involved in the work which actually fosters published papers.

38. "In Praise of Learning", *Francis Bacon*, A. Johnston, ed. (London: Batsford, 1965), p. 13.

39. J. Languish *et al.*, *Wealth from Knowledge* (London: Macmillan, 1972), p. 35. Cf. D. J. de Solla Price, "The Structure of Publication in Science and Technology", *Factors in the Transfer of Technology*, W. H. Gruber and D. G. Marquis, eds. (Cambridge: Massachusetts Institute of Technology Press, 1969), p. 97.

CHAPTER FIVE

POLITICS IN SCIENCE

INTRODUCTION

With this chapter begins the second main unit of this study. Here we begin to examine more specifically some of the impacts of society and polity on science, just as in Unit I some of the impacts of science on society and polity were analyzed and criticized. To come to the matter of the political impact on science is to come exactly to the question of science policy. "Perhaps the most important question about Science Policy is whether it exists."(1)

It is true that there exists a widespread belief that the products of science are desirable. The only existing threat to this ethos is the recent concern with ecology, environment and energy. These concerns have been more or less blunted by the technocratic structure. While admitting the destructive aspects of much of our science-related technology, the technocratic structure has deflected criticism by claiming that the only solution to the problem is more technology, perhaps of a different kind, but technology all the same.(2) These concerns have been further diffused by what can only be called top level infiltration by technocratic interests such as the Club of Rome.(3)

If the products of the activity of science are perceived as desirable, as they are, then it follows quite clearly that steps will be taken to enhance the quality of these products. If we like any product, it is only natural that we should wish to improve the activity of its production. When this happens for science, then the external justification of science for material benefits has led to the desire for an external control of science, a control that like its justification will be material in emphasis.

Of course, the external, material justification of science is not the only justification of science. There are others, which focus on the cultural and intellectual values of science. It is all too clear that materialist arguments, in this justification for an activity, are more widely and more seriously received than non-materialist appeals. Needless to say, no argument over a reasonably significant social decision can be classed as either wholly materialistic or wholly idealistic. This is because no decision has only materialistic or idealistic consequences. Nonetheless, interest in science is motivated by material considerations, as discussed in Chapter Four, which stem from the larger social orientations toward a technocratic society, as discussed in Chapter Three. That materialistic justification should, like bad money driving out the good, sweep away from the public consciousness competing modes of justification should not surprise us. Because of their materialistic trappings these arguments seem to be--and on occasion are--very immediate, concrete, practical and aggregative across people. They are much more immediate, concrete, practical and aggregative than idealist arguments, and more people are more interested in the immediate, the concrete, the practical and the aggregative, than in the values which can be contained in ideas. More people are interested in the material, than in the cultural. So much is this so that our culture has been said by some to be nothing more than materialism. In case it is necessary to establish that non-materialistic, non-utilitarian justifications for science have been driven from public consideration of science policy, despite the efforts of a few scientists, the reader is asked first to try to conjure up a science-for-the-sake-of-science argument and then to evaluate such an argument. Here two things may be noticed: (i) how difficult it is to put forward a science-for-the-sake-of-science argument: we hardly know how; and (ii) that we reject such arguments as soon as we recognize them.

Materialist, utilitarian arguments and interpretations receive sympathetic hearings. This is so not because people are necessarily born to be materialistic utilitarians, or even because they have chosen to be that, but rather because they have been taught to be like that. No one who experienced career counseling in school can dispute this claim. In what terms other than lifetime earnings are various occupational alternative presented to impressionable minds?

From this results what can only be called a double standard. When we look back into history, individually or in the publically directed institutions of education, our gaze is turned to and so often captivated by, not the materialistic, but rather the cultural accomplishments of others. Others we judge, admire, remember are not the builders of ever larger gross national products. They are rather achievers of cultural excellence, for example, the Greeks for their dramas--few of which concerned bread; the French for their philosophy; the Germans for their music and the Russians for their physiology. Yet when we judge ourselves, which is what part of politics is, then attention goes to the material, to production and consumption.

Other justifications of science might not imply and might even preclude external control. However, such other justification take on an immediately terminal prognosis when materialist justification comes on the scene.

Hence, the external justification of science emphasizes not only the desirability of the products of science, but also the advisibility of the external control of science so as to best yield those products. After all, it is not odd to suppose that if the scientific goose that is thought to lay the golden egg were more properly directed and encouraged, then bigger and/or better eggs might be issued. Connecting input with outputs in this way is not always an unwarranted assumption, if outputs are in some sense produced from the inputs. This relationship is usually presumed to be linear. Linear or otherwise, the relationship between inputs and outputs will be the focus of attention in the subsequent discussion of the external control of science. Suffice it to say for the moment that external justification brings forth external control.

The form in which such control is contemplated may vary. As divergent as the forms of control may be, it is perhaps safe to venture the assertion that there are three principal alternatives. It should be ~~clearly~~ noted that the alternatives are by no means mutually exclusive nor jointly exhaustive. They are not jointly exhaustive for there are other alternatives not here treated. These missing alternatives are minor ones, in the sense of having attained few advocates and in the sense of addressing a limited part of the science policy arena. They are not mutually exclusive. Instead they combine in various ways. Thus the alternatives are matters of emphasis, not selection. Any science policy will include aspects relating all these alternatives. The issue is which alternative to emphasize, which to try to extend.

After so long an introduction as this, the three alternatives may seem to be disappointingly simple. Let us hope that their generality makes up for their simplicity. Yet the simplicity itself is not something for which to apologize. Most of the matters of science policy are simpler than is suggested by the guise of technological complexity in which they are cloaked. For any part of the jurisdiction of science policy "there is a large area where there is no need for any new body of theory." This is so because "there is no new phenomenon to understand."(4)

Serving as it does to initiate a new unit of the study, this chapter touches on a wide variety of issues, a few amongst which will be further developed in Chapter Six and criticized in Chapter Seven. These issues are dealt with in six parts. Part (1) discusses three general interpretations of assessments which find science policy feasible. These are (1.1) passive utilization, (1.2) genius-to-order and (1.3) direct intervention. The next part, (2), concentrates on analyzing (1.2) and (1.3). Part (3) studies the association between the idea of external control through funding and the presumptions of an inductive conception of the activity of science. Part (4) surveys the extent and origin of a popularly held inductive conception of science. The last part, (5), relates the instrumental conception of science examined in Unit II with the idea of inductive science.

1. THREE INTERPRETATIONS OF ARGUMENTS FOR SCIENCE POLICY

(1.1) Passive Utilization

Passive utilization does not subscribe to interference in the activity of science. It rather only monitors the activity of science looking for useful products. It scans the literature, funds undirected research and seeks to generally advance post-secondary education.

The passive utilization approach to science policy may be the most widespread of the three. It may be the most widespread of the three because it is the one emphasis most acceptable to scientists. It may be the most acceptable to scientists because it is the emphasis which would seem to show cause for continued or increased levels of science, while not calling for and perhaps even warning against external control of the activity of science due to its exclusive focus on the products of science. This view, an exclusive attention to the products and not the activity of science, may be predicated on any one of at least three different theoretical accounts of science. Each of these three theoretical accounts has been championed by authoritative spokespersons within the community of science.

These three theories pertaining to the control of science view it as: (i) a delicate autonomous enterprise, like a flower; (ii) a vigorous enterprise, like a weed; or (iii) a social overhead investment. Each of these three theories can be sketched briefly to good advantage.

Theory (i) understands the activity of science as entirely self-contained and self-regulating. It views any departure from this autonomy with alarm. Departures can do only harm to the fabric by which science is stuck together. This is because science is a delicate enterprise in which the activity of science and the community of science from which it is sustained is at best only finely balanced. Accordingly, on this understanding, it is thought that the best means to enhance the social value of science is to insure that science is carried on in its most effective and efficient ways. And the most efficient and effective ways of science are those determined, consciously or unconsciously, by scientists themselves. Who can know and understand the details of any activity better than a practitioner of that activity, one might ask. Do not we recognize this axiom for many other professions which are legally self-regulating in their professional conduct and often practically self-regulating in their teaching and research activities, such as lawyers, doctors and engineers?[5] This professional sovereignty surely must be permitted to science too. When science is free from outside intervention it governs itself in a highly disciplined fashion. Michael Polanyi, chemist cum philosopher, is one of the outstanding proponents of this view.[6]

If by theory (i) science is a delicate plant which would surely wilt if troubled by the heat of social attention, under theory (ii) it is a vigorous weed, a beneficial volunteer. It is a beneficial volunteer having so strong a will of its own that it cannot be controlled or interfered with from the outside. While by theory (i) society should not interfer with science, by theory (ii) society cannot interfere with it. Impressive arguments for this conception of science are presented by Derek J. de Solla Price, physicist turned historian.[7]

Finally, under theory (iii) science is conceived as a social overhead. On this view, specific aspects of the activity of science cannot be uniquely, causally associated with particular social purposes. Yet science is held to be an investment which makes possible many particular social goals. In this way science is understood to be general landscape or background investment in the way education is. Clearly this theory does not specifically reject the social control of the activity of science. Equally clearly, it does not necessarily imply social control, though it would seem to suggest that social control would be difficult, but not impossible. In this it is close to theory (ii) above, and unlike theory (i). A most distinguished advocate of this view is sociologist Daniel Bell.[8]

As now can be seen, a programme of the passive utilization of science is a programme which eschews the activity of science, choosing to concentrate instead on the products of science. Hence, passive utilization is not concerned with the social control of science, for the social control of science is the social control of the activity of science. The society's right to make whatever use it chooses of the products of science has never been questioned within the domain of science policy.

> "From the time of the atomic bomb onward, and even more so after Sputnik in 1957, we taxpayers have supported scientific research and development on the apparent basis that science creates wonders and if we want wonders, all we have to do is support science."[9]

And it is wonders we want. As Chairman of the Senate Special Committee on Science Policy, Maurice Lamontagne has said,

> ". . . the major interest that society has, and therefore what the government should have in science and technology centers . . . around the innovation process."

Continues the Senator, "it is through this process that society either benefits or suffers from the applications of science."(10) And apparently not to benefit is to suffer, according to the Senator.

A science policy of passive utilization has proven itself to be more viable in larger states where the size of the scientific community ~~is~~ greater.(11) The greater the absolute size of the scientific research community, the more diverse and intense it is, the more likely it is to burn with a brighter, hotter flame casting off more and stronger sparks, which are to be quickly collected and their heat used by the applications programmes generated by the policy.

This sort of policy emphasis may well have been characteristic of the approach to science policy in the United States during the decades of the fifties and the sixties. There existed then such well known monitoring and applications organization as the Rand Corporation and the National Aeronautics and Space Administration and the Office of Naval Research, plus any number of smaller and less visible government departments.

(1.2) <u>Genius-to-order</u>

The second main type of science policy has been labelled for convenience, genius-to-order. For fairly obvious reasons this school of thought on science policy is more than a little atheoretical. On this approach to science policy the supposition is that science is the result of purposeful actions by extraordinary persons, geniuses. To fulfill the desired standard of external justification what is needed, on this account, is an external control which directs the genius to this problem or that.

This approach attempts to meet the researchers half-way, unlike the passive utilization approach which does not try to involve the investigator at all and unlike the direct intervention method which tries to involve the scientist actively. Among the techniques used in this way are hiring people:

> ". . . from outside who are interested in the area we have chosen and hope that they will come up with new ideas."(12)

~~Accordingly~~, a recruting advertisement for an electronics firm claimed "you'll think you're doing research in a university."(13)

Coupled with the foregoing assumption about how the activity of science proceeds is an assumption about human motivation. It is that people in general, and no less geniuses, are motivated to undertake this task or that by the thought or reality of material reward, by money.(14) Hence if an industrial laboratory offers an atmosphere appropriate to a university and pays better it will attract staff, and discrepancies in the atmosphere may be compensated for by additional salary. Scientific attention can be led and directe with the carrot of money and the stick of the withdrawal of the money.

This carrot and stick approach to science policy is probably the least emphasized of the three approaches here examined. Yet it is far from unimportant, for the conception of science from which it springs permeates other approaches as well. Some of these will be described here and now, others will be considered later.

Atheoretical or not, less emphasized or not, it certainly bespeaks an approach to science policy that has been employed. Major scientific projects undertaken during the Second World War were operated successfully in this way. However, particularly for those projects (for example, the Chalk River Ontaria installation or the American Manhattan Project) we may confuse technological wizardry with scientific creativity. If the emphasis is technology then the matter is different. People can be paid and directed to apply what is known in an inventive way. It is less certain that people can be paid and directed to discover what is unknown, for consider: How would we even know that we have or have not got what we want?

There are occasions when the matter is clearly one of knowing, not making. Where that is the case, though, progress is so irregular and abnormal that it hardly lends itself to the rigorous cost-benefit analysis required in public finance, enough so to give any accountant headaches and any political opponent ammunition.

The whole the genius-to-order approach is so hit-and-miss that it alone does not provide adequate perspective from which attempt to fabricate a science policy. It is difficult to specify the sort of genius and to identify it afterward. The normal surrogates like a proven track record may be counter-productive. They may be based on evaluations that emphasize the normal, the comprehensible, and not the extraordinary. Indeed, the mere fact that science policy has been brought into reconsideration is sign that neither this approach nor the preceding one of passive utilization, has been found adequate.

(1.3) Direct Intervention

The last of the three perspectives on science policy of concern here is that of direct intervention. Direct intervention means just that, namely, political authorities acting for the society directly intervene in the activity of science so as to influence the products of science. An option such as this is especially attractive to dollar conscious economies, particularly in smaller nations where available resources are fewer and require more careful husbandry. It is more attractive in such circumstances because it gives the appearance of reducing uncertainty by disciplining effort. As may now be seen, the focus to be derived from this approach is on the inputs to the activity of science.

Certain of the early skirmishes in the Canadian science policy field bore heavy loadings of the direct intervention kind of approach: for example, the Glassco report, or, more recently, the de-emphasis on certain categories of research by the Federal Government, by the expedient of not compensating for inflation in allocations for current costs. This serves to reduce research activity, yet seemingly maintains the existing levels of funding. Such is also implicit in the Corry-Bonneau Report on research in universities.[15]

Inputs to the activity of science may be said to be of three kinds: personnel, finances and equipment. There can be no doubt that the principal, though not exclusive, focus of the Canadian debate on national science policy is the disbursement of funds. Only a lesser attention is given to personnel and instruments. Thus in the first volume of the Report of the Senate Special Committee on Science Policy, where an attempt is made to bring the present state of Canadian science into comparative perspective, the focus is on monetary inputs from the start. Revealingly, in Chapter Six of the Senate Report ten of the fourteen tables presented by the Senat[illegible]lusively concern the financing of research and development, only one of the remaining four tables is exclusively devoted to personnel, and none concern instruments. Eight of the eleven charts address finance alone; one for personnel, none for instruments. The emphasis is clearly on financial investment in research and development. At least for the present this is the principal issue of science policy. It was in anticipation of this emphasis that Chapter Three dealt with only monetary inputs.

Preoccupation with dollar inputs is not incomprehensible, especially in Canada. Thanks to immigration, the Canadian market is well stocked with highly qualified labour. And of course money can buy instruments, or in time start an instruments industry. Or for that matter, if money is available it can be used to train and encourage highly qualified labour. Here as in so much of Canadian life the perceived stumbling block seems to be capital.

A policy of direct intervention, a policy of the social control of science, aims to affect scientific products by variously, even subtly, encouraging or discouraging different aspects of the activity of science. The aspects of the activity of science are determined by analytic distinctions according to the intention of the performer of the research activity. Principally these distinctions are by sector and category of research and development. Sectors of research and development are industrial, university, governmental, private non-profit, while categories of research and development are basic, applied and developmental. In special cases particular substantive areas of research are singled out, like cancer research.(16)

That the precise funneling of research and development to substantive areas is unusual is itself revealing. It is unusual in present policies related to research and development and it is unusual in the recommendations of the advocates of science policy too. Other than in the most general pointing kind of way, even the staunchest advocates of science policy are slow to be more specific than research and development regarding environment, ~~or health~~. Such reluctance may reveal the difficulty in external control of science or the timidity of politicians. Which it is [illegible] be [illegible] seen in the following chapters of this Unit.

As vague as existing or advocated policies for science may be, it would be an egregious error to suppose them to be ineffective. How effective such directions can be is seen by simply recalling the post-Sputnik swelling of the ranks of scientists in particular, and the post-World War II swelling of the ranks of higher education in general.

2. GENIUS-TO-ORDER AND DIRECT INTERVENTION

The latter two main channels in the river of the science policy debate, (2) genius-to-order and (3) direct intervention, have many points in common. For the purposes at hand they will be treated together, on the view that the latter represents an elaborated and maturer, a more sophisticated version of the former. This is done on the view that, while the policy orientations to be derived from the two are not identical, they are similar, though they spring from significantly different conceptions of the activity of science. Both the genius-to-order and direct intervention positions view the activity of science as susceptible to external control. This is their first point of similarity, not their last. Rather it implies still other similarities. To suppose that science can be controlled from the outside, as both do, is itself to imply a certain conception of the activity of science.

The supposition that science can be externally controlled in the way just adumbrated finds support in two theories: (i) the first is the commonsensical view that the effort devoted to a task stands in some proportion to the results of the effort. (ii) The second is that science is a technical overhead on social goals.

Being a slightly more specific formulation than (i), (ii) may be taken up first. Under (ii) society is understood as being primarily dedicated to allocating resources to technological payoffs. Some part of the investment in technology is then reinvested by the technological system to the support of science. This is done in the hope that science will contribute indirectly to the improvement of technology. Director of the Atomic Energy Commission's Oak Ridge Laboratories, Alvin Weinberg, can be seen to take this view.(17) This theory purports more to describe how science is conceived by others than to recommending a conception per se. This theory departs from that of the commonsense equation of inputs and outputs, for it makes no linear presumption. By so doing, it erodes the theoretical justification for external control by direct interference and reverts more to passive utilization, a theory of science policy that is of decidedly secondary interest in the Canadian debate. Of the greatest significance in the Canadian debate, and everywhere laypeople begin to view science, is the problem of the relationship of inputs to outputs.

That control over inputs to the activity of science can be used to govern the resulting products of science is a view roundly rejected by many scientists, and others, for various reasons. While most diverse, there exist amongst these rejections three principal theoretical positions that may be singled out now.

The first of these theoretical positions supposes that the irregular and erratic social benefits that science does throw up, and which ben fits cause others to think of science as an overhead or as a directly controllable resources, are small compared to both the effort needed to try to control science and the value of science as a consumer good. Hence, from the hardest of economic points of view, science is best treated as a luxury consumer good. Like art or music, science is one of the many ways in which society expends its excess product. Being a luxury good, it is accessible only to a few people; those privileged to have the education and leisure to appreciate it. Economist Harry Johnson exemplifies this position.(18)

The second of the theoretical positions attempting to negate external control of the activity of science through inputs comes from economist Richard Nelson from the Rand Corporation.(19) Nelson's view was mentioned in the Lamontagne report where it was titled the "Republic of Management".(20) The theory takes science to be a decentralized operation, in the sense that each disciplinary area works pretty much alone. Thus, at best is needed is not a science policy, but rather a series of science policies, one for the health sciences, one for agricultural sciences and so on. This permits the tailoring of each policy to the substantive nature of the field. Only then can control be effective in the particular cases where it counts. Generally, though, such an approach to science policy is so enormous and complicated that it might be impossible to unpack the assumptions upon which it is predicated and to test the assertions which it mak s. Consequently, it would be exceedingly difficult to make so particular a series of policies, let alone to administer them once made.

There is a third theoretical position which opposes the external control of science. It views science as a part, not a servant, of social purpose. And while this view is more widely held than explicitly articulated, in Canada is one of its most vigorous exponents, Nobel Prize winner Gerard Herzberg.(21) This theory holds that science is one of the most advanced forms of high culture. It sees the achievements, perpetuation and dissemination of high culture, including science, as an intrinsic purpose of society. Generally, this line of argument is taken as science-for-the-sake-of-science. As such it is instantly offensive to lay persons. However, interestingly enough, the reaction to the discipline-for-the-sake-of-itself argument varies in intensity with (i) the perceived potential of social utility and (ii) the involvement of public monies. Art-for-the-sake-of-art causes much less outcry than does science-for-the-sake-of-science. Moreover, scientists do not interpret this argument as meaning science has no relevance to the public, though it should be funded by it. Rather to them it means that (i) science has long term undirected practical benefits and (ii) intellectual and psychological benefits.

As material lacks are brought under control in even the most affluent of societies, people will still continue to be troubled by intellectual lacks. These intellectual lacks are neither dissolved nor generated by material lacks or fulfilments. No less ancient and venerable are intellectual lacks than material lacks. As long as people have experienced hunger, they have also experienced uncertainty of their place in the world, of the future, of the unknown, of other people, all of these latter being partly ameliorated by intellectual activity, by learning. Just as the first people looked to the soil for the material comfort of food, so too they looked to the sky for the intellectual comfort of some understanding of their situations.[22] In view of the widespread popular and academic concern with just such matters of the intellect surely no further comment is necessary for the purpose of establishing the basic merits of a case that could relate science to culture. Science would be one of the tasks by which people come to learn about and feel comfortable in their environment.

While parts of the first two theories opposing external control are occasionally advanced there can be no doubt that both generally and specifically in Canada the third is far and away the most significant. It is significant in the suspicion that it is widely though silently held. Yet this significance does not lend itself wholly to the purposes at hand, which are to examine the science policy debate. This view is seldom directly entered into the debate. It just is the case that the proponents of a science policy have set forth cases more clearly and more often and more loudly than their opponents. For this reason, first attention will be given to the pro science policy side.

3. CONTROL THROUGH FUNDING AND INDUCTION

To concentrate on the arguments advanced by the proponents of science policy, especially in Canada is to concentrate on monetary inputs, as argued earlier. There is reason to believe that a conception of science that permits or implies that science may be externally controlled through dollar inputs views science as an inductive activity. It is surely true that much of the cause in the decision to focus particularly on monetary inputs is the result of other considerations. Doubtlessly, one important other consideration is a feeling that the flow of dollars is easier to control than the direction of people and it has subsequent impacts on people anyway. Alternations in the capital stock involves less lag time than alterations to the personnel stock.

The belief is that capital and current investments will affect the products of science. As was stated above, this belief is predicated on the commonsensical presumption that dollars input affect the quantity and quality of the activity of science and that this will affect the quantity and quality of the products of science. A view so predicated is more than a little persuasive, especially so in a culture so materialistic as our own.

To be more than commonsensical, to be established, it would be necessary to show that dollar inputs control some aspect of science as an activity that is determinate of the products of science. And this would have to be shown in the face of the well known historical role of luck, accident and serendipity in science.

What then do financial inputs control? Well, as has been seen already, they control the quantity of scientific activity. That much is clear. Where there is more money invested, there will be a larger volume of activity. More experiments will be conducted. More laboratories will be constructed. More institutes will be opened. More students will be exposed to science. More students will choose to become scientists, all depending on how long and how widely the financial door is held open. That the presumption of such a linear relationship exists is all too clear.[23] While it holds for the activity of science, it does not hold for the product of science. Indeed, in a sense, whether explicit or implicit, it is the only presumption which makes sensible many of the advocacies of science policy in Canada. And this linearity is expected to manifest itself in the short run, not the long run. "In budgetary politics a short run is generally the winner."[24] Now as always, "government patronizes science for its utility."[25]

The commonly held conception of the activity of science, when combined with a preoccupation on monetary inputs, yields a conception of science which can only be called inductive.

Here the purpose is to show what the most common image of scientific activity is. It is the most common image in two senses, first, in the way of common sense, and, second, in the sense of the most widely held.

Even refined in this way, bringing evidence to sustain the plausibility of this assertion is no easy matter. Yet there is some evidence available which bears on the issue. Before turning to the evidence it would be advantageous to have a clearer idea of what an inductive conception of science would look like. Such preliminary clarity will prove especially useful when the evidence is examined, for that evidence will require a good deal of interpretation. This is so simply because is was not compiled for precisely the purpose at hand. Before beginning to interpret it, let us examine more thoroughly what the purpose at hand is.

4. INDUCTIVE SCIENCE

In the general way in which differing conceptions of science are being treated here three main types can be distinguished. They are: (i) hypothetico-deductive, (ii) eliminative induction and (iii) enumerative induction.

The hypothetico-deductive view gives pride of place to the hypotheses or premises of the activity of science. According to the hypothetico-deductive conception, a theory is hypothesized and its implication for observables are deduced. At the level of observables, aspects of the theory and the theory itself are tested against the facts for confirmation or disconfirmation.

> "If the theory holds, certain empirical laws will also hold. The predicted empirical law speaks about relations between observables, so it is now possible to make experiments to see if the empirical law holds."(26)

For the moment we need only notice here that the hypothesis precede the experiment.

A conception of the activity of science that could be called inductive elimination would be one in which it was permissible to assure that a particular scientific domain was known to constitute a finite set of known outer limits. The possible evidence and argument within those limits could then be sorted. On this assumption the activity of science proceeds as a process of elimination, slowly and surely.

Finally, an enumerative induction image would be one in which the activity of science builds from the bottom up. It is built from the bottom up so that: ". . . a conclusion about . . . the members of a class is drawn from premises which refer to observed members of that class."(27) Building from the bottom up is, by definition, atheoretic, systematic and painstaking. It is a thorough collection, sorting and examination of facts. Cumulating observations of members of classes is the method of this the activity of science. Cumulation rest upon the comparability of the observations amassed. Consequently, the scientist is understood to approach the activity of science methodically. This method proceeds slowly and carefully from the known to the unknown. It asks questions designed to be answerable so as to ensure smooth, well founded progress.

(4.1) <u>The Image of Induction and Textbook Science as a Source</u>

In 1957 a nationwide survey on the transmission of scientific information in the media was conducted in the United States by the Survey Research Center for the National Association of Scientific Writers.(28) Some of these data may be usefully brought to bear at the present juncture.

In Table 5.1 it can be seen that aspects of the activity of science that laypeople have learned to think of are those compatible with an inductive conception. It can be seen that thoroughness was the most frequently mentioned characteristic. There exists also an emphasis on method. In addition, mention was made of measurement and collection of facts. It is significant to notice that for this, an open-ended item, creativity, imagination, discovery, were not volunteered.

> "In the popular imagination these men of science appear as sober ice-cold logicians, electronic brains mounted on dry sticks."(29)

More specifically, respondents were queried about specific attitudes towards scientists. This was done with forced-choice questions. Of the six items, receiving the second-highest agreement was the statement "scientists work harder than the average person". The rate of agreement was 67%. No question about imagination, creation or discovery was asked, so no comparison can be made. It is of interest in itself, however, that the question went unasked. This omission forbids our learning directly about the public opinion, but it

TABLE 5.1

THE MEANING OF SCIENTIFIC STUDY

Thoroughness; studying it deeply, getting to the bottom of it.	33%
Analysis; taking it apart to see what makes it tick.	22
Method expressed; e.g., description of experimental method.	10
Open-minded approach; skepticism; suspended judgement.	4
Measurement stressed.	2
Exploration of the unknown.	2
Science is a collection of facts.	2
Other, miscellaneous.	11
Misunderstood the question.	5
Don't know.	27
Not ascertained.	3
	**
	N = (1919)

Note: Totals to more than 100 per cent because more than one response was given.

SOURCE: Robert Davis, *The Public Impact of Science in the Mass Media* (Ann Arbor: Survey Research Center, 1958), p. 183.

does say something about the opinion of opinion leaders, science writers. Had science writers been interested enough, room might have been made on the seventy-one item interview.[30] That no room was made at least gives one reason to believe that science writers do not feel a need to give emphasis to creativity. Certainly had the survey been about the image of art or music it would have been asked.

Finally, respondents were asked to indicate from a range which characteristics were most appropriately applied to scientists. Unfortunately, Table 5.2 does not speak for itself, since it was partitioned for other purposes and cannot be disaggregated. Still this much is clear: aspects of the activity of science that are of a piece with an inductive conception of science are emphasized, beginning with "studious, dedicated and methodical" which together yield 35%. On the other hand, creative is mentioned by 1% of the sample. Exploration was mentioned by 6%.

At approximately the same time as this nationwide random sample discussed was being conducted there appeared a more restricted study of the image of science. While this second study was more restricted it is, for some purposes, more revealing. It is more revealing because, it focused on the images held by high school students. It is in high school more than anywhere that conceptions of science for most of us are fixed for there is the last con~~tact~~ most of us have with science. Moreover, the particular set of students examined in 1956 are those now occupying the central age and

TABLE 5.2

PERCEIVED CHARACTERISTICS OF SCIENTISTS AS PEOPLE

Positive Characteristics	
Intelligent, brilliant, smart, high IQ.	37%
Educated, studious, highly educated.	23
Dedicated to work, hard working, methodical.	12
Creative, imaginative.	1
Exploring-the-unknown, curious.	6
Humanitarian, wants to help others, benefit mankind, sense of social duty.	7
"Normal", well-balanced, not different from average, same range of personality as everyone.	15
Miscellaneous positive traits or neutral description of characteristics.	21
No positive traits mentioned.	7
Don't know.	16
Not ascertained.	3
	**
	N = (1919)

Note: Totals to more than 100 per cent because more than one response was given.

SOURCE: Davis, *The Public Impact of Science in the Mass Media*, p. 188.

organizational positions in our society. This study too was conducted in the United States.(31)

The composite image of the activity of science, of what a scientist does, held that "hard work--not imagination--is the source of (scientific) knowledge."(32) It was felt that the work of the scientist was uninteresting, dull, monotonous and tedious, all of these adjectives indicate an inductive view of the method of science. Indeed, seemingly in recognition of this, the study notes several specific indications about the teaching of science on which the public image is based on good part. It was found that: (i) the present image of science lacks any sense of the delights of intellectual activity and (ii) it portrays science as passive, not active. This last point is worth underscoring. A passive science is an inductive science; it cannot be a hypothetico-deductive science. It collects existing data; it does not create data through (re-)conceptualization. Often Senator Lamontagne has referred to what he calls "the basic science" as passive.(33)

There exists a still more restricted study of relevance. It was conducted in 1970 for the Canadian Association, Physicists and employs the semantic differential.(34) While this study was confined to two Ottawa high schools, the evidence it gives when combined with the commonly known cultural spillovers from the United States provide more than adequate grounds for believing that the conception of science discussed for the United States is not inappropriately applied in the Canadian context. When compared to themselves these respondents saw scientists as slow, passive, calm and colourless. Once again characteristics more suitable to an inductive than to a hypothetico-deductive conception.

That an inductive conception of the activity of science does predominate over its rival should not surprise us. It is, after all, the image rather unselfconsciously emitted by scientists. Emitted by scientists in their teaching, their writing and their speaking, it is no wonder that this is the popular conception. There is an etiquette of scientific presentation such that theories or laws are presented in a crisp, precise and unproblematic fashion, seemingly moving up the ladder of induction from observation, to conceptualization, and to theory construction. This etiquette is most evident developed in the most well developed medium of scientific communication, writing.(35)

> "Scientific 'papers' . . . are notorious for misrepresenting the process of thought that led to whatever discoveries they describe."(36)

Visible science in the published context of justification seems cool, concise and methodical. Take the Nobel Prize winning nine hundred word letter of James Watson and Francis Crick to *Nature* on the DNA molecule.(37) It is sparse and taut. Watson and Crick state the problematic, report on their observations and offer a model, one that fits. Yet in Watson's forty thousand word autobiography the account of this project includes a range of interpersonal relationships, mistakes and dreams, all of which bore on the discovery.(38)

Many, if not most, outside observers of the activity of science forget that how one states a conclusion for colleagues is not necessarily how it was arrived at. A report of the outcome of an inquiry is like an iceberg in the activity of science. Only its upper part is visible in scientific writings. In this context the movement is methodical, from observation inevitably and efficiently to theory. What lies beneath the waterline is another matter.

When we laypeople as outsiders consider science we naturally look to scientific writings, or recall our own early scientific education. In doing so we encounter and are misled by this etiquette. That the activity of science is difficult to penetrate casually is neither odd nor unique. Every activity is Janus-faced.(39) It is one face which engrosses the actor. It is another which attracts the observer. Were this not so, an activity would not be of interest to an actor for boredom would soon set in, or an activity would be of no interest to an observer as confusion would result. In an intellectual activity like science, it is the detailed experience and knowledge derived from a domain of inquiry that commands the actor's attention. The observer of science is captivated by the general features of the activity, by far the most general of which is its methods. This leads the two to widely different conceptions of sciences.

Methodology often comes to occupy a more central place in the conception of science held by observers than by practitioners. Scientific methodology described by learned laypeople as they observe science "is not attended to by scientists" in the activity of science."(40)

In the most purposeful of scientific writings, textbooks, this distortion is greatest. Moreover, it is textbooks that reach the widest audience directly. Textbooks are statements of what a scientific community believes it knows. They display only the finished products of the context of justification. By the activity of science in the context of discovery such knowledge is created. This is at the frontier of science. The frontier of science is often unreported in textbooks.

Unfortunately for the purposes of clarity, many natural scientists do not appreciate this distinction themselves. This further complicates the conception of the activity of science that laypeople can be expected to develop. Many natural scientists do claim to do the activity of science by the book, but as Albert Einstein once said:

> "If you want to learn something from theoretical physicists about the methods they employ, I advise you to observe this principal: do not listen to their words, but confine yourself to their acts."(41)

It may be that even the most reflective scientists are not able to adequately explicate the activity of science, or explicate it differently than in the foregoing account. This must not lead us to doubt the conception here detailed. Such scientists, being deeply involved in and committed to the fine details of their activity, may be unable to see the forest for the trees. When speaking of method, they tend to fall back onto the commonsensical notion of scientific method, much as a layperson might. Mis-information may be at its greatest on this most important policy relevant issue.

More attention than the lipservice of a first chapter in a textbook must be given over to the creative side of science. This is a tall order. Even so elite a group as professional political scientists have been unable to understand the activity of science in this way. In the succeeding chapter the adequacy of the inductive conception will be examined. Political scientists will be referred to as an example of a lay group of people who have studied science but have been unable to distinguish the activity of science from its products, and are therefore unable to give full credit to the creative side of science.

Before passing onto these matters the more specific effects of the inductive conception of science on science policy needs to be considered.

(4.2) Inductive and Instrumental Science

The link between the desire for the control of science and an inductive conception of the activity of science is two-fold, there being a political connection of convenience and a theoretical one of justification.

Politically the connection is this. If external justification, then external control is implied. As soon as science is understood to be important principally because of its social benefits, it becomes eligible for and receives public funding. Inexorably, with funding from the public purse comes control from the watchdogs of the public purse, self-appointed or designated. The power of the purse is a most jealously guarded responsibility of government. To draw from the public purse is to draw, in addition to resources, attention and control, as the purse is attended and controlled. The greater the tap on the purse, the greater the attention received. By whatever intention funding started originally, control is inescapably turned to, even as it is now being turned to for science.

The budgetary process is in conventional understandings very much the political process. Because it is taken generally as the basic means by which to control the dependent activities, it is carefully considered. For every dollar invested an accounting is to be expected. This accounting is nothing else than a statement of what was done with that dollar, and what important and concrete results were achieved with that dollar which otherwise would not have been attained. Certainly, as the reports of those privileged to observe the workings of the Treasury Board when it was responsible for science policy show, this was the method applied in Canada.[42] And the first Minister of State for Science and Technology was apprenticed previously as the parliamentary secretary to the President of the Treasury Board, which suggests strongly that that method was at least partly carried over.

Of course, experiments and data collection and analysis and reduction could not go on without money, but thinking can. And in a certain sense to be made clearer later, the two are not synonymous and may even be mutually exclusive as activities.

All budgeting is to the extent possible controlled piece by piece, item by item. This control is annually reviewed. Arguments for science budgets do not rely on (i) claims to theoretical advances made or approached, or (ii) the cultural value of science, or (iii) the thinking that is to be done in the activity of science. Rather the experiments done and practical results are pointed to as what counts.

Equally, when a politician--known in the polite language of technocratic political science as a decision-maker--makes an onsite inspection the itinerary has and is expected to have more laboratories than libraries, more computer installations than coffee rooms and more hardware than software. This is because the hardware is less likely to be questioned by a layperson. It is big, impressive, concrete and busy. The software of science is ideas. The decision-maker is neither shown nor taught the importance of pencil and paper science, of theory. Consequently politicians exclude those softer, less predictable and tangible features of the activity of science from their conceptions of science.

Just as we give so great an attention to the material outputs of science, equally we give great attention to the material inputs. It is almost as if the attempt is to relate a discrete unit of scientific product, data or gadgetry, to a discrete unit of scientific input activity, indexed by a dollar sign.

Theoretically, the link is this. Only by trial and error can what it is that is useful be determined. Utility, instrumentality can be best attained from that science which is closest to the world. That science which is closest to the world is that science which makes the fewest assumptions about the world--that science which is based upon facts, not theories. And the science is of an inductive kind. To wit: instrumentalist philosophers are very likely to be inductivist methodologists: for example, Dewey, Bentley, Pierce, James and Meehan.

It is important to be clear about what is here claimed. It is that the two--instrumentalism and inductivism--have considerable affinities in their bases, representing the application of an essentially shared metaphysic and methodology to different levels of understanding. They have structural similarities in their logic, for example, in their incrementalist, trial-and-error approaches. These are affinities which are accentuated in the political context in which science has come to be placed.

In short, on this view the activity of science is controlled by the monetary input. Explicitly emphasizing the relationships of inputs in this way belies an inductive conception of the activity of science for it supposes that the results--the product--is, in a sense, inferred from the input, rather than created, and hence cannot be greater than what goes into it. The output will be neither greater nor smaller than the input.

5. CONCLUSION

Were science the product of just exactly what goes into it, and were what goes into it just money, then a science policy would be easy. As to possibility there is precedent for caution. Exclusive attention to inputs without appreciation of either context or process is all too common an occurrence.(43)

The conception of science discussed above is of course only loosely drawn. This is as it should be, for the conception at issue is that one which is prevalent in the debate and that one is loosely drawn.

A conception of science which turns on nearly an exclusive focus on induction is a conception to be treated with caution. It is a conception that misconceives the activity of science and perpetuates a false impression. When employed in advocacy it leads to a misselling of science. Science is missold as an activity easily controlled from the outside.

Science is not easy to control. It is not easy to control because it is not inductive in the fashion envisaged by the common conception of science. Of course, this is not to deny that science is partly inductive. The collection of data is an absolute necessity. Induction is a necessary condition for science, but it is not the sufficient condition.

By overlooking the creative side of science in the context of justification scientific problems are reduced to technological puzzles, matters of application. And matters of application are matters of money.

FOOTNOTES

1. D. Price, "The Implications of Theoretical Studies for Decision-Making in R and D Management", *Management of Research and Development* (Paris: O.E.C.D., 1970), p.263.

2. Jacob Bronowski, "Technology and Culture in Evolution", *Philosophy of Soci.l Science*, I (1971) 3, pp. 195-206.

3. Meadows, *et al.*, *The Limits to Growth* (Cambridge: Massachusetts Institute of Technology Press, 1970). Some of the pitfalls to a technocratic approach to technocratic criticism such as the *Limits to Growth* represents are discussed in M. W. Jackson, "The Limits to Growth: Ecological Stability and Political Activism", *The Gateway*, LXIII (22 March 1973) 45, pp. 6-8.

4. Price, "The Implications of Theoretical Studies for Decision-Making in R and D Management", p. 264.

5. On professional self regulation in technocratic society see Alan Davies, *Essays in Political Sociology* (Melbourne: Cheshire, 1972), p. 9.

6. Polanyi, "The Republic of Science: Its Political and Economic Theory", *Minerva*, I (1962) 1, pp. 54-73 and "The Autonomy of Science", *Scientific Monthly*, LX (1945), pp. 141-50.

7. Derek Price, "The Science of Scientists", *Medical Opinion Review*, X (1966), pp. 88-97 and his Statement in the *Hearings before the Subcommittee on Science, Research and Development of the Committee on Science and Astronautics*, United States House of Representatives, Ninety-first Congress, Second Session, 15-7 September 1970, No. 23, pp. 649-52.

8. Daniel Bell, "Notes on the Post Industrial Society, I", *Public Interest* (1967) 6, pp. 29-35.

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CHAPTER SIX

THE INDUCTIVIST METHODOLOGY AND SCIENCE POLICY

INTRODUCTION

It is easy to see why science can appear to be an inductive activity. Many of its outward features lead to that impression. And, as we have seen, there is evidence that it is so seen by the populace generally and even by more specialized groups who attempt to learn of science, e.g. social scientists.[1] An inductivist conception of the activity of science is associated with an instrumental view of the products of science for it seems to allow the activity of science to be controlled for product-selectivity. For this reason it was given expression by the politician Bacon. Whether this inductive concept is properly applied to the activity of science is an empirical question in a certain sense. Whether operating from an inductive conception leads to enhanced or diminished attainment of product goals is a question of fact. Unfortunately, it is a question of fact in such a way as to make its empirical resolution unlikely. The way in which it is an empirical question is in a comparison to a non-inductively based science policy operating in a like circumstance. Such a social experimentation is not available.

However, a considerable body of knowledge which bears on this question is available. This will be the focus of this chapter. Specifically, an inductive conception of the activity of science will be discussed as to creativity and then with respect to implications for presumed job motivation. The first rests on a number of philosophical points; the latter on a number of sociological ones.

In the pages which follow four main points regarding the activity of science are discussed. (1) The conception of the activity of science held by methodologically conscious political scientists is explicated and criticized from a philosophy of science perspective. Political scientists are chosen as an example of informed, lay understanding of the activity of science. (2) Next, the social system of science is considered. The emphasis on the sociological accuracy of the lay inductive and instrumental ideas previously surfaced in a general way, particularly in Chapter Five. Part (3) considers the idea of legislating science. The last and concluding part (4) considers the idea of there being a middle ground between the extremities of the science policy debate.

1. THE POLITICAL SCIENCE CONCEPTION OF THE ACTIVITY OF SCIENCE

This discussion of the idea of science held by political scientists breaks its explication and critique into two parts. The first introduces and focuses on creativity in the activity of normal science. The second introduces and considers the process of justification in the normal activity of science.

The character of science has been understood to be methodically technical by the relatively specialized group of social scientists. Many of even these highly trained and skilled observers construe natural and physical science as methodical induction. To see let us need consider one prominent example.

Heinz Eulau, political science editor of the International Encyclopedia of the Social Sciences and a past president of American Political Science Association, has held repeatedly that:

> "A science . . . that deserves its name must build from the bottom up by asking questions which can, in principle, be answered; it cannot be built from the top down by asking questions that, one has reason to suspect, cannot be answered at all, at least by the methods of science."(2)

In this passage is found a clear and familiar indication of an understanding of the activity of science. The distinguishing characteristic of science for Eulau is procedural, methodical. Questions must be asked, he says, so that they may be answered "by the methods of science." Was the answer--whatever it is--originally achieved in response to a question which was phrased so as to be answerable by the conventionally accepted scientific method? This is Eulau's first question. Only then can an answer be accepted as scientific. To Eulau and to the not small group of lay people and professionals who harbor similar views, the achievement of theory is based on an empirically focused scientific method.(3) Progress is slow. Data are accumulated until a threshold is reached. When enough data have been assembled to devise and test a generalization, a law is formulated. In the same way, generalizations are cumulated and merged into even greater generalizations, or theories.

This view of the activity of science as methodical is common-sensical. In it, as in all commonsense, there is much truth and some falsity. This view of science may be translated from a commonsense rendering to the logical status of induction.

There are, as pointed out earlier, three logics which the activity of science might follow: deductive, eliminative induction or enumerative induction. The idea of attaining theory by building from the bottom up as Eulau has described it is not deductive in its reasoning. Deduction begins with generalizations and is based on the form of argument.(4) Conversely, Eulau begins with facts, the content or arguments.

Neither is his notion of theory construction inductive elimination. To be eliminative induction, it would be necessary to assume that the domain of interest to a scientist is a finite set and the fact that it is a finite set is known to the scientists at the outset.(5) Under such circumstances, a scientist could proceed by the process of elimination. Eulau's position is not compatible with eliminative induction. Eliminative induction requires assumptions about the subject under study, namely that it is a finite set with known parameters. Avoidance of such assumptions is precisely what Eulau wishes to achieve. Assumptions may be erroneous, but facts never are. It is facts, not assumptions, that Eulau has in mind when he speaks of an empirical discipline building modestly from the bottom up.

In inductive enumeration "a conclusion about . . . the members of a class is drawn from premises which refer to *observed* members of that class."(6) Here there is movement from particular cases to generalizations, as it were, building from the bottom up. Facts precede theory and build into it. Observations are accumulated and low-level generalizations formulated. A generalization reached in this way is either a universal generalization that extends to all members of a class or a statistical generalization that refers to a certain percentage of the membership of the class.

The cumulation of observation that eventually yields generalizations requires the comparability of the data. Comparability is attained through the application of method. Accordingly, a scientist proceeds slowly, carefully, rigorously, laboriously--in short, methodically. This is the conception of the activity of science implied by inductive enumeration. It is a conception wholly in keeping which the general perceptions of science by the populace and by policy makers described in Chapter Five.

Although a variety of competing and conflicting positions exist under the rubric of philosophy of science, nearly all seem agreed on some basic points which bear heavily on the matter at hand. First amongst these is the analytic distinction between the contexts of discovery and justification. This distinction parallels that between the activity and the product of science for it allows a separation of the argumentative and creative aspects of sciences.

This distinction is generated by the "well-known differences between the thinker's way of finding his theorem and his way of presenting it before a public."(7) Scientific discoveries occur as a result of the subjective variable of the imagination and genius of the scientist. The vehicle of this subjective dimension is the "many abbreviations and silently tolerated inexactitudes" in any scientific language. Inexactitudes not admitted in the precise enumeration induction account. Indeed, there are so many of these inexactitudes "that neither an inductivist nor a logician will . . . be fully content with" it.(8)

Thinking in science is of two kinds. One is "the form in which thinking processes are communicated to other persons." This is the context of justification where the finished products of science are inspected in routine, normal ways. The other kind is the "form in which thinking processes are subjectively performed."(9) This is the context of discovery. It is here that creative activity of sciences goes on. Being creative, it cannot be routine or normal; it is abnormal, frontier science.

In the context of justification rules of argument obtain, but not in the context of discovery.

> "The act of discovery escapes logical analysis; there are no logical rules in terms of which a 'discovery machine' could be constructed."(10)

Integral to the activity of science is an implicit dimension, which allows for the unusual and the creative.

A typical scientist surely engages in both kinds of thinking and activity in the course of a day's work. It might be exceedingly difficult to put a particular behavior-item unambiguously under one heading or the other. This should not bother us or lead us to doubt the distinction. All that is claimed is that any informed view of science must include considerable emphasis on the context of discovery.

As can be seen, it is in the context of justification that the motion of scientific method is sensible. However, it is not sensible in the context of discovery.

(1.1) <u>Discovery in Abnormal Science</u>

That it is not sensible in the context of discovery can be concluded from no less than three philosophical explications of the activity of science. These three explications will be brought to bear on the inductive enumeration account of the logic of the activity of science. First there is the character of observation in the so-called natural sciences.[11] What is the grist of the inductive mill? Second, there is the translation of what is observed to more removed levels of abstractions. Observations are related to theory and vice versa. Third, there is the nature of theory-making itself. How is a theory made?

What is the character of observation in science? It is Norwood Hanson's thesis that "given the same world, it might have been construed differently."[12] A multiplicity of acceptable descriptions exist for any state of affairs. This multiplicity exists for both the classroom examples of the vase-two faces profile and the world. Varying interpretations are a product of the subjective dimension in the context of discovery. "People, not their eyes, see," Hanson writes, for:

> ". . . rentinal reactions are virtually identical, so too, are our visual sense data. There is no place in the seeing for the differences, so they must be in the interpretation put on what we see."(13)

For example, a newspaper headline can then read "A Scientist 'Saw' What Others Suspected", in noting the award of a Nobel Prize in chemistry to Gerhard Herzberg of the National Research Council.(14) Herzberg saw in the available evidence what others had only suspected. In still other cases, like the famous legend of Sir Isaac Newton sitting under an apple tree, scientific discovery is the result of good luck or serendipity.(15) Facts do not precede inquiry, though it is precisely this which enumerative inductive supposes. How could inquiry begin with the simple observation of facts? In short, "in physics", says Stephen Toulmin,

> ". . . it is no use even beginning to look at things until you know exactly what you are looking for: observation has to be strictly controlled by reference to some particular theoretical problem."(16)

No scientist does unplanned experiments. And only unplanned experiments conform to the ideal of unjaundiced inductive observation.

Not only is the status of observation itself questionable, in addition not all of the language of science is composed of references to observables. It is not wholly defined operationally or empirically. Due to systematic requirements of a theory, some scientific terms cannot be entirely defined operationally.[17] Such terms have been given a host of names including hypothetical constructs, theoretical constructs and theoretical concepts.[18]

Theoretical concepts are, according to Carl Hempel, "presumptive objects, events . . . which cannot be perceived or otherwise directly observed by us"[19] even on a broad definition of observation such as that used in contemporary physics.[20] Though a part of the meaning of such concepts is stated in terms of empirical references to observables, it is only a part and not the whole. The remaining meaning of a theoretical concept is reduced by reference to its context in a theory and the systemic requirements of consistency and simplicity.

Theoretical concepts are required if theoretical laws and theories themselves are to be achieved.[21] Empirical laws, like induction itself, are inherently limited to constitutive data. Theoretical laws are not so limited; they are more comprehensive. This is the difference between "wood floats on water, iron sinks in it" and "a solid body floats on a liquid if its specific gravity is less than that of the liquid." Theoretical concepts connect observables which are unconnectable observationally.

The stipulation of the theoretical part of concepts is difficult and requires decisions by scientists over and above the fact.

Scientific theory may, therefore, require going beyond what is known, taking the risk of asking questions whose answers are not known beforehand. "If one knew what questions could be answered, one would not need to ask them" since one then would implicitly know their answers.[22] To ask questions that are known to be answerable is contradictory. They would already be answered in principle. Consider the example of an invention, say, the corkscrew.

> "If it were possible for that invention - for it to be announced prior to ten p. m. on 1 March 1650, that a particular man would invent the corkscrew - then the observer who made this prediction would be the first person to announce the invention of the corkscrew. But if he knows about the corkscrew before the 'inventor' has invented it, he, the observer, must be the true inventor . . . neither creative work nor inventions are in principle predictable."[23]

Not only must the risk of unanswerable questions be entertained, but also the risk of speaking in a language which is only partially grounded in observables.

Further, advances in scientific theory construction are not the process of an inevitable and smooth unfolding. "No theoretical law was ever found" by collecting data and generalizing beyond empirical laws "until we reach theoretical ones," maintains Rudolf Carnap,[24] directly denying the inductive enumeration conception of the activity of science.

As a satisfactory theoretical account of the method of scientific theory construction, enumerative induction was rendered its classic criticism by David Hume. His argument was that there can be no sufficient reason for us to assume "that those instances, of which we have had no experience, resemble those of which, we have had experience."(25) Put differently:

> ". . . premises about observed instances of empirical predicates never entail generalizations or predictions about unobserved instances of those predicates."(26)

Hume's reasoning is very simple. No contradiction exists between maintaining that "All A's thus far observed are B's" and "Some A's yet to be observed are not B's." We do not wait passively: "for repetitions to impress or impose regularities upon us, we actively try to impose regularities upon the world."(27) On this view it is possible to understand that our attempts to force interpretations on the world are logically prior to the observation of similarities. Theories precede facts. In science "freedom from bias means having an open mind, not an empty one."(28)

A caveat is now in order. The claim that "theories precede facts and facts do not precede theories," like its opposite, is an exaggeration. Neither claim--that theories precede observables or that observables precede theories--is true. Science is [illegible] rule-bound as to be always and inevitably one or th[illegible] And that is the point. The relationship bet[illegible] observation is dialectical. The activity of science is not rule bound. This is so true that even Hume's argument against induction does not bind.

Clearly for Hume his anti-inductivist argument demonstrated a logical or philosophical limitation, not a practical one. Inductive inference goes on all the time; this is clear. It is no less clear that each inductive inference cannot be predicted.(29) Induction happens. How it happens is not clear. How then can the activity of inductive inference be regulated? How can what cannot be expected be required? Here the role of science policy seems unclear.

(1.2) Justification in Normal Science

Having examined the context of discovery of abnormal science, we may now consider the context of justification of normal science. Here the notion of scientific method and hence inductive enumeration has a place. It is a place in the products of science, not in the activity of science. It is the persuasion of one's professional colleagues through justification that rightly demands methodicalness.

> "Scientific discoveries do not consist only in arguments which are plausible *ad hominem*, but rather in explanations which will stand on their own feet before one's scientific colleagues."(30)

In a dream or through induction by enumeration a law or theory may occur to the scientist. This counts not at all. What does count is the truth of the law or theory. This is determined by testing it against the facts and the competing theories and by no other means. Discovering a theory inductively is possible but it is not in itself the whole process. It is not the justification for it. Justification requires testing, and testing makes different demands than discovery.

In testing, a theory is hypothesized and its implication for observables are then deduced. At the level of observables a theory is then tested against the facts for confirmation or disconfirmation. Says Carnap:

> ". . . if the theory holds, certain empirical laws will also hold. The predicted empirical law speaks about relations between observables, so it is now possible to make experiments to see if the empirical law holds."(31)

This involves empirical confirmation of the theory (1) in terms of its own requirements and (2) as compared to alternative, competing theories.(32) It is thus that a theory can be simultaneously deductive and empirically sound. At the non-observable, theoretical level a theory is tested against competing theories in terms of prior probability, breadth, consistency and simplicity.(33) In its bare bones this is the hypothetico-deductive method.(34)

At this point it can be seen that, once more appropriately and humbly attired, the notion of an inductive scientific method does have a place in understanding science. That place concerns the form of argument used in scientific communication and the procedures for testing these arguments. Because the advocates of science policy are largely lay people it is these communications, these products of science, to which they have looked to learn of the activity of science. What is to be learned from the activity of science in so doing is the truth, but only half of it. And it is a half-truth which becomes unacceptable when stretched from the product to the activity of science. A commonsensical notion of scientific method is important in understanding science, but it is not, as so many advocates of science policy would have us believe, the whole of science.

2. THE SOCIAL SYSTEMS OF SCIENCE

The following selective examination of the social system of science takes up three issues deemed to be of relevance to science policy. They are (2.1) the motivation of the scientist, (2.2) the duplication of scientific effort, and (2.3) the survival of excellence alone. Each issue is subjected to a critical analysis.

(2.1) Motivation

The incrementalist inductivist account of the activity of science is not philosophically adequate. Not surprisingly, neither is it sociologically adequate. Its implications for policy are no more sufficient in their context than is the inductivist theory in its own context. Specifically, its implications for the external control of science are not adequate. Because the stretched inductivist view misconceives the justification for the activity of science, it also misconceives the motivations for undertaking the activity. Having misunderstood the manner of the activity, it misunderstands what influences the manner.

The approach to the stimulation of specific research that operates in tandem with the inductivist theory is one in which the focus is on the motivation of scientists. So far, so good. In this focus the assumption is made that the activity of science is like other familiar activities, such as driving a cab, inspecting gas lines or making a door, and hence that the motivations to engage in it are no different. Basically in our society this is a long way around saying monetary. Directly in answer to the question of how external control was to work, Senator Lamontagne said: through the market forces of dollars.(35) The presumption is that if a higher salary will lead a person to drive a truck instead of a cab, then a higher salary may lead a person to this kind of science rather than that. This presumption once rose to the level of a public controversy in the nation's capital, as we have seen. A Civil Service Commission proposed treating the hirings of scientific staff at the National Research Council in the normal way, ending its exemption from public service conditions.(36) There followed a course of CBC lectures by E. W. R. Steacie, then President of the National Research Council, in which his opposition to the proposal was stated.(37) Later, the head of the Commission replied.(38) More forcefully, though less specifically focusing on hiring, the clarion call that government science be run in a businesslike manner received its most influential presentation from that captain of industry and poetry, John Glassco.(39) Normal motivation is thought to be materialist and hence monetary. No reason--like creativity--is seen for distinguishing science from normal activities.

This belief in the efficacy of monetary reward survives despite the long extant evidence that science is not an activity like the rest and that scientists are not actors like the rest. A 1953 study by the United States Bureau of Labor Statistics found that for most scientists the primary requirement in a job was challenging work in their own field of specialization.(40) Science requires creativity and that is not so common a characteristic.

More specifically, consider data collected by N. W. Storer by questionnaire on the motivation and attitudes of 88 research workers in a major state agricultural station in the United States.(41) The questionnaire was self-administered and the response of 88 represents 77% of the 110 scientists polled. Storer differentiated the scientist as basic and applied with a three-item, Guttman-type scale. The scale addressed the orientation of the scientist, by inquiring whether the scientist would prefer to report findings in a professional or a popular journal, whether she preferred to work on problems important to the farmer and the processor or to contribute to the development of the corpus of scientific knowledge, and how important the opportunity to serve people was to the respondent. Application of the scale to the questionnaire results allowed the classification of twenty applied and twenty-eight basic scientists. The purpose of examining Storer's data is this. It reveals considerable differences between applied scientist and basic scientist. If so great a gap exists between these two allies, still greater a gap seems likely between scientists and lay people. Moreover, the pattern of the differentiation is one in which applied scientists approach the normal portrait of motivation. Not so for those called to the activity of basic science.

Only half of the applied scientists are attracted by the content, the activity of science. On the other hand, fully three-fourths of the basic scientists are captivated by it. This is to be seen in Table 6.1. Already it can be seen that the paths to the respondents' present careers have been different.

Motivation on the job is addressed by Table 6.2. Here the respondents reported the stage of research in which they found themselves most interested. There emerges once again a clear difference between the two groups. A greater personal involvement in their work is indicated by the basic scientists the applied scientists--more than twice as much.

Finally, in Tables 6.3 we see that for these applied scientists, who derive less satisfaction from their work as an end in itself, salary is much more important than it is for the basic scientists. Indeed, the cash nexus is selected by only one-fifth of the basic scientists. Rather than seeking satisfaction from the material proceeds of the task, scientists tend to seek to identify themselves with what Storer calls, in later research, the social system of science. They attain from that system recognition and prestige which they value more than money. Hence 70% of these basic scientists felt more in common with a distant specialist in the same field than with

TABLE 6.1

MOTIVATION TO A SCIENTIFIC CAREER

Cited as most Important Factor	Applied Researcher		Basic Researcher	
	%	N	%	N
Content (e.g. interest in content of field)	50.0		75.0	
People (e.g. influence of a teacher)	20.0		18.0	
Practical (e.g. opportunity for employment)	30.0		7.0	
	100.0	(28)	100.0	(28)

SOURCE: N. Storer, "Research Orientations and Attitudes Toward Teamwork", *Institute of Radio Engineering, Transactions on Engineering and Management*, IX (1962), p. 31.

TABLE 6.2

MOTIVATION ON THE JOB

	Applied Researcher		Basic Researcher	
	%	N	%	N
Reported as highest or last point of interest in the research process. "When I have integrated these findings into some 'larger picture for myself' and 'never lose interest'"	21.0	(19)	54.0	(28)
Report that it is 'very important' or 'or utmost important' to 'see in a concrete way just how good or useful my work is'	84.0	(19)	50.0	(28)
	*		*	

Note: Totals do not attain unity because the answers were not mutually exclusive.

SOURCE: Storer, "Research Orientations and Attitudes Toward Teamwork", p. 31.

TABLE 6.3

MOTIVATION BY INCOME

	Applied Researcher		Basic Researcher	
	%	N	%	N
Reported that it is 'of utmost importance': "good salary--earning enough to make a good living"	60.0	(20)	21.0	(28)

SOURCE: Storer, "Research Orientations and Attitudes Toward Teamwork", p. 31.

a person at hand with different interests.

The social system of science is as complex as any societal subsystem. Consequently, only parts of it can be sketched here. Its full presentation and elaboration would require a book itself. Fortunately, several such books exist and need only be summarized.

The social system of science is based on exchange, as all social systems are based on exchange.[42] Creativity is the basis for the exchange in science.[43] Scientists are compelled to communicate their findings and ideas to those few others who can understand and appreciate them, even if these others are imaginary readers in the future.[44] Scientists are eager to do this so as to achieve recognition and, what is more important, reinforcement of their scientific identity, reassurance that their best efforts are indeed valued.[45] It is for this reason that there exists a very considerable race for priority in making discoveries.[46] Because the scientist is reporting "a truth that lives outside himself," speed is all the more important.[47] Colleagues who can validate one's claim may also pre-empt it if one is not careful. The importance of one's colleagues, and hence of the scientific community which they together represent, is indicated by the fact that one of the severest criticism which can be made of a physical scientist is that of being a poor correspondent or that of being uninterested in the work of others.[48] The exchange of the social system of science is by communication.

> "Too many questions from 'outside' will disrupt the universe of discourse upon which the social system of science is based . . ."(49)

It is precisely the external injection of questions that national science policy proposes. This is an injection that could strain some crucial seams of the activity of science unless done with exceeding care. As we shall see, care and moderation are not the principal characteristics of advocates of science policy; eagerness is.

That money is not a guarantor of creativity has been more recently evidenced by an experiment conducted by Professor C. R. Viesti, Jr., of the University of Victoria.(50) In an insightful, creative learning task, subjects did not perform significantly differently in pay and no-pay situations. Nor did increasing the amount of money differentiate the results. Performance was affected only by prior experience with the materials involved in the task.

> "These results indicated that insightful performance by humans can be facilitated by increasing familiarity with the task but not by presentation of *external* rewards."(51)

(2.2) Duplication

One battle cry of the advocates of science policy in their never ending millenarian pursuit of efficiency is duplication. Thus it is easy to find newspaper headlines that read "Avoid duplicated research",(52) or "Money, efforts wasted in duplicate research".(53) The idea of duplication in research is one which can reveal much about allied conceptions of the activity of science. The eradication of duplication of effort has been made a goal by more than one investigation of science policy.(54)

Duplication discussions usually consist of the claims that duplication exists, that it is wasteful, and that its end would usefully rechannel people-power.(55) Duplication is understood in its commonsense meaning. The sums of money involved are often thought to be considerable. They are not, as shown by some comparisons made in Chapter Four and still others made in Chapter Five. However, that it is untrue may be the least significant aspect of this claim. Of far greater significance when writ large is the simple emphasis on the monetary dimension. It obscures what should not be obscured. Namely, what is duplication?

The presence of the same equipment at two universities does not imply that the same work is being done at both places. Still less does it mean that the same people are involved with both. And this is an important point. Science is an activity of people, a creative one. The unit of analysis to which that creative activity can be reduced is the scientist, not the machine or the project.

Even if the same work were being done at the two installations, this does not mean, as the history of science seems to document conclusively, that the same results, let alone experiences, will issue. Different scientists often will see the "same" things in importantly different ways. The determination of such occasion is the key to much of the dynamics of the social system of science, but they cannot be foretold. Thus some classical discoveries like that of penincillin mold by Fleming occurred from puttering around.(56) After the discovery is made it may not be appreciated, even by the discoverer. Thus, Rutherford himself dismissed the idea of atomic energy as "talking moonshine."(57)

Moreover, if the results were identical, the different personnel involved in the two locations would have gained new experience, thereby qualitatively improving the labor stock. Application of the word "duplication" depends on what one supposes to be the proper product of science and the actual activity of science. Such suppositions may be erroneous.

Nor is the fellow traveller of duplication, waste, any easier to conceptualize. Does waste occur when a project shortfalls on its goals? Is the totality of the effort to that point definitely without fruit?

That many errors are made in the activity of science is all too plain. Countless projects, plans, theories and ideas die at one stage or another of their incubation, despite what are often herculean efforts by scientists to bring them to life. They die because they are untrue, according to the existing state of knowledge.

Finding out what is not true by testing is central to *do* science. Eliminating conventionally accepted ideas when they can be shown to be false is progress of a kind all too rare.(58) Knowledge of what is not true can provide, moreover, a perspective which may allow the truth to be discovered.

In short: duplication in the activity of science does not imply duplication in product. This is true whether the product is narrowly conceived as a specific discovery or widely as the learning of an inquirer. Whatever the activity of science is, it is not neat. For example, historians of science can seldom pinpoint the exact time and place of a scientific discovery. A single discovery is something of a process which exhibits a structure and extends over time.[59] Thus, duplication is not always easy to identify. The act of creation is not always definitive, or if it is, it may not be recognizable as that. Hence the community of science devotes much of its effort to sorting out conflicting claims to discovery. What is more important here is that discovery is something that has to be sorted out.

Basically, the pattern of this social system of science suggests that the:

> ". . . scientist, unlike the inventor, requires for his work a deep immersion in a pre-existing tradition. Such a tradition, acquired through professional training, informs him of the unsolved problems confrinting his profession and tells him what will be acceptable as solutions to them. Without an immersion in that tradition he could scarcely operate as a scientist at all."[60]

(2.3) Excellence Alone

The activity of science is as much a community as an individual activity. Yet the Senate Special Committee on Science Policy has recommended that excellence alone be supported in scientific research.[61] The question is: can excellence survive alone? Could Gerhard Herzberg have done the work that led to his achieving the recognition of the Nobel Prize without being surrounded by chemists and immersed in chemistry? Had he been the National Research Council's solitary chemist, would he have been able to achieve excellence? It seems unlikely and would surely have to be proven, for commonsense indicates that a person with no one to talk to about ideas cannot develop or elaborate those ideas as well as one who could. This is, after all, part of the historical conception of joining the teaching and research function of universities.[62]

Moreover, a principle under the application of which excellence alone is established self-defeating. If only established excellence is supported, from whence will new excellence emerge? In science this is no small question, since creative science is very definitely a young person's game. In physics a young person's research paper is more often accepted for publication than that of an older scientist.[63] Not only will new cohorts of excellence be lost, but also much valuable work would be lost by the support of established excellence alone.

3. CAN SCIENCE BE LEGISLATED?

The preceding discussion of the sociology of science is focused on the middle and lower level units of analysis. Supporting evidence for the picture emerging there can be found at the macro-level too. At the macro-level the market for inputs in research and development is a world market, not a series of national markets. The quality of qualified scientists and engineers and hardware is determined by international standards. They all went to a few schools and studied the same subject in the same way. All the hardware is manufactured according to common principles by a handful of companies. What differentiates national research and development efforts is not the quality, but rather the quantity. The absolute level of research and development is the key.(64)

Hence, advocates of Canadian national science policy do give primary emphasis to quantitative changes in the levels of investment, namely the percentage of the gross national product devoted to research and development and the percentage allocation of that sum by the various sectors and categories of research and development. Central amongst the recommendations of the Senate Special Committee is one on the percentage levels of the gross expenditure on research and development.(65) Here the recommended level is less important than the manner in which it was derived. It was derived by comparison with other nations thought to represent a desirable state of technology and economic dynamism. Naturally, this level is one approximating that of the United States. Targeting for it leaves the distinct impression that quantitatively similar research and development expenditures will be associated with similar technological and economic expansion. As we have already seen in Chapter Four, the evidence for this claim is indistinct.

Not only must the claim be resisted on the basis of the available macro evidence. It must also be resisted because it overlooks the effects of absolute quantities of purchasing power by concentrating on the relative quantity of percentages of the gross national product. Three percent of Canada's gross national product does not even approximate three percent of that of the United States. Neither does ten percent.

Attached to this first claim of the Senators is a second. While it will be treated thoroughly in the next chapter, it is appropriate to anticipate some of that discussion now. Cognizant of the ultimate difficulties in comparing levels of spending across gross national products leads the Senators to a second recommendation. It is that industrial-developmental research should be accentuated in the foreseeable future while university-basic research should be held at its present levels. This second claim is advanced on the basis of the belief that Canadian investment in university-basic research is disproportionately high. This claim will be criticized in the following chapter.

Even if the claim were beyond question, it would still be problematic as to whether it would issue in the recommendation(s) of the Senators, for external control of the balance between parts of science may not be possible.

Before treating that question there is a prior issue to be considered. It is the Senators recommendation that university-basic research be left unplanned and allowed to advance though not as rapidly as industrial-developmental research.(66) As it stands, this recommendation admirably supposes that both basic and developmental research should advance, that there is not an either/or choice to be made between the two. Pleasant though the presupposition is, it is unwarranted. It is because government is interested in saving money that it is interested in the prospect of a science policy. Hence, if in the course of arguing for such a policy university-basic research is shown to be less worthwhile than other forms of the activity of science, it will surely fall on hard times. As early as April 1973 it was claimed by a number of physicists that this had already happened. They held that government funding for basic university research was being allowed to decrease by the simple expedient of not compensating for the inflation factor.(67) "The promise that planning would leave unplanned activities unaffected . . . is altogether specious."(68)

If it is believed that there are concrete reasons to value science and to plan it, then the vague cultural values of basic science will not long survive. Either basic science will be eliminated or it will be planned. Certainly, there is no reason to assume that basic science will be respected in Canada. In the Canada Patent Act the only reference to science is preceded by the adjective "mere". This is in a brief paragraph primarily attending to inventions for illicit purposes, and illicit inventions are mentioned first, seemingly being taken to be more important than a "mere scientific principle or abstract theorem."(69)

> "Toutefois, il est clair que le governement fédéral ne peut pas accorder le même appui à tous les domaines d'activité scientifique mais doit adopter une politique selective et concentreé."(70)

Naturally, such selective concentration will favour those parts of science thought to be the most valuable.

Is the manipulation of the balance between various types of scientific activity possible? Perhaps not,

> ". . . there seems to exist some general minimum of science that it is difficult to transgress so that there is a rather well-defined lower limit for scientific size versus economic size of the group in the case of all nations."(71)

This is because, as we saw earlier, the activity of science is contingent on an elaborated and dynamic community of science. One part of science depends on other parts, and growth in one part cannot outstrip growth in all other parts. "Above all, there is in the field of science a cumulative accretion of contribution that resembles a pile of bricks." Every researcher in each field adds bricks to the whole interlocking pile.(72)

In a world of conflicting ideologies there have been many attempts to exploit basic science for the achievement of partisan goals by concentrating on exploitable innovations but not research and the like.

> "Strangely enough, these surmises are not true. The game of basic science is played according to the same rules by almost all participating nations."(73)

This can be illustrated by taking up the examples of physics and chemistry.

At the outset it would seem that more advanced nations invest more in the activity of science. Further investigation by Price shows that "an overwhelmingly large component of such expenditures is accounted for by the cost of development work . . ." Development work in aviation and electronics for the design and construction of prototypes for military projects. "The expenditures thus reflect the size of the military production budget rather than scientific activity in the nations concerned."(74)

Price's data in Table 6.4 yield a Pearson equal interval correlation coefficient between proportion of the world's Gross National Product and the world's physics papers of +0.79, as shown in Table 6.5. The Spearman rank order coefficient is +0.87. Between the Gross National Product and chemistry papers the Pearson value is +0.86, while the Spearman is +0.95. In this case, use of rank order data assumptions reveals a clearer relationship than equal interval assumptions. The coefficients of concordance are +0.74 for physics and +0.52 for chemistry. Hence for physics the regression equation based on a Pearson matrix is .95326 GNP + 1.2702.(75) For chemistry it is .92944 GNP + 0.84945. The high intercept values indicate that science may follow economic level, not cause it. A high intercept indicates a high economic level before science enters the equation. In both cases the Canadian residual is definitely below the regression line, physics -1.511418 and for chemistry -0.694414.

The relationships are indeed impressive. Especially so, for according to Price the scientific strengths so measured

TABLE 6.4

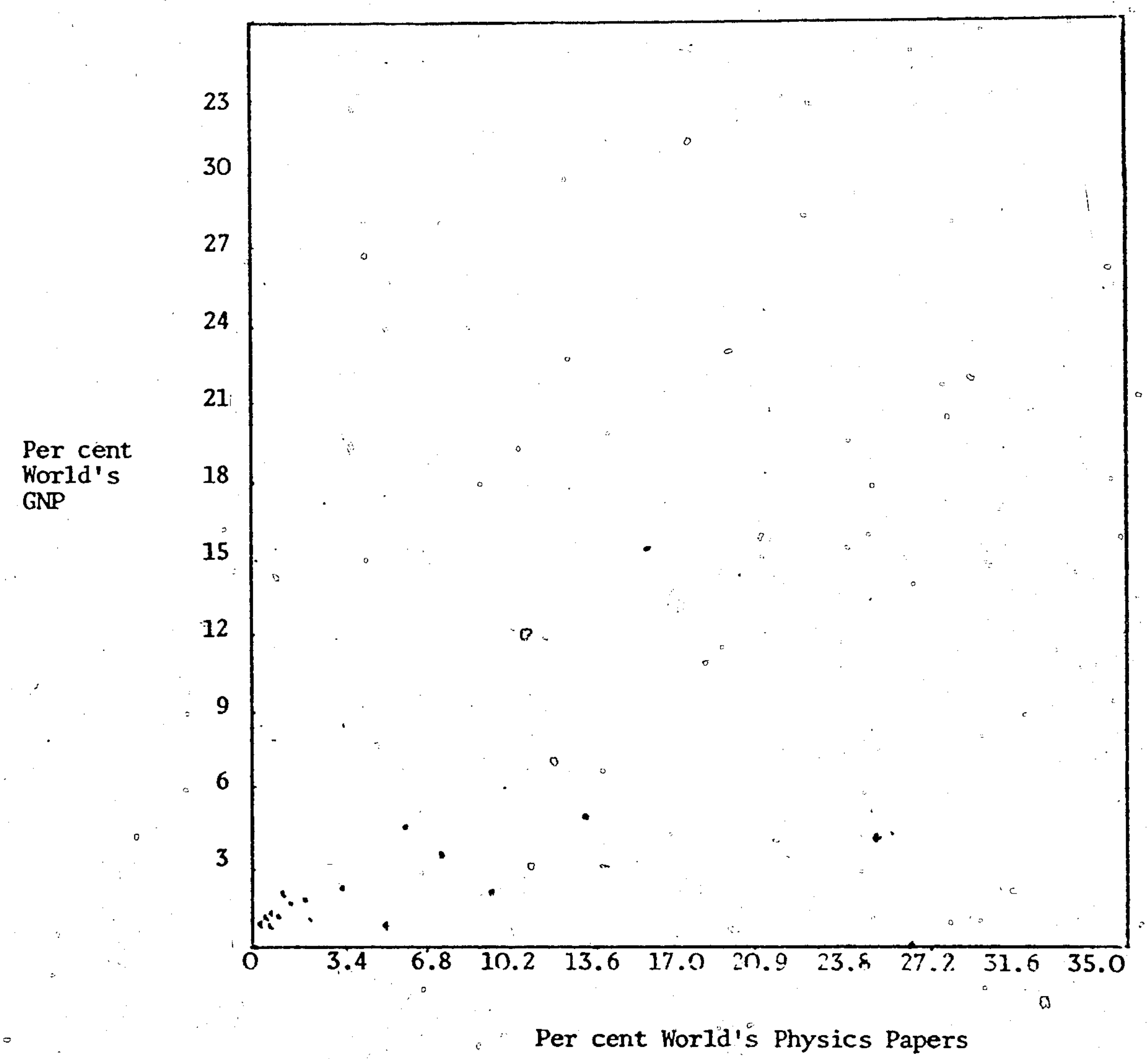
WEALTH AND KNOWLEDGE

Country	Percent of World's GNP Produced (1964)	Percent of World's Physics Papers (1961)	Percent of World's Chemistry Papers (1965)
United States	32.8	31.6	28.5
U.S.S.R.	15.6	15.6	20.7
W. Germany	5.2	6.2	6.3
E. Germany	0.8		2.2
United Kingdom	4.8	13.6	6.7
France	4.5	6.3	4.5
Japan	3.6	7.8	7.3
Italy	2.6	3.4	2.7
Canada	2.2	1.1	2.0
India	2.2	1.8	2.2
Poland	1.6	1.5	2.4
Australia	1.1	0.5	1.2
Romania	1.0	0.6	0.9
Spain	0.9	0.2	0.4
Sweden	0.9	0.7	0.9
Netherlands	0.9	5.2	0.8
Belgium	0.8	0.3	0.6

SOURCE: Derek Price, "Nations Can Publish or Perish", *International Science and Technology* (October, 1967), p. 86.

Figure 6.1

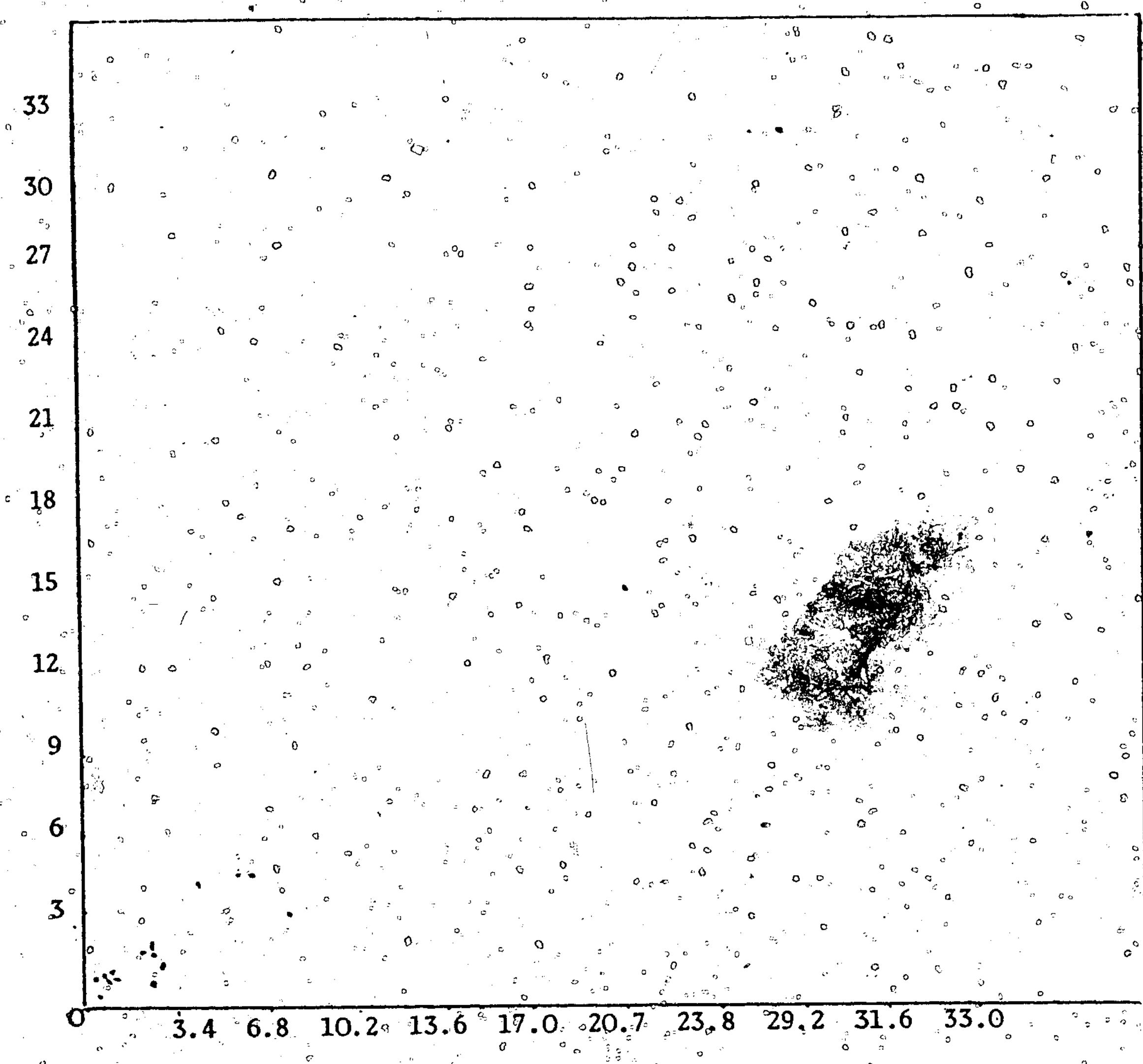
Production of the World's GNP and Physics Papers



Source: Table 6.4 The original plots were produced through a BMD plot routine.

Figure 6.2

Production of the World's GNP and Chemistry Papers



<u>Source</u>: Table 6.4. The original plots were produced through a BMD plot routine

TABLE 6.5

STATISTICAL RELATIONSHIP BETWEEN SHARE OF THE WORLD'S GROSS NATIONAL PRODUCT AND SHARE OF THE WORLD'S PHYSICS AND CHEMISTRY PAPERS

	Correlation Coefficient	
	Pearson	Spearman
GNP and physics papers	0.79	0.87
GNP and chemistry papers	0.86	0.95

SOURCE: Table 6.4.

are *not* related to total population, urban development or even *research and development* investment. For example, the U.S.A. has 6% of the world population and 50% of the research and development.[76] The threshold of the world gross national product at which a commensurate return in papers begins is 0.7%.

What all this means is that "strength is proportioned to some measure of affluence." This is hardly surprising. What is more important is that "a country must either pay a basic entrance fee or never expect to get off the starting line."[77] Whether or not a certain amount of basic science causes a particular degree of economic prosperity cannot be determined. However, this much is clear.

> "In all the basic science areas there can be little or no real freedom of policy. Each nation must use about 0.7% of its GNP to support people whose business it is to advance science, and it must do so with whatever pattern of deployment is the world consensus at the time."[78]

This most basic part of a science policy cannot be regulated. There is a

> ". . . relatively small degree of freedom that countries have in the matter of the size and direction of their scientific and technological expenditures. In basic science, it appears there is virtually no freedom of action whatsoever."[79]

4. SEARCHING FOR A MIDDLE GROUND ON THE ENDLESS FRONTIER

It may be claimed by some observers that the arguments and analysis of parts (1) and (2) create myths about the intellectual and sociological operations of science, for example, in it's alleged creativity, the hypothetico-deductive method, disciplinary inter-relations, impersonality or motivation. This is an important criticism which requires attention. First it has to be clarified. Insofar as (1) and (2), and Chapter Seven later, consciously partake of myth, it is not the conventional myth about inductive, objective scientific method, held by the lay public. At the very least it is a counter myth, and may serve the purpose of checking the conventional myth. But the question remains, are the counter claims asserted above nothing but myths themselves? It is true that they are frequently asserted by the scientists who have a vested interest in them, just as they are denied by vested interests to the contrary. Nothing is proven by that.

Two points can be made. First, even if the counter claims are not fully realized in the behaviour of scientists they are still articulated. To the extent that ideas are relevant to behaviour, the counter claims may be relevant to the activity of science. Admittedly, these conventions, like any other, are transgressed. Doubtlessly, emotions and personality effect science, this is emphasized in consideration of disciplinary socialization and creativity. Even so, that scientists verbally aspire to these counter conventions tells us something of how the actor views the activity and is, if only partially, oriented to it. Moreover, that their activity can be logically reconstructed along such lines encouraged belief in the soundness of the partial claims. Second, where available empirical evidence touches on these matters, there is some support for the counter claims, as was seen in Price's analysis of the interrelations of physics and chemistry literature in part (3), the cases of serendipitous discovery pointed out in (1), or the aspirations detected by Storer and the criteria of publication mentioned in (2).[80]

Science may not be an activity like the rest. It certainly demonstrates any number of unusual, if not singular, characteristics which give that impression. That this impression did not come forward during the hearings of the Lamontagne Committee should not be surprising. As far as can be determined, the Lamontagne Committee, despite its own best efforts, did not even once talk to a working scientist. Rather its parade of scientific witnesses was composed of science administrators, persons who were once working scientists but who are now holders of preoccupying administrative roles as heads of departments or institutes or faculties or units or programs or whatever. Such persons quickly come to have more in common with other administrators than with other scientists. This is not surprising for this is the purpose of administrators, to administer and that means to get along with other administrators elsewhere in the system, even to anticipate them. Science administrators are externally oriented. Their views are not representative of those of scientists at the bench. For example, as far as participant observation in 1971-72 indicates, the composition of the Association of the Scientific, Engineering and Technological Community of Canada

(SCITEC) is overwhelmingly science adminstrators.[81] Most of the encouragement that science policy receives from scientists comes from science administrators, as the Senators are proud to point out.[82] When criticized for failing to hear from the basic scientists about whom he is so concerned, Senator Lamontagne replied that they might have attended even though they were uninvited. Had they come forward, they would have been heard. Meanwhile, the Canadian Historical Association and the Canadian Political Science Association were invited to present briefs.[83]

It may be that the alternatives open are mutually exclusive and jointly exhaustive. Either science is viewed as useful and controllable or it is not. Admittedly these two options are polar extremes. This has lead some commentators to think that there must, of logical necessity, exist a compromise middle ground. While the polar conceptions each are the consequence of a long series of arguments, in contrast this middle ground seems *sui generis* for it is presented without the benefit of argument or analysis showing its sensibility. Instead, it is simply clothed in the all purpose terms "pluralistic, pragmatic".[84] Such a view holds that each of the extreme positions because it is extreme can only be, at best, partially correct, and must necessarily be partially false. Such may be the most generous and convenient and pacific conclusion, one derived from the fact that the extremes standing alone are irreconcilable, hence conflicting, and the hidden assumption that there neither need be nor should be conflict. However, the unstated assumption has no support. It is just that--an assumption--one which is not made in these pages. Truth may lie at an extreme. Compromise may be the worst, not the best, solution. There is no logical or sociological evidence to endorse a compromise based, not on what we know, but on what is expedient. Over time, such a solution will only incubate existing difficulties, not solve them. Moreover, any compromise will most likely be one which emphasis perceived social utility over claims to scientific detachment. Desirability will publically outweigh arguments about philosophical and sociological feasibility. Hence, arguments against science policy as now conceived must not be limited to feasibility. They must also confront the issue of desirability. Opponents of science policy cannot accept assertions of scientific utility while opposing science policy and expect to be successful. To do so is to admit the most politically popular and philosophically contentious claim of the advocates.

FOOTNOTES

1. For example, see M. W. Jackson, "The Application of Method in the Construction of Political Science Theory", *Canadian Journal of Political Science*, V (1972) 3, pp. 402-17, and "Method, Theory and Science in Political Science", paper read at the Fourth Annual Meeting of the International Society for the History of the Social and Behavioral Sciences, Calgary-Banff, 1972. Much of what follows is based on these and related works.

2. *The Behavioral Persuasion in Politics* (New York: Random House, 1963), p. 9. Cf. his "An empirical discipline is built by the slow modest, piecemeal cumulation of relevant theories and data", *ibid.*, p. 114; and his "The Behavioral Movement in Political Science", *Social Research*, XXXV (1968) 1, p. 28; "Tradition and Innovation", *Behavioralism in Political Science*, Eulau, (ed.) (New York: Atherton, 1969), p. 15. See also David Truman, "Dissolution and Regeneration", *American Political Science Review*, LIX (1965) 4, p. 872 and L. Stanford, "Beyond the Mumbo Jumbo", *Journal of Canadian Studies*, IX (1969) 3, p. 55.

3. The inductive theory-building approach is overwhelmingly favoured by political scientists. Only a very few have given serious and extended consideration to deductive alternatives. See T. H. Greene, "Values in the Methodology of Political Science", *Canadian Journal of Political Science*, III (1970) 2, p. 281.

4. I. Copi, *Introduction to Logic*, (3rd ed.) (London: Macmillan, 1968), p. 20-1 and W. Salmon, *The Foundation of Scientific Inference* (Pittsburgh: University of Pittsburgh Press, 1966), pp. 8-10.

5. I. Copi, *Introduction to Logic*, pp. 346-48; J. J. Smart, *Between Science and Philosophy* (New York: Random House, 1968), pp. 179-80; Salmon, *The Foundations of Scientific Inference*, pp. 129-31; D. Stove, "Hume, Probability and Induction", *Philosophical Review*, LXXIV (1965) 1, pp. 160-77; reprinted in *Hume*, V. C. Chappel, (ed.) (Gordon City, N.Y.: Anchor Books, 1966), p. 202.

6. Salmon, *Logic* (Engelwood Cliffs, N.J.: Prentice-Hall, 1963), p. 55; his *The Foundations of Scientific Inference*, pp. 18-20; and Copi, *Introduction to Logic*, pp. 327-28.

7. Hans Reichenbach, *Experience and Prediction* (Chicago: University of Chicago Press, 1938), p. 6.

8. *Ibid.*, p. 7.

9. *Ibid.*, p. 6.

10. Reichenbach, *The Rise of Scientific Philosophy* (Los Angeles and Berkeley: University of California Press, 1966), p. 231.

11. With Stuart Rice it is the view taken here that the use of the term "natural science" in contrast to or mutually exclusive from the term "social science" is illogical. It is impossible to conceive of a science which is not natural, which is unnatural, and certainly there is nothing more natural than society. See his, *Quantitative Methods in Politics* (New York: Knopf, 1928), p. 14N.

12. *Patterns of Discovery* (Cambridge: Cambridge University Press, 1968), p. 35. Cf. his *Perception and Discovery*, W. Humphreys, (ed.), (San Francisco: Freeman, Cooper & Co., 1969), pp. 59-198, esp. at pp. 171-85.

13. Hanson, *Patterns of Discovery*, pp. 6 and 9.

14. Theodore Shabad, "A Scientist 'Saw' What Others Suspected" *New York Times*, 3 November 1971.

15. Current examples from the daily press are "Dentistry compound discovered", *Edmonton Journal*, 2 August 1972, p. 26, in which the first sentence begins, "'Dumb luck' enabled two Boston dental researchers to discover a compound . . .", and "Hormone spurs growth", *Edmonton Journal*, 4 July 1973, p. 34, in which a discovering scientist says that "he discovered the effects of the hormone by chance." See also D. S. Halacy, *Science and Serendipity* (Philadelphia: Macrae Smith Co., 1967) and B. Barber and R. Fox, "The Case of the Floppy-Eared Rabbits", *The Sociology of Science*, Barber and W. Hirsch, (eds.) (N.Y.: Free Press, 1963), pp. 525-38.

16. *The Philosophy of Science* (Cambridge: Cambridge University Press, 1961), p. 54.

17. R. Carnap, *Philosophical Foundations of Physics* (New York: Basic Books, 1966), p. 248.

18. See, e.g., K. McCarquodale and P. Meehl, "On the Distinction Between Hypothetical Constructs and Intervening Variables", *Psychological Review*, LV (1948) 2, pp. 95-107 or G. Sartori, "Concept Misformation in Comparative Politics", *American Political Science Review*, LXIV (1970) 4, pp. 1033-53.

19. C. Hempel, *Aspects of Scientific Explanation and Other Essays* (New York: Free Press, 1965), p. 177. Hempel's specifications can profitably be qualified by the presentation of Ramsey's sentences in Carnap, *Philosophical Foundations of Physics*, pp. 247-56. Ramsey's own account is much more detailed, and difficult. See his, *The Foundations of Mathematics* (London: Routledge and Kegan Paul, 1931).

20. Carnap, *Philosophical Foundations of Physics*, p. 227.

21. Hempel, *Aspects of Scientific Explanation and Other Essays*, p. 178.

22. J. Ziman, *Public Knowledge* (Cambridge: Cambridge University Press, 1968), p. 98.

23. Maurice Cranston, *Freedom* (3rd ed.) (London: Longman's, 1967), p. 118.

24. Carnap, *Philosophical Foundations of Physics*, p. 230.

25. D. Hume, *Treatise on Human Nature*, Vol. 1 (London: Dent, 1817), pp. vi and xii.

26. Stove, "Hume, Probability and Induction", p. 188.

27. Popper, *Conjectures and Refutations* (London: Routledge and Kegan Paul, 1963), p. 46.

28. A. Kaplan, *The Conduct of Inquiry* (San Francisco: Chandler, 1964), p. 377.

29. See M. Jackson, Review of Eugene J. Meehan, *The Foundations of Political Inquiry*, *Canadian Journal of Political Science*, VI (1973) 2, pp. 256-7.

30. Toulmin, *Foresight and Understanding* (London: Hutchinson, 1961), p.57.

31. Carnap, *Philosophical Foundations of Physics*, p. 231.

32. Salmon, *Foundations of Scientific Inference*, p. 18.

33. A. J. Ayer, "Conversations with Philosophers", *The Listener*, LXXXIV (1970) 2179, p. 908.

34. Of course inductive enumeration is not totally without philosophical utility, just as the hypothetico-deductive method is not entirely without fault. To this point all that is claimed is that there is a variety of philosophy of science persuasions, all of which collectively reject the central or near-central role granted to inductive enumeration by lay people.

35. Panel on Science Policy, Annual Meeting of the Canadian Political Science Association, Winnipeg, 1970.

36. A. Heeny, *Personnel Administration in the Public Service* (Ottawa: Queen's Printer, 1958), p. 141.

37. E. W. R. Steacie, "Science, Society and the Individual", Three C.B.C. Lectures (Ottawa: National Science Library, 1959).

38. I. Norman Smith, "Heeny Answers Steacie Re Scientists and Commission", *Ottawa Journal*, 29 September 1959, p. 6. "Exploitation of R&D cannot be based on methods used in other fields of business activity", K. Paritt, "Technology, International Competition and Economic Growth", *World Politics*, XXV (1973) 2, p. 184.

39. J. G. Glassco, *Royal Commission on Government Organization*, Vol. IV, Report No. 23, *Scientific Research and Development* (Ottawa: Queen's Printer, 1963).

40. See T. R. Shapiro, "What Scientists Look for in Their Jobs", *Scientific Monthly*, LXXVI (June 1953), pp.335-40; Leo Meltzer, "Scientific Productivity in Organizational Settings", *Journal of Social Issues*, XII (1956) 2, pp. 32-40 and Mitchell Wilson, "On Being a Scientist", *The Atlantic*, CCXXVI (1970) 3, pp. 101-6. Consider this, a scientist's confession: "I felt guilty coming back to the lab after hours to get a little more done, and still I always come back. . . . I know very well that whether I come in or not on Sunday, there will be no great change in science. I neglect my wife and my little daughter for those few extra hours--yet I keep coming. Why? Is it really only curiosity? Because if that's all that's driving me, then it's wrong for me to come for that additional time." 'Then why do you come in?' I persisted. "Because it is my happiness . . . This is where I want most in the world to be--this is what I want most in the world to be doing." Wilson, "On Being A Scientist", p. 104.

41. N. W. Storer, "Research Orientations and Attitudes Toward Teamwork", *IRE Transactions on Engineering Management*, IX (1962), pp. 29-33.

42. Storer, *The Social System of Science* (New York: Holt, 1966), p. 55.

43. *Ibid.*, p. 57. Cf. J. Hodara, *Condiciones e indicadores de prodictividad científica* (México, D.F.: Universidad Nacional Autonomia de México, 1968).

44. Carl Rogers, "Towards a General Theory of Creativity", *Creativity and its Cultivation*, H. A. Andesman (ed.) (New York: Harper and Row, 1959), p. 78.

45. Storer, "Basic vs. Applied Research", *Indian Sociology Bulletin*, II (1964) 1, p. 37.

46. See J. Watson, *The Double Helix* (New York: Atherton, 1959). Cf. R. Merton and R. Lewis, "The competitive pressures", *Impact*, XXI (1971) 2, pp. 151-61; S. and J. Cole, "Scientific Output and Recognition", *American Sociological Review*, XXXII (1967), pp. 377-90; and J. Davy, "The Double Helix: Scientific Life as it Really Is", *Science Forum*, I (1968) 4, pp. 31-2.

47. C. P. Snow, *The Search* (New York: Signet, 1960), pp. 112-3.

48. Storer, *The Social System of Science*, p. 124.

49. *Ibid.*, p. 115.

50. C. R. Viesti, Jr., "Effects of Monetary Rewards on an Insight Learning Task", *Psychon Science*, XXIII (1971) 2, pp. 1813.

51. *Ibid.*, p. 181.

52. "Avoid duplicated research", *Edmonton Journal*, 27 October 1971, p. 60.

53. "Money, efforts wasted in duplicate research", *Edmonton Journal*, 9 November 1971, p. 77.

54. M. Lamontagne, *A Science Policy for Canada*, Vol. I (Ottawa: Queen's Printer, 1970), pp. 278-79.

55. Senator Cameron in *Hearings of the Senate Special Committee on Science Policy*, First Session, Twenty-eighth Parliament, 21 May 1969, p. 5677, Cf. M. Jackson, "What is Rational and What is Research", A Brief Submitted to the Commission to Study the Rationalization of University Research of the Association of Universities and Colleges in Canada, Ottawa, 1972 and "Rationalizating the Rationalization of Research", *Gateway*, LXIII (23 November 1972) 22, p. 5. See also R. C. Quittenton, "Education--What's in it for Industry", Address to the 58th Annual Meeting, Canadian Pulp and Paper Association, Montreal, 1972.

56. D. Greenberg, *The Politics of Pure Science* (New York: New American Library, 1967), p. 114.

57. Interview in *New York Herald Tribune*, 12 September 1933. Quoted in Greenberg, *The Politics of Pure Science*, p. 208-9 N.

58. L. P. Bonneau and J. A. Corry, *The Quest for the Optimum* (Ottawa: Associations of Universities and Colleges of Canada, 1972), p. 20.

59. T. Kuhn, "Historical Structure of Scientific Discovery", *Science*, CXXXVI (1962), pp. 760-4.

60. Kuhn, "Comment on D. W. MacKinnon, 'Intellect and Motive in Scientific Inventors'", *The Rate and Direction of Inventive Activity*, National Bureau of Economic Research (Princeton: Princeton University Press, 1962), pp. 379-84.

61. Lamontagne, *A Science Policy for Canada*, Vol. II, pp.431-3, and Corry-Bonneau, *Quest for the Optimum*, pp. 171-85. Cf. Canadian Political Science Association, *Responses to the Corry-Bonneau Report* (Ottawa: Canadian Political Science Association, 1973), p. 1.

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75. This regression was produced by a system subroutine.

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82. *Debates of the Senate, Science Policy: Consideration of Volume I of the Report of the Special Committee*, 1971, pp. 16 and 19.

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CHAPTER SEVEN

BIG SCIENCE AND SCIENCE POLICY

INTRODUCTION

All concerned with science and science policy seem to be agreed on one point: the costs of science are rising, comparatively, relatively and absolutely.(1) Costs are rising compared to past science expenditures, relative to other current expenditures, and absolutely in terms of the number of scientists, technicians, machines and journals involved.

As the expense of conducting the activity of science mounts, science is compelled to seek ever greater funding from wider sources.(2) Of course, since the creation and expansion of public universities, science has been partly and indirectly supported by the public purse. This tap on public funds provided the salaries of a large number of scientists, provided equipment, so long as it was primarily for teaching purposes, and assistants in the form of graduate students. Gradually, exclusively research-oriented funds were also provided in a limited way. The indirect tap on public funds through universities has not proven itself to be altogether adequate since World War II so that science has sought and attained, in various ways, more direct access to the public purse. The well known contributions that science, scientists and scientific work made to many of the War's technical problems led many political and administrative figures to an unprecedented interest in science. This interest was further magnified by the Cold War, for it, even more than the shooting war which preceeded it, was a symbolic technical struggle.

Not only did the size of the required investments imply a public, rather than a private, source. It was also implied by the nature of science as a public good.(3) It is a public good because when once completed the results are diffused into the public realm. They cannot be held for exclusive use. No law of nature can be patented. Although such a scientific breakthrough can have very profound effects on the technology of a society as a whole, say in the form of an invention like the transistor. Still it is not in one particular person's or group's interest to underwrite the basic scientific research that years later would eventuate in the transistor. This is so because no person or group can be assured a large enough share in its exploitation to repay, let alone reward, the investment. Although it is not in the interest of any in particular, it is in the interest of everyone in general, since the discovery would serve to elevate the level of technology, a change in which all could share. And what else, if not this, is the classic circumstance of government involvement? In short, the high and increasing costs of contemporary science means that it must more and more rely on the jealously guarded public purse for support.(4) Disbursements from it are carefully scrutinized, by administrators, politicians, and the public.(5) To draw funds from the public purse it is necessary to show a resulting contribution to the public realm, especially to the public purse, collectively or individually. Alternatively, one may show that an undesirable event will occur if the funds are not allocated. Either a positive or a negative utilitarian approach is customary. The larger or more rapidly increasing such a request is, the more dramatic and substantiated its public justification must be. For example, the large allocations made to defence in most countries is given a life and death justification, in which defence-related research and development can share.

To turn to the public and the public purse for funding invites public, external control. This is so in two ways. First, if the arguments about the public importance of scientific products which are used to justify funding are accepted, then there should be, on normal assumptions, public control of the activity of the community of science, regardless of funding. If it is important to the public, then *prima facie* the public should have a corresponding measure of control over it. Second, to the degree that public money is involved there is *prima facie* justification for budgetary control. Budgetary control can be restricted to maintaining existing policies or it can be used to *de facto* make new policies.

It always is fashionable to believe that one's own times are extraordinary. As superficial as this fashion may be, serious consideration of it may be stimulating on some occasions. For science this may be one of those occasions. It is the thesis of this chapter that contemporary science is different from previous science. Quantitative changes in the amount of scientific activity have led to qualitative changes in the character of that activity. These changes have together affected the nature of the products of science. The work completed by the increasing number of scientific workers has steadily reduced problems, focusing scientific communities onto a narrow range of remaining problems, which require extensive and carefully controlled investigation by specialized scientists with expensive equipment. Because this work is usually undertaken in the interests of application, it has little theoretical importance. Expenditures on it are justified on the basis of its importance to application, not to theory. These trends have led to the development of the idea of scientific teams coming to the fore over the idea of the lone wolf scientist.

In one sense the question at hand is empirical. Is the contemporary activity of science different from that heretofore? However, to be answered as an empirical question it would have to be asked of each discipline. But even this would not do, because one of the distinctive features asserted of the contemporary activity of science is the proliferation of subdisciplines. Because the phenomenon of the proliferation of sub-disciplinary specialization is part of the thesis asserted it cannot be used as a basis of proof. Instead here the argument will be pursued at the more general level of the scientific community, where it cannot be empirical, but only analytic at best and intuitive at worst. Specifically, this argument proceeds [illegible] parts by (1) examining the notion of big science, and (2) then tracing its increasing prominence. Next (3) some inferences will be drawn about the activity of big science and creativity, and these will be implicitly contrasted with the implications about the activity of little science based on the philosophical and sociological analysis of Chapter Six. (4) Fourth, conventional justifications for big science will be presented and criticized. (5) Two limitations on big science are discussed next. (6) In closing this chapter some policy relevant conclusions are drawn on the basis of some assumptions about the exhaustion of governing scientific theories.

1. THE NOTION OF BIG SCIENCE

What is the quantitative effect of big science? How is big science different from little science?[6]

In contrast to big science, little science is that activity of science performed by an individual scientist working alone, or in the company of a few students. Until recent decades it was this form of the activity of science which predominated, if not monopolized the field.

The work of little science was pure, fundamental or basic research. Having little in the way of equipment or facilities available, little science was in large part pencil and paper work at the theoretical level, buttressed with the occasional experiment. More often than not the atmosphere was that of a university. Due to the lack of equipment and facilities the work had to be more theoretical than applied.

2. EMPHASIS ON BIG SCIENCE

World War II heralded many social changes whose implications have yet to be fully fathomed. One of these was the establishment of the idea of big science. It was in the Second World War that the notion of project, or team, science took hold over the conception of many science public authorities, science administrators, laypersons and scientists. "It is hard to imagine a greater contrast than that between the physical sciences before and after the Second World War."(7) One objective indicator of an increasing emphasis on the team research of big science is the documented growth in multiple author papers.(8)

Like the major projects of the War, big science today attempts to weld together the diverse talents of a team of individually specialized scientists and pieces of equipment working on a project determined and selected by external authorities.(9) A contemporary example would be the National Aeronautics and Space Administration in the United States.

Big science has its advocates in Canada. After all, the mission oriented research and the multidisciplinary research which the Lamontagne Committee has found worthy of recommendation is nothing more than big science. It is big science in that the projects envisaged for them are of considerable scope. Mission-oriented science is big science in the further sense that its goal and direction are determined externally by the authorities footing the bill. Insofar as big science implies external funding, it implies external direction. Multidisciplinary research is big science in that it requires the combining of the skills of persons from diverse disciplines in the service of the goal. These alone, however, are not what puts the "big" in big science.

The size of the operation undertaken in a big science project is determined by the size of the goal, and the goal is set by the external authority, not by the scientific community. Hence, in two ways the size of the big science project may obscure the amount of science being done. By virtue of the project's being well staffed and housed, the outward appearances may symbolize more scientific activity than is actually occurring. By virtue of the project's goals being determined externally, they may be so huge and diffuse that even unprecedented advances would fall short of the target, minimizing in the eyes of lay critics the amount of science occurring. Commonly, public policies are given none but the broadest responsibilities and expectations. Subsequently, the policy is judged less by what it does and accomplished than by what it leaves undone. This latter problem has a continuous illustration in the lay judgements passed on social science. Social science is judged by the size (and importance) of the questions it leaves unanswered.(10) Because it is presented with questions people always find of the greatest moment--namely questions about themselves--when it falls short it leaves the largest unanswered questions, blinding onlookers to its record of questions answered, of accomplishments.(11) So it is too for public policy.

3. ACTIVITY OF BIG SCIENCE

In combining the diverse interests and skills of a team of scientists, it is hoped that together they will be able to produce something none was capable of alone, or in any combination short of the entire group. This is the hope behind most organization of effort, and it is certainly appropriate in some cases. It is certainly not appropriate in other cases, for example, it has not (yet) been suggested that the Mona Lisa would have been better painted by a team of artists. Where then is the appropriate?

The artistic example of the preceeding paragraph has a serious purpose. No one would assume that artistic creativity would be necessarily issued from a mission-oriented, externally controlled, multi-disciplinary group of artists.(12) It would have to be proven. It may not be any more sensible to assume scientific creativity can be gotten through teams. It too may need to be proven, though aside from the material mentioned in Chapter Six little work seems to have been done along these lines and still less has entered the public debate on science policy.

To this point several considerations apply. The teamwork of mission-oriented and multi-disciplinary research in science is committee work. When working together there may be some elevating synergetic effects. What is perhaps even more likely and is certainly more well than synergy is the achievement of the lowest common denominator. This arrival at the lowest common denominator can be especially humbling in multi-disciplinary settings where the highest common feature of the participants is that of being educated laypeople.

Indeed mission-oriented, multi-disciplinary research efforts often take pride in the ordinariness of their participants. "There is little room for virtuoso performances." As a documentary film from the Monsanto Chemical Company said several years ago: "No genuises here; just a bunch of average Americans working together."(13) The creativity and productivity of such mission-oriented laboratories as those of industry are not altogether positive recommendations for more, similarly organized, research. "Even when a large firm spends substantial sums on research and development, it may still find that most of its new ideas come from outside."(14) One study of the research and development activities of the Dupont corporation in the United States found that its research and development budget increased thirty-eight fold from 1920 to 1950, without any increase in the number of inventions generated within the firm.(15)

Furthermore, and most simply, no committee ever had an idea. Individuals have ideas, not teams. Once the idea is generated the team may be better equipped to exploit it, that is true, but as a team it may never have an idea to exploit.

Perhaps it will not because a committee of equals functions by consensus. Decision by consensus means that it functions very slowly, very conservatively, giving pride of place to more established ideas and individuals, the more established the better. No mission-oriented project in its search for new ideas and applications is ever likely to appoint as its research director a known maverick. None but the most established scientists are invited to participate. Their ideas are those of the mainstream of their respective disciplines. After all, in respect of any established idea or individual there is already a *prima facie* consensus, much easing the committee's otherwise difficult deliberations.(16)

Moreover, because, however labelled, the role of the committee is administrative, even if only over its own membership, non-scientific criteria become directly engaged. These criteria are administrative and, perhaps, enforced by the scientists themselves, but enforced nonetheless. Administrative criteria naturally tend to be things. Things that can be added and subtracted and totalled and preserved. They are book-keeping criteria. This should not be surprising because when peeled back to its centre that is what administration is, ultimately. The importance of the Treasury Board and the Auditor General should remind us of this point. Book-keeping criteria require clarity, precision, explicit planning, scheduling--all criteria which the activity of science cannot meet.

4. JUSTIFICATION FOR BIG SCIENCE

Most big science is, directly or indirectly, supported for military purposes. Many such projects have been seen in Canada, including the Arrow, Dart and Stol programmes, to name but a few. Despite the difficulties with such programmes as these, big science has many proponents in the present Canadian situation, including the second Minister of State for Science and Technology and, of course, the Chairman of Senate Special Committee on Science Policy.(17)

Usually big science can be understood as being advocated for one of two reasons. First, for its alleged ability to deal with a particular substantive problem. The problems mentioned in connection with big science in Canada are of course less audacious than those of the United States, but they are also less specific, for example, urban decay, or transportation.(18)

There is no difficulty in determining when a successful moon flight has occurred. In contrast, how could we ever tell if Canada's transcontinental transportation problems were to be solved. After all, are they not in constant political flux? A political flux so constant that it is not even clear that the issue is a technical one or a political one. Here one need only call to mind the compound mysteries of freight rates as a present example. As a future example one might consider the transportation of resources from the far North.

There is a second, less particularistic, more diffuse justification of big science projects which has its representatives too. It is that big science projects should be undertaken for the purpose of building a basis of experience which would prove valuable in attacking other unnamed social problems.(19)

When the first justification is thwarted by the inability to point to unanimously perceived successes, the second justification serves. And the first justification does run thin on specifics: in Germany where a science policy took inchoate form between the world wars a number of mission-oriented, multi-disciplinary research projects foundered without success,[20] in the United States big science work is being given a second look, much more critically than ever before,[21] and in Canada when asked to specify in concrete terms the advantages of big science, the Research Director of the Science Council of Canada, P. T. McTaggart-Cowan, was self-admittedly unable to do so.[22] The normal response to such a question as this seems to be to beg the question. As in this way:

> "Congressmen who demand that the N.A.S.A. produce specific examples of commercial utilization of space technology fail to appreciate the broad sweep of overall technological advance from the space effort."[23]

This second, diffuse justification has a more precise version. It is that technical spinoffs of big science projects have so dramatic an effect on the economy as to warrant the project.[24] So far as can be determined the impact of spinoffs has never been precisely calculated.[25] Against the assertion that spinoffs must exist and ergo must have a considerable, positive impact, there are three criticisms. The three criticisms are alike in being predicated on the assumption that all big science projects are influenced (read: dominated) by military consideration.

First, some industrialists in the United States have complained that military big science competes with direct industrial research in attracting skilled labour and pulls the local market prices of research equipment upward. This is a complaint taken seriously enough to warrant repetition by a former Science Advisor to the President of the United States.[26]

Second, and related to the matter of research costs, on behalf of the spinoff thesis it is said that government projects will lead to more rapid progress than would private commercial projects because costs, which would cripple even a large private consortium, do not deter or impede government. Having purchased more rapid progress in this way leads to a further implication. It is that research supported publicly will then be ahead of its time, thus providing the economy with knowledge not otherwise available.

Does this mean that such projects contribute to economic growth? Not necessarily. Precisely because they are advanced, big science technologies are increasingly difficult to adapt to the existing civilian technology.[27] Further, due to the background military purposes a thick security filter keeps many findings under wraps.

Additionally, because mission-oriented research is so specific in direction, the technology produced by it will be so precisely adjusted that it cannot be transferred to other applications. "If R & D is aimed at creating information needed to build a better rocket engine, it is likely to do just that and precious little else."[28] The better the control of the mission, the fewer the spinoffs it will produce. The more efficient it is, the less broadly effective it will be. Moreover, because it is developed without severe financial restrictions due to its defence purposes, many of the available spinoffs cannot be manufactured and marketed at existing cost and price levels.[29] The value of spinoffs has yet to be determined, and there are reasons to doubt that it would be as high as the National Aeronautics and Space Administration's public relations claims once asserted when they coined the word.[30] The value of spinoffs may have been overestimated.

What is more, the purpose of having spinoffs may be mistaken too. It may be that the technological additive that spinoffs represent have only a marginal, not a central, impact on the economy of a country.

There can be no doubt that in the eyes of the foremost advocate of science policy in Canada, Senator Maurice Lamontagne, research and development, and technological innovation are the sure route to more hasty economic growth.[31] Hence, the Senator speaks of a "new technological revolution" in which "the innovative process will be the centre of economic growth." Consequently, "R & D activities leading to innovations will be a cause of growth."[32]

The assumption is that an increased supply of technology will push the economy toward growth. It is another pivotal assumption about which expert opinion is divided. Much of the traditional economic analysis and history holds that growth is the result of demand pull and not supply push, as Senator Lamontagne would have it. In the absence of precise evidence the advocates of science policy push the payoff point into the future, thus making its being tested impossible. This is rather what adherents of basic research do. According to certain studies by the Organization for Economic Cooperation and Development, demand pull, not technology push, issues in economic growth.(33)

Many Canadian big science projects have been started, fewer have been completed, fewer still have been completed successfully. Some projects became co-opted into American efforts, as with the Queen Elizabeth the Second telescope, others are cancelled in mid-stream, some are cancelled too soon, some are started too slowly, others are concluded but not marketed.(34) Even today, with this record of disappointment, one highly placed person has seriously advocated big science for the sake of big science.

> "This means that a nation often might be better advised to carry on some major programme, even when the objectives are only provisional or subject to later revision, than to wait for definitive studies to establish that they are the absolutely right choices. The future, after all, is largely unpredictable, and a nation will be better able to cope with the new and unexpected if it already has on hand an establishment of advanced capability than if it has to start from square one."

The contractor's dream, the taxpayer's nightmare, is this sort of Russian roulette justification.

5. THE LIMITATIONS OF BIG SCIENCE

For two reasons, turning to big science for salvation may be an error. One reason has to do with the technology involved in big science and is practical. The other concerns the science involved and is theoretical.

Because its aim is application, big science relies on technology. The bigger the science, the more advanced the technology. The goal of economic growth and well being may be lost if care is not taken here.

Endeavours to develop products and technologies in one field through big science may have offsetting, obverse effects in other fields. For example, Canadian attempts to perfect a marketable communications satellite technology may succeed. A great revenue may be gained from the system. But this is a gain the effects of which may be offset by escalating payments to the United States for the use of rocket launchers to orbit the system, rocket launchers being a technology not developed in Canada. This is not, however, the most important issue with big science, though it does indicate what the main issue is, namely the connection of science and technology.

The second and more important reason that should dampen enthusiasm for big science is that it is conservative. It constitutes the application of *existing* technologies to particular problems. In order to use existing technologies it necessarily assumes, and therefore depends on the *existing* scientific theories which define the reality with which that technology was developed. In order to apply the technological product, the science under whose imprimatur it exists must be held constant, taken as given. Yet,

> "Many great discoveries are characterized by the extent to which they contradict previous scientific opinion. In this way they open wholly new territory. Working in terms of existing beliefs tends to yield only improvements, not basic discoveries either in science or technology."(36)

Application forecloses the two key areas of scientific creativity--the conceptualization of reality and the theory inferred in support of that conceptualization. They are foreclosed because to probe and apply at a specific point, as big science does, means that all other points must be held fixed. Were they not fixed, their movement would shift the point in focus.

This is why big science is big. Holding all else constant is not merely a matter of saying so. For example, in cancer research it may be that pure leukemia occurs in only one in one million diseased rats. By far the largest part of a cancer project might go to finding specimens under controlled conditions. Practically, big science means that a vast number of variables must be controlled while a very few are isolated and sin-gled out for attention. It is this that the large numbers of machines and persons associated with big science are doing, holding variables constant. They not creating or discovering. They are employed not so much on the project, as on protecting the project from disruptive influences.

Big science is conservative because it is encumbered by the weight of a vast body of conventional knowledge.(37) It carries the weight in the hopes of finding applications, of not overlooking any possible application. Carrying so great a weight slows its pace to a walk, which is normal science. It depends on theory, it does not add to it.[38]

So too it may depend on the public purse, not contribute to it. Since World War II there has been an unparalleled growth in science. Most of living scientists have less than ten years experience and are thus in the prime of their most productive years. Ninty percent of the scientific papers ever published have been written since 1945.[39]

Not only has the amount of scientific work available increased, but also its accessibility has increased. Through improved transportation and communication, work done anywhere in the world is available. And once acquired its wide dissemination is only a xerox machine away.

These effects on the activity and products of science have, of course, had implications for the community of science. It seems safe ~~to say that~~ the already tight discipline in scientific disciplines has been increased. Increased levels of funding and the increased number of scientists have doubtlessly led to better administration of the community. Specifically, external aid has certainly provided many a scientific association with a permanent headquarters and a secretariat and/or journal. Together or separately, each of these would bring the association's members into closer communication and community. So too does attendance at conferences, which is a favourite use of external funds. Added to these specific effects are spillovers, from the larger society, which contribute to the same point, for example, increased geographic mobility. No longer does the average scientist, or bus driver, work for the same institution for a complete career. All of this increased communication presumptively means that there is an even more intense, common focus in scientific disciplines. An empirical indicator of this focus might be the rejection rates of journals. The common focus of scientific journals have always given them much lower rejection rates than those of the social sciences or humanities. It may also be that their rates are lowering over time.(40)

6. BIG SCIENCE, THEORETICAL EXHAUSTION AND POLICY

The life cycle of scientific theories in today's geometrically enlarged world of science will be much shorter, perhaps geometrically shorter than they were in bygone days. Because there are more scientists alive today than ever before, and because they are in the most active, creative years of their careers, accepted theories can be and presumably are being normally filled out and exhausted sooner and sooner, throwing up periods of abnormal science. The number of scientific papers in existence now doubles every ten to fifteen years, a growth explosion exceeding that of the population.(41)

Some very rough indication of the lack of productivity of big science can be found. We assume that the trend of contemporary science in the United States is toward big science and that indirectly patents are a sign of new ideas. In the United States the number of scientists and technologists quadrupled from 1941 to 1958. At the same time the number of new patent applications filed fell from fifty-three per one hundred scientists and technologists to twenty-four, a decrease of over fifty percent. It seems to have become more difficult to find a new idea within established conventions.[42]

That we laypeople do not hear about abnormal science in our contemporary communities of science is interesting in itself. Apparently, most of present day science remains in normal stages and has been there since World War II, or earlier, despite the vast increase in the amount of scientific work being done. Certainly it is safe to assume that a scientific revolution would have made itself known to laypeople, as they always have before, by causing controversy in science. That they have not made themselves known perhaps means that they have not occurred, it does not mean that they have occurred and have been withheld. As we have seen, scientists are too eager for acclaim for that to happen. Thus *Time* magazine could report Werner Heisenberg as arguing against the construction of:

> ". . . even bigger (and more expensive) atom smashers on the ground that little more of a fundamental nature can be learned of the subnuclear world."[43]

Meanwhile, molecular biologist Gunther Stent assumed that all basic questions in that field are solved or will be in the foreseeable future.[44] The same conclusion is reached by another participant-observer who says that:

> ". . . after the thirty fat years in the beginning of the present century, we are now dragging through the lean and infertile years, and looking for better luck in the years to come . . . theoretical physics has made very little progress during the last three decades . . ."(45)

Australian Nobel Lauret Macfarlane Burnet drew attention to one sign of this exhaustion when he wrote:

> "It is illuminating to watch how, as soon as a new phenomenon is recognized in any field of science, there is a swift mobilization of dozens or hundreds of scientists who can cheerfully leave their current research activity to join in the gold rush. Clearly there are more competent scientists than there are exciting . . . problems for study."(46)

Burnet goes even further, asserting that ninty-nine percent of the scientific generalizations and applications which can have a bearing on human affairs have been made. They need only to be developed, a task independent of science.

Meanwhile, Derek Price has suggested that the phenomenon of big science may be heralding a crisis in the growth curve for science.(47) Certainly as big science absorbs available funds for scientific investment, it debilitates little science which provides the theoretical underpinnings of science.(48)

Admittedly the preceeding discussion of big science is not a single coherent argument leading to a decisive conclusion. Rather it is a series of arguments which can be interpreted in one of two main ways, either as pointing to the need for a policy to apply existing science, a technology policy, or to the need to re-invigorate basic, little science through a non-directive laissez faire science policy of the pre-World

War II type. What is important to notice hefe is that either conclusion rejects the idea of a directive science policy which occupies so central a place in the minds of the advocates of science policy. However, either of these conclusions could be consistent with a reduction of scientific investments, on the one hand to channel funds to technology and on the other to cut out the orientation of science, say in graduate education, to big science and to reduce the complacency which the easy money days of big science bred. A lower level of funding without direction may be preferable to a higher level of funding with direction, and this may be the choice to be faced on the basic science-side of science policy.

FOOTNOTES

1. H. L. Nieburg, *In the Name of Science* (Chicago: Quadrangle, 1970) (Rev. ed.), p. 75 and D. Greenberg, *The Politics of Pure Science* (New York: New American Library, 1967), p. xi.

2. Leo Marion, "Science Policy and the Universities", *Transactions, Royal Society of Canada*, 4th Series, III (1965), pp. 5-6.

3. Former Science Adviser to President Nixon, Edward David, Jr., "Making Objectivity Credible and Acceptable", *American Psychologist*, XXVII (1972) 1, p. 91.

4. *Ibid.*, p. 91 and Senator Alister Grosart, Address to SCITEC, *Proceedings of SCITEC IV* (Ottawa: SCITEC, 1972), p. 34.

5. Jacob Schmookler, "Technological Progress and the Modern American Corporation", *The Corporation in Modern Society*, Edward Mason, ed. (Cambridge: Harvard University Press, 1960), p. 143.

6. Originally this distinction was propounded by A. Weinberg, "Impact of Large-Scale Science on the United States", *Science*, CXXXIV (1961), p. 164. The following description of big and little science is based on Derek Price, *Little Science, Big Science* (New York: Columbia University Press, 1963).

7. Edward Teller, "The Era of Big Science", *Bulletin of Atomic Scientists*, XXXII (1971) 4, p. 34. Cf. Spencer Klaw, "The Styles of Big Science", *Knowledge, Politics and Public Policy*, P. Melanson, ed. (Cambridge: Massachusetts: Winthrop, 1973), pp. 33-41.

8. B. L. Clarke, "Multiple Authorship Trends in Scientific Papers", *Science*, CXLII (1964), pp. 822-4; and H. Zuckerman, "Nobel Laureates in Science", *American Sociological Review*, XXXII (1967), pp. 391-403; and L. Sklair, *Organized Knowledge* (London: Paladin, 1973), p. 75.

9. See, e.g., Pierre Trudeau, "Quebec and the Constitutional Problem", *Federalism and the French Canadians* (Toronto: Macmillan, 1968), p. 12.

10. Adolf Grünbaum, "Science and Man", *Perspectives in Biology and Medicine*, V [illegible]62), pp. [illegible]-502.

11. Jackson, "Let's not [illegible] the social and physical sciences", *Science Forum*, V (1972) 5, pp. 30-1.

12. Ben Shanh, *The Shape of Content* (New York: Vintage, 1957).

13. W. H. Whyte, Jr., *The Organization Man* (Garden City, N.Y.: Doubleday, 1957), p. 235.

14. Solomon Encel, "Science, Discovery and Innovation: An Australian Case History", *International Social Sciences Journal*, XXII (1970) 1, p. 46.

15. W. F. Mueller, "The Origin of Basic Inventions Underlying Dupont's Major Product and Process Innovations", *The Rate and Direction of Inventive Activity* (Princeton, N.J.: National Bureau of Economic Research, 1962). Cf. M. J. Peck, "Invention in the Postwar American Aluminium Industry", *ibid.*

16. This observation applies, e.g., to the staffing of the Alberta Human Resources Council, which was an action-oriented social research agency, 1967-71.

17. The Honourable Jeanne Sauvé, "Incentives for Innovation in Canadian Industry", Address to the Canadian Club, Toronto, 1973, p. 17.

18. Science Council of Canada, *Towards a National Science Policy* (Ottawa: Queen's Printer, 1968), pp. 1-2.

19. Cf. R. W. Jackson, "Major Programs in R & D", *Science Forum 8*, II (1969) 2, p. 11. Cf. his lengthier "The Rational of Major Programs in R & D", unpublished paper, Science Council of Canada, Ottawa, 1968.

20. See Brigitte Schroeder-Gudehus, "Science as a Substitute for Power", Paper read at the Annual Meeting of the American Political Science Association, Washington D.C., 1972; "La notion de 'science' comme substitut de puissance", Paper read at the Triennual Meeting of the International Political Science Association, Montreal, 1973; and "The Argument for Self-Government and Public Support of Science in Weimar Germany", *Minerva*, X (1972) 4, pp. 537-70.

21. See, for example, Ellis Mottur, "Conversion of Scientific and Technical Resources, Economic Challenge--Social Opportunity", National Aeronautics and Space Administration Report, Washington, D.C., 1971.

22. In floor discussion of Science Policy at the Annual Meeting of the Canadian Association of Physicists, Edmonton, 1973.

23. W. J. Coughlin, in *Technology Week*, 10 April 1967, quoted by Jackson, "Major Programmes in R & D", p. 11.

24. *Ibid.*

25. Mottur, "Conversion of Scientific and Technical Resources".

26. Donald Hornig, "Scientists and Politicians", *Chemistry and Industry*, 10 May 1969, p. 602.

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31. N. Lithwick, "Technology and Progress", *Science Forum 26*, V (1972) 2, p. 10.

32. Maurice Lamontagne, Text of Question Period, Canadian Television Network, 22 January 1972, p. 9. Cf. his "The Sickness of Canadian Industry", Canadian Forum, January 1972, pp. 18-21.

33. Organization for Economic Cooperation and Development, *Technological Gaps* (Paris: O.E.C.D., 1970).

34. See, for example, Lynn Trainor, "Science in Canada", *Close the 49th Parallel*, I. Lumsden, ed. (Toronto: University of Toronto Press, 1970), pp. 242-59 and Doern, *Science and Politics* (Montreal and London: McGill and Queen's University Press, 1972), pp. 103-19.

35. Jackson, "Major Programs in R & D", p. 12.

36. Schmookler, "Technological Progress and the American Corporation", p. 160.

37. T. S. Kuhn, *The Structure of Scientific Revolutions* (Chicago: University of Chicago Press, 1969) (2nd ed.), pp. 35-42 and *passim*.

38. Teller, "The Era of Big Science", p. 35. Cf. Barry Castro, "The Scientific Opportunities Foregone because of More Readily Available Federal Support for Research in Experimental than Theoretical Physics", *Journal of Political Economy*, LXXVI (1968) 4, Part I, pp. 601-14.

39. Price, *Little Science, Big Science*, p. 15.

40. See H. Zuckerman and R. Merton, "Patterns of Evaluation in Science", *Minerva*, IV (1971) 1, pp. 66-100.

41. Price, "The Structure of Publication in Science and Technology", *Factors in the Transfer of Technology*, W. H. Gruber and D. G. Marquis, eds. (Cambridge: Massachusetts Institute of Technology Press, 1969), p.93.

42. Fritz Machlup, "Patents", *International Encyclopedia of the Social Sciences*, XI, p. 461. This would be in contrast to the fertility of alternate expenditures in little or basic science.

43. "Reaching Beyond the Rational", *Time*, 23 April 1973, p. 51.

44. *The Coming of the Golden Age* (New York: Natural History Press, 1971).

45. George Gamov, *Thirty Years that Shook Physics* (New York: Anchor, 1966), p. 161.

46. "After the Age of Discovery", *New Scientist*, LI (9 December, 1971) 773, p. 96.

47. Price, *Little Science, Big Science*, p. 31.

48. Doern, *Science and Politics in Canada* (Montreal and London: McGill-Queen's University Press, 1972), p. 168.

CHAPTER EIGHT

THE POLITICAL ECONOMY OF RESEARCH AND DEVELOPMENT

INTRODUCTION

Now it is time to confront one of the central issues in the Canadian consideration of science policy. It is the claim that Canadian investments in science place an inordinate emphasis on the less socially beneficial activities and sectors of science at the expense of the more socially connected areas. Specifically it is charged that investments are excessive in basic and government research at the expense of developmental and industrial research. Upon the basis of this claim, a variety of changes in the Canadian pattern of investment is advocated by many observers. Before these alternative suggestions are attended to, it is necessary to scrutinize the claim which gives them life. Before competing arguments for change are examined, it is advisable to ask: Change from what? What exactly is the state of affairs? For surprisingly enough, as one critic as recently noted, the idea of change is so headying that these questions are not always asked or answered before a commitment to reorganization occurs.(1)

Although repeated far and wide, chief amongst those who have brought this claim to public attention are the Senate Special Committee on Science Policy of Maurice Lamontagne and the Ministry of State for Science and Technology. The expression of this claim by the Ministry seems to be based on the evidence provided by the Committee, since no additional evidence is cited by the Minister when originally echoing the claim. Hence, the focus here will be limited to the claim as presented by the Lamontagne Committee. It is the purpose of this chapter to criticize one of the fundamental empirical claims which has engendered debate over science policy.

This fundamental claim divides into three parts. First is the claim that Canadian basic research activity and in-house government sector research are high compared to those of other countries. Second is the claim that developmental and industrial research levels are low. Third, it is implicitly claimed that excesses in basic and government research either caused originally or may now cure deficiencies in developmental and industrial research. While the maximum charge of cause can be distinguished from the minimum one of cure, they seldom are and so will not be distinguished to any extent in these pages.

What follows is an attempt to analyse and interpret the evidence which exists relative to this tri-partite claim. This investigation proceeds through three stages. (1) It will be demonstrated that when the methodology employed in describing the activities and sectors of scientific investments is altered, the ranking of Canada in international comparisons of basic and government research changes. (2) Further, it will be argued that in the United States, which is presumably the country of principal, though not exclusive, comparison for

Canadian advocates of science policy, the higher levels of developmental and industrial research, to which many Canadians aspire, are misleading models. (3) Finally, an attempt will be made to describe certain of the economic constraints in the environment of Canadian developmental and industrial research. One of the major factors to be identified will be the operation of the subsidiaries of multinational corporations. Once identified, multinational corporations will be discussed further in Chapter Nine. Generality, it is the purpose of this chapter to determine whether in simple quantitative terms basic and government research stand in a causative or curative relationship to what, if anything, ails developmental and industrial research. And, if not, to suggest a more proper direction for causative and curative analysis. Part (4) summarizes and concludes the chapter.

1. RE-DESCRIBING SCIENTIFIC INVESTMENTS

Normally comparisons across activities and sectors of research and development are taken as proportions of each country's gross expenditure on science. When the base of this comparison is changed from that to gross national product the insuing picture changes. This picture is examined in this part (1.1) first as between basic and developmental research amongst the activities of science and then (1.2) between government and industrial sectors of funding.

Both in volume one and volume two of their report the Senators have specifically maintained that the principal defects of Canadian science are an inappropriate concentration of funds in the activity of basic research,[2] which is by definition taken to have no presently known applied value,[3] and an inordinate effort in in-house government research.[4] Each claim is made on the basis of comparisons of Canada's efforts with those of other industrialized nations which enjoy a comparable standard of living and for which data are available.[5] Investments are compared in terms of the distribution of financial resources across the scientific activity categories of basic, applied and developmental research and across the economic sectors of industrial, governmental, private non-profit and educational research.

From the outset there is reason to be suspicious of comparisons of this kind. When the economies of the countries compared differ by several orders of magnitude, caution is not an unwise posture. One need not be a believer in Walt Rostow's stages of economic growth to appreciate that some thresholds may be reached with their concomitant opportunities in one economy and not in another.[6] The diversity and the intensity of economic activity will be greater and more dynamic in the larger of the two economies. Doubtlessly, it is for this reason that the Organization for Economic Cooperation and Development itself is careful to group data on its members into four distinct classes. Within each class the absolute magnitudes of the gross national products are comparable.[7] First is the United States, in a class by itself. Second is a class composed of France, Germany, Italy, Japan and the

United Kingdom. The third class consists of Austria, Belgium, Canada, Norway, Netherlands and Sweden. In the final class is Greece, Ireland, Portugal and Spain. This same method of classification will be followed here. Accordingly, some of the tabular evidence of original sources will be adjusted to reflect this system of classification. A final caveat needs to be recorded. It is that different countries may be in different positions and make different choices, which are obscured, not revealed by simple ex post facto comparisons. When all is said and done these are, however, only preliminary reservations, not persuasive arguments.

(1.1) Basic and Developmental Research Investments

Support for the claim that allocations for the activity of basic and developmental research are unusual is found in the data summarized in Table 8.1. The table however, reveals that Canada's basic research effort as a percentage of the total effort is well within line with one country of a comparable gross national product, Belgium, and with one of a larger gross national product, Japan. Still the Senators find the ratio of basic to developmental research to be worrisome, as does the second Minister of State for Science and Technology.[8]

To have become worried on the basis of this evidence, the attention of the Senators must have been drawn to Canada's deviation from the model offered by the larger economies of the United States and the United Kingdom. This is apodictic. This concern was reiterated in the release of volume two.[9]

TABLE 8.1

CONCENTRATIONS OF R & D BY TYPE OF ACTIVITY

	UNITED STATES $	FRANCE $	JAPAN $	UNITED KINGDOM $	BELGIUM $	CANADA $	NETHERLAND $	SWITZERLAND $
Basic	14.1	-	26.7	11.0	20.5	23.1	-	14.5
Applied	21.6	-	30.8	24.4	42.2	38.0	-	-
Developmental	64.3	47.8	42.5	64.6	37.2	38.9	48.7	-
Total R & D	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

SOURCE: Senate of Canada, *A Science Policy for Canada*, Vol. I, p. 125.

Caution is necessary in order to prevent resting a case on deviation from the United States example. After all, what nation does not deviate from that example? Deviation alone is no mandate for either change or imitation, no more so than the fact that the United States deviates from the models offered by all other countries necessitates that it should change or imitate. Fortunately, however, antecedent studies show a bit more clearly the nature and scope of the Canadian pattern. Undeniably it is a pattern deviant from the norm of most other countries, not just the United States.

As a percentage of total scientific effort, Canadian investment in basic research exceeds that of six countries, including the United States and the United Kingdom. Meanwhile concentration on developmental research is less than that of seven countries, again including the United States and the United Kingdom. From Table 8.2 it can be seen that in proportion of science categorized as basic, Canada ranks in a tie for fifth out of twelve. For developmental research it ranks eighth. Canada is always on the wrong side of the United States and the United Kingdom, as far as the champions of science policy are concerned, but it is frequently ahead of other economies of the same class. For instance Canada gives less emphasis to basic research than does Holland and more to developmental work than Italy.

Although not conclusive, the evidence is no longer vague. That being so, it is now time to examine scientific investments by activity and sector in more detail. In Table 8.3 the three

TABLE 8.2

BASIC, APPLIED AND DEVELOPMENTAL RESEARCH AS PERCENTAGE OF TOTAL DOMESTIC R & D

	COUNTRY					
Year	UNITED STATES 1964	FRANCE 1963	ITALY 1965	UNITED KINGDOM 1964-65	AUSTRIA 1964	BELGIUM 1963
Type						
Basic Research	12.4	17.3	19.8	12.5	22.6	20.9
Applied Research	22.1	33.9	43.7	26.1	31.9	41.2
Developmental Research	65.5	48.8	36.5	61.4	45.5	37.9
Total R & D	100.0	100.0	100.0	100.0	100.0	100.0
Year	CANADA 1965	NORWAY 1963	NETHERLANDS 1964	GREECE 1963	IRELAND 1963	SPAIN 1964
Type						
Basic Research	22.2	22.2	27.1	23.8	03.5	25.4
Applied Research	40.8	34.6	36.4	53.2	53.1	48.1
Developmental Research	37.0	43.2	36.5	23.0	43.4	26.5
Total R & D	100.0	100.0	100.0	100.0	100.0	100.0

SOURCE: Organization for Economic Cooperation and Development, *Review of National Science Policy: Canada*, pp. 36-7.

TABLE 8.3

CURRENT INTRAMURAL BASIC, APPLIED AND DEVELOPMENTAL RESEARCH BY SECTOR OF PERFORMER

	UNITED STATES 1964 %	CANADA 1965 %
Basic Research		
Business	25.2	07.5
Government	15.9	32.0
Private N-P	09.2	01.2
Higher Ed	49.7	59.3
Total	100.0	100.0
Applied Research		
Business	63.4	30.3
Government	23.4	56.3
Private N-P	02.6	01.8
Higher Ed	10.6	11.6
Total	100.0	100.0
Developmental Research		
Business	83.5	82.0
Government	12.3	15.1
Private N-P	01.3	00.3
Higher Ed	02.9	02.6
Total	100.0	100.0

SOURCE: Organization for Economic Cooperation and Development, *Review of National Science Policy: Canada*, pp. 36-7.

categories of the activity of science are shown by the sectors of performance in the United States and Canada. From this table it can be seen that the government's share of basic and applied research is noticeably greater than that of the United States government. This alone, however, is not sufficient evidence to warrant the conclusion that basic research expenditures represent either the cause or the cure for developmental allocations, for the configuration of that category shows no difference to speak of from that of the United States. Were present Canadian government basic research funds channeled to developmental research that would cause a departure from the model of the American pattern of performance of developmental research. In the status quo there is not such a difference. Indeed, if anything, Table 8.3 shows the Canadian government to be playing a comparatively larger role in developmental research, 15.1% to 12.5%, than the United States government.

Even so, now the source of the Senate Committee's concern can be more clearly isolated. Developmental research is assumed to be the most economically rewarding research. Basic research is assumed to be the least economically rewarding. And developmental research is comparatively less emphasized than basic research in Canada.

Clarity is important at this point. Earlier it was argued that the assumption that developmental research is linked linearly to economic growth was questionable. That claim stands, but it does not refute the assumption at hand.

The case now in view is a more moderate claim. It is that developmental research is *more* related to economic benefits than is basic research, a claim which must be admitted, not without exceptions, but generally.

The question of emphasis on developmental research remains to be answered. It is an empirical question. Normally, it is answered by calculating as a proportion of total research and developmental expenditures those funds concentrated in each category of the activity of science and in each economic sector. These proportions are then compared with those of other countries. This is the conventional method of comparative analysis, as has been done heretofore in Tables 8.1 to 8.3. There is however, a second way to analyze these data.

The alternative method of analysis calls for each of the category and sector funds classes to be calculated as proportions of each country's gross national product. Comparison is then made between each sector and category heading concentrations as proportions of each GNP. This is the standard method by which aggregate research and development expenditures themselves are calculated. Only rarely, and then never in official sources, are sector and category research and development data so treated.

When this alternative manner of analysis is not employed there is a danger. If the total investment of country A is 4.0% of its gross national product and if that of B is 1.0%, the fact that only 25% of B's total goes to developmental research may be far less important in dollars and cents than the fact that its total investment is one-fourth that of A. The total size of the investment may be as important as its distribution. This is a problem only if A is the United States whose gross national product is ten or more times that of country B, if it is Canada.

If scientific expenditures are redescribed in the alternative way sketched above, then the international ranking of the Canadian effort changes considerably. Indeed, if this is done, then our basic research effort empirically is comparatively less than that of the United States relative to the different gross national products--a finding contrary to the impression which the Senators seem to wish to leave.

Nonetheless, it is true that the Canadian developmental research effort empirically is far less than that of the United States. However, this alone does not imply that the effort in basic research is the cause or the cure of the comparatively lesser emphasis in developmental research. Had *all* Canadian investment in basic research for the year 1965 been directed to developmental research, the percentage of the gross national product which developmental research represents would have risen to only 0.6% of our gross national product, as compared to 2.1% in the United States. Moreover, as Table 8.4 illustrates, Canada's Gross Expenditures on Basic Research is not out of line with those of the United States and the United Kingdom. It is 0.29% which is equal to that of the United Kingdom, only slightly in excess of that of France, and *less* than three-quarters that of the United States. A further

TABLE 8.4

BASIC RESEARCH AS A PERCENTAGE OF G.N.P.

COUNTRY	YEAR	GROSS EXPENDITURE ON BASIC RESEARCH %
United States	1963-64	0.42
France	1964	0.28
Italy	1965	0.12
United Kingdom	1964-65	0.29
Austria	1964	0.07
Belgium	1963	0.18
Canada	1965	0.29
Norway	1963	0.18
Ireland	1963	0.02
Spain	1964	0.06

SOURCE: Organization for Economic Cooperation and Development, *Review of National Science Policy: Canada*, p. 24.

TABLE 8.5

GROSS EXPENDITURE ON RESEARCH AND DEVELOPMENT CATETORY OF ACTIVITY: BASIC, APPLIED AND DEVELOPMENTAL AS PERCENTAGE OF G.N.P.

COUNTRY	BASIC RESEARCH %	APPLIED RESEARCH %	DEVELOPMENTAL RESEARCH %
1. United States	0.34	0.63	1.88
2. United Kingdom	0.23	0.48	1.14
3. Netherlands	0.52	0.70	0.70
4. Sweden	n.d.	0.23	0.72
5. Canada	0.23	0.41	0.38
6. Belgium	0.16	0.31	0.29
7. Norway	0.13	0.20	0.25
8. Italy	0.09	0.20	0.20
9. Ireland	0.02	0.22	0.18
10. Austria	0.07	0.09	0.14
11. Spain	0.05	0.07	0.03
12. Greece	0.03	0.06	0.03

SOURCE: Computed from O.E.C.D., *International Statistical Year for Research and Development, Vol.2, Statistical Tables and Notes*, pp. 58-9 and *International Financial Statistics*, XIX (April, 1966), 4.

analysis is provided in Table 8.5.

It is evident on the basis of Table 8.5 that Canada's commitment to basic research has not been comparatively remarkable. Gross national comparisons show the Canadian Gross Expenditure on Basic Research to be quite average. It is developmental research that is exceptional; it is low.

(1.2) Government and Industrial Research Investments

There is a second part to the claim of the Senators, which too is echoed in the higher reaches of the Ministry of State for Science and Technology. It is that too much of Canadian research and development work is done by the central government in its own laboratories.(10) To them this is important on the supposition that governmental research is far less likely to result in material advances. As a point of clarification it should be noted that this supposition seems to be predicated on a slightly different belief than the similar one made in reference to basic research. Basic research is supposed to be less productive because of its distance and isolation from the applications stage. Here the supposition is different. It applies not to the kind of work that is done, but rather to where it is done. The belief is that work done in a government laboratory will stay there without sufficient effort being made to have it exploited. Since governments are not in the business of governing to make money, opportunities may not be recognized or vigorously seized. Thus far the assumption is permissible, but offers no guide to policy. For it to do that, some other kind of research must be nominated to absorb government research funds thought to be excessive. This, of course, the Senators do. Theirs is the alternative of industrial research. Chairman of the Senate Committee's Steering Committee, Allister Grosart, stated the Committee's view thusly:

> "We found that Canada is at the bottom of the comparative international list in research and development performed by industry, but at the top of the government and university sectors."(11)

The assumption here is that industry is more likely than government to try to exploit every aspect of a scientific investment. There is only one difficulty with its application in Canada. It flies in the face of the widespread and well substantiated belief that Canadian industry is neither research nor developmentally oriented because the subsidiaries of multinational corporations which comprise the builk of the high technology fields are not innovative, but only administrative. And it may be for this reason that Canadian industrial and developmental research are low in the first place. As we shall see, while the typical subsidiary does more research than the typical Canadian firm of the same type, it does less than its American counterparts. Hence, these subsidiaries place a lower ceiling on Canadian research in the key high technology fields they dominate. It will not be presumed here that industrial research in Canada is any more likely to be exploited for Canadian benefit than Canadian governmental research.

The basis for the Senator's claim that Canadian governmental research stands out. It is highest in Canada of the ten countries shown. Overall the Canadian configuration in this table is distinctively different from all the other countries shown. The only possible exception to this is France where there is a considerable concentration in the governmental sector and a paucity in the industrial sector.

As will have been surmised, like the first claim, this one suffers from the defect of being relative to the wrong thing. If the absolute expenditures in each sector are computed for each country as proportions of the gross national product, then the degree of Canadian deviance is greatly suppressed. The results of the computations done under the new calculus are shown in Table 8.7. There it can be seen that governmental research in Canada is *less* than it is in the United States. Hence, the Senators' view that Canadian government research expenditures are too high as compared to those of the United States cannot be sustained on either empirical or logical grounds. Governmental research investments are not so disproportionally high as to give credence to the belief that they cause the lacks in industrial research. Were present levels of governmental research causative in that way in Canada it would have to be explained why even higher levels are not so causative in the United States.

Nor can it be the cure. Altogether Canadian governmental industrial and higher education scientific investments come to considerably less of a proportion of the Canadian gross

TABLE 8.6

R & D CONCENTRATION BY SECTOR AS A PERCENTAGE OF TOTAL DOMESTIC R & D

COUNTRY	INDUSTRIAL RESEARCH	GOVERNMENT RESEARCH	UNIVERSITY RESEARCH	PRIVATE NON-PROFIT RESEARCH	TOTAL
U.S.A.	69.8	14.5	12.2	03.6	100.0
France	54.2	32.1	12.9	00.8	100.0
Germany	68.2	05.1	16.3	10.4	100.0
Japan	62.5	13.0	22.9	01.6	100.0
U.K.	64.9	24.8	07.8	02.5	100.0
Belgium	66.8	10.4	21.4	01.3	100.0
Canada	37.7	35.6	26.7		100.0
Netherlands	58.1	02.7	17.7	21.5	100.0
Sweden	69.9	14.2	15.5	00.4	100.0
Switzerland	76.5	06.3	17.1	-	100.0

SOURCE: Senate of Canada, *A Science Policy for Canada*, I, p. 128.

TABLE 8.7

GROSS EXPENDITURE ON RESEARCH AND DEVELOPMENT BY CATEGORY OF SECTOR: INDUSTRIAL, GOVERNMENTAL, PRIVATE NON-PROFIT OR UNIVERSITY, AS PERCENTAGE OF G.N.P.

COUNTRY	YEAR	INDUSTRIAL RESEARCH %	GOVERNMENT RESEARCH %	PRIVATE NON-PROFIT %	UNIVERSITY %
United States	1964	2.11	0.60	0.08	0.41
United Kingdom	1965	1.38	0.54	0.01	0.16
Netherlands	1964	1.07	0.05	0.52	0.40
France	1963	0.79	0.57	0.01	0.23
Japan	1963	0.88	0.17	0.05	0.26
Sweden	1964	0.94	0.22	0.00	0.25
W. Germany	1964	0.85	0.05	0.15	0.27
Canada	1965	0.45	0.36	0.01	0.19
Belgium	1963	0.06	0.09	0.01	0.12
Norway	1963	0.38	0.16	0.02	0.18
Italy	1963	0.38	0.14	n.d.	0.09
Ireland	1963	0.13	0.22	0.02	0.05
Austria	1963	0.19	0.03	0.00	0.08
Spain	1964	0.04	0.11	n.d.	0.01
Greece	1964	0.02	0.11	0.00	0.02

SOURCE: Computed from O.E.C.D., *International Statistical Year for Research and Development*, Vol.2. *Statistical Tables and Notes*, pp. 42-3 and *International Financial Statistics*, XIX (April, 1964) 4.

national product than that of industry alone of the larger gross national product of the United States.

It is worth mentioning the National Research Council in this context because it is singled out for attention by advocates of a national science policy. At times their arguments are made more specific by the claim that the National Research Council dominates the government research sector, and that the Council is preoccupied with an orientation to basic research. In confrontation with the facts of the matter this charge proves difficult to sustain. What is true of government research as a whole is true of that of the Council. First, however, it is important to note that the Council controls only 18% of the total government research investment, which hardly seems to be a portion whereby it could be said to dominate government research.(12) The breakdown of the Council's activities by category shows a display not outrageously dissimilar to the total Canadian picture. However, it is one which is different. That is true. The Council's activities are not devoid of developmental research. Despite these data, the Senators have clearly articulated the conviction that the National Research Council is either causitively or curatively responsible for a good part of whatever it is that ails Canadian science policy and must therefore go.(13)

When investments are compared as proportions of the gross national product, rather than as proportions of gross expenditure on science, Canada's commitments to basic and

TABLE 8.8

INTRAMURAL RESEARCH AND DEVELOPMENT ACTIVITY OF THE NATIONAL RESEARCH COUNCIL BY CATEGORY OF ACTIVITY

YEAR	BASIC RESEARCH %	APPLIED RESEARCH %	DEVELOPMENT RESEARCH %	TOTAL %
1965-6	37.0	51.0	12.0	100.0
1966-7	47.3	43.5	9.2	100.0

SOURCE: For 1965-6, Lithwick, "Science Policy in Canada", *Journal of Canadian Studies*, III (August, 1968) 3, p. 33 and for 1966-7, O.E.C.D., *Reviews of National Science Policy: Canada*, p. 115. More recently one may consider *Federal Government Expenditures*, p. 45.

government science are not remarkable. However, those in developmental and industrial research are; they are low. But, as can now be seen, they are low, not because of excess attention to the former. Rather they may be low because of the overall level of scientific investment.

2. COMPARISONS WITH THE UNITED STATES

The United States is most frequently held up as an example of the kind of policy for science that Canada lacks and needs. Therefore, some brief consideration of its case is warranted. Not the least point relevant to that case is the comment by one observer that said there was no science policy in the United States.(14)

There is no denying the ineluctable political and economic importance of defence and space research and development in the United States.(15) However, if defence and space research are withheld from a comparative presentation of the research and development activities of the United States and Canada, then the pattern of concentration shows no difference whatever. This, Table 8.9 shows.

More than some evidence does confirm the view that defence and space science expenditures are crucial, even determining, factors in American research and development in the developmental category and in the industrial sector. First, it just is the case that defence and space research are primarily, though not exclusively, developmental research. The intention is the applications. That is the purpose of such

TABLE 8.9

RESEARCH AND DEVELOPMENT BY ACTIVITY EXCLUDING MILITARY RESEARCH IN CANADA AND THE UNITED STATES

COUNTRY	YEAR	BASIC %	APPLIED %	DEVELOPMENT %	TOTAL %
United States	1964-5	32.0	53.0	15.0	100.0
Canada	1966	33.7	53.2	13.0	100.0

SOURCE: Lithwick, "Science Policy in Canada", p. 35.

TABLE 8.10

INTRAMURAL INDUSTRIAL RESEARCH BY SOURCE OF FUNDS IN THE UNITED STATES AND CANADA

COUNTRY	YEAR	BUSINESS %	GOVERNMENT %	FOREIGN %	TOTAL %
United States	1963-4	48	52	0	100
Canada	1963	85	14	1	100

SOURCE: O.E.C.D., *International Statistical Year for Research and Development*, Vol.2, *Statistical Tables and Notes*, pp. 42-3.

research, and it is by its purpose that we classify research. In short there is ample reason to believe that defence and space expenditures for science are critical factors in the pattern of developmental and industrial research in the United States. It is worth mentioning that this fact was pointed out in the opening pages of the report on science policy in Canada by the Organization for Economic Cooperation and Development in cautioning against comparisons to the United States.[16] Second, fully fifty-five percent of that American scientific investment goes for military research.[17] From two-thirds[18] to three-fourths[19] of this amount is contracted to business, hence showing up in accounting records in the industrial sector of performance. This sort of research has the same private, amateur status as Russian hockey players. Indeed, as Table 8.10 demonstrates, well over half of industrial intramural research is funded by the central government, mostly it may be assumed, for military research and development. In contrast, the Canadian government is not committed to such programmes and consequently makes no such funding available to the industrial sector. Solely quantitative assessments of science policy too often overlook just such simple facts as these, namely that a good share of the legendary research and development activities of the United States are for military purposes which do not have prima facie social or economic justifications or benefits, as argued in Chapter Seven.[20]

Focusing on qualitative aspects of science policy, if among the primary characteristics of an adequate policy for science is that it be attuned to activities presumably related normally to civilian purposes, then Canada may very well rank rather highly. At best defence and defence-related space research insure only the absence of an external threat, no more. The daily and immediate benefits of such military research are minor, perhaps even limited to only those persons who receive direct payments and profits for overhead expenses in construction and salaries. Presumably research and development aimed at economic problems, like productivity, or social problems, like disease, are of greater benefit than manned orbiting laboratories. Looking at Table 8.11, Canadian research and development activity more than that of the United States is concentrated in just those areas. In fact, on this score the United States ranks a dead last amongst the members of the Organization for Economic Cooperation and Development.

Table 8.12 shows that Canada's placement on the scale of social versus military research orientation is well towards the former. Contrastingly, that of the United States is preponderantly given over with concern to military research whose main socio-economic impact is in overhead costs and wastes.

3. THE ECONOMIC CONTEXT OF CANADIAN INDUSTRIAL RESEARCH AND DEVELOPMENT

It is important now to attempt to understand whether the arguments of leading advocates of a policy for science in Canada are, or are best understood as being, that (i) Canada has too little developmental-industrial research or that (ii)

TABLE 8.11

ALLOCATIONS OF NATIONAL R & D AMONGST DIFFERENT RESEARCH OBJECTIVES

COUNTRY	YEAR	MILITARY %	CIVILIAN %	ECONOMIC %	WELFARE %	TOTAL %
U.S.A.	1963	55	07	28	10	100.0
France	1963	23	22	41	14	100.0
Germany	1964	09	08	62	21	100.0
Italy	1963	06	15	63	16	100.0
Japan	1963	-	-	73	27	100.0
U.K.	1964-5	33	07	51	09	100.0
Austria	1963	01	11	62	26	100.0
Belgium	1963	-	-	82	14	100.0
Canada	1963	16	10	51	23	100.0
Norway	1963	07	07	56	30	100.0
Netherlands	1964	-	-	70	25	100.0
Sweden	1964	08	27	50	16	101.0
Greece	1964	02	27	61	10	100.0
Ireland	1963	-	-	89	11	100.0
Portugal	1964	-	05	72	23	100.0
Spain	1963	05	12	64	19	100.0

SOURCE: Organization for Economic Cooperation and Development, *International Statistical Year for Research and Development*, Vol. I, *Overall Level and Structure*, p. 58.

TABLE 8.12

R & D BY OBJECTIVE, RANK ORDERED, CUMULATIVE RANK

COUNTRY	YEAR	MILITARY	ATOMIC	ECONOMIC	WELFARE	CUMULATIVE
U.S.A.	1963	1	9	15	14	10
France	1963	3	3	15	16	14
Germany	1964	5	8	8	7	11
Italy	1963	8	4	7	10	6
Japan	1963	-	-	3	2	1*
U.K.	1964-5	2	9	12	17	15
Austria	1963	11	6	8	3	3
Belgium	1963	-	-	2	12	6*
Canada	1963	4	7	12	5	10
Norway	1963	7	9	11	1	6
Netherlands	1964	-	-	5	4	2*
Sweden	1964	6	1	14	10	11
Greece	1964	10	1	10	14	11
Ireland	1963	-	-	1	13	6*
Portugal	1964	-	10	4	5	3**
Spain	1963	9	5	6	9	5

*Based on two entries alone. **Based on three entries.

SOURCE: Organization for Economic Cooperation and Development, *International Statistical Year for Research and Development*, Vol.I, *Overall Structure and Level*, p. 58.

it has the wrong kind, and why either conclusion is important. When the Senators speak of international trading competition and the need for Canada to keep pace in the competition, one very distinct impression is given. It is that Canadian industry is under-technologized. This impression needs correction.

To service this correction three points will be discussed. They are (3.1) opportunity costs, (3.2) exploration costs, and (3.3) transfer payments. The third point here is one of considerable interest beyond the boundaries of this correction. It will serve to bridge from this correction to reach other, larger issues, and so will be reserved for discussion in Chapter Nine. Canada is in a group of countries which includes Australia and Norway that shows low levels of investment in research and development.

> "These are countries in which agriculture, forestry mining and fisheries--all industries with a relatively low research input--still make a relatively large contribution to the gross national product. In the particular cases of Canada and Australia a considerable part of the industrial sector is foreign owned and uses to a large extent the results of research 'imported' from parent firms. Payments for these imports, whether real or imputed, are not included in the statistics, but they are extremely important."(21)

With this foreshadowing of the following points let us now take each in turn.

(3.1) <u>Opportunity Costs</u>

In complaining about the existing levels of industrial and developmental research, critics imply that there exist good purposes to which additional funds could be put. Additional purposes are doubtlessly limited only by the imagination of those involved. Whether or not such additional purposes could be achieved is quite another matter. Whether any opportunities were actually forgone is an empirical question. There exists a closely related case in which the answer is arguably no.

What is at issue here is whether untapped capital investment opportunities in technological development existed and exist in Canada. While this question has not been answered, the more general question to which it contributes has been answered. The more general question is the availability of investment opportunities in Canada. Kari Levitt has argued that in fact there are few opportunities.(22) There are few, on her account, because the expansive areas of the economy are in the hands of the subsidiaries of multinational corporations which cannot be invested in since they are wholly owned by the parent corporation, and even the parent corporation may be inaccessible to investment. What is true of the Canadian capital market is no less true of its technological market. Hence, even if a government made money available, finding takers with projects in hand might prove surprisingly difficult.

Specifically as to research and development, there must be some question as to whether or not any opportunities at all have been foregone, because it is not at all clear that the present structure of Canadian industry could absorb any additional research and development activity. No firm should do more research and development than it finds profitable. The present market level of research and development intensity in Canadian industry is 1.2 percent of sales. To reach the levels of industrial research and development advocated by the Senate Special Committee without changing that level of intensity would require an additional 170 billions of dollars in sales. If the intensity were brought up to American levels, 4.0 percent, then an additional 50 billions of dollars of sales would be necessary.(23) To increase the intensity to that level could not be done without considerable changes in the structure of Canadian industry.

(3.2) Exploration Costs

Most of the overall economic significance of levels of research and development lies in the belief that they are activities that lead to economic expansion and diversification, doubtlessly, a modest and sound belief in an advanced industrial society with an industrial structure based on manufacturing. It is manufacturing that technology can expand and diversify. All too obviously the Canadian economy is not based on secondary industry. It is based more on primary industry, and while research and development are certainly not irrelevant to sucy industry, they are far less relevant to established resources industry than to manufacturing. What is more important than research and development to the dynamics of a primary industry is exploration. In a sense, for a primary industry or a primary industry based economy, exploration, not research and development is the most relevant aspect of inquiry. What is most lacking is resources, not the means to extract them. To the extent that this is true, the expansionary drive of the Canadian economy would be better indicated by an index that considered both research and development and exploration investments, rather than by the indicators of research and development alone. Otherwise the Canadian effort in the area of investigation is underestimated.(24)

Minimization of the Canadian effort is misleading enough alone, but what is worse, it is sometimes further distorted by the use of comparative American figures. The procedures of national accounting vary considerably from one country to another. Even where the procedures are similar, because of structural differences in the economies there will be differences in the states of research and development, differences which reflect structural dissimilarities, not the superiority of one case to the other. For instance, because military research aims at the development of some physically large products like rocket launchers, there is much need to build prototypes, to see if they work. Prototype outlays are high; most are virtually handmade. There can be no doubt that there are some projects in which prototype outlays constitute 90% of the total cost of the project.(25) Since Canada does not do this kind of research there are not comparable prototype costs. Hence, these costs pad American figures when compared to Canadian figures. A level of research and development that is padded by such outlays sets an unfair standard for Canadian practice. To the point at hand, the Canadian economy may be less technologized than that of the United States but that alone does not mean that it is under-technologized or that arything could be done about it, let alone that anything should be done about it.

4. SUMMARY AND CONCLUSION

It has been the purpose of this chapter to criticize some of the fundamental empirical claims which have engendered debate over science policy in Canada. From this criticism certain issues have been abstracted for further consideration in succeeding chapters. The first claim to be clarified and criticized is that Canadian expenditures for basic and government research are out of proportion with those of other nations. When the basis is changed of the empirical data in such comparisons this claim is refuted. However, its companion claim of under-investment in industrial and developmental research remains plausible. Through these data a second, implicit, claim is denied. It is that the redirection of all or part of basic and government research funds to developmental and industrial research would make-up the under-investment. The under-investment in developmental and industrial research is shown to be quantitatively greater than the total, let alone any excessive part, of basic and governmental research. On the whole, the Canadian pattern of science investment appears normal, save for industrial and developmental research. On this basis attention was turned to the Canadian gross expenditure on science with the suggestion that the overall quantity of scientific investment, not its distribution, is what sets off the Canadian pattern. That is, the problem lies in an inadequate investment in industrial and developmental research by the industrial sector, and not in the distribution of existing public funds for basic and in-house government research.

It seems to be the assumption of the Senate Committee that deficiencies in the quantity of the activity of industrial and developmental research implies deficiencies in the quantity of the technological products of industrial and developmental research in Canada. Hence, on the first page of its first report, the Committee stressed the dire situation of Canadian industry in a fierce international competitive "technology race" for economic survival and autonomy.(26) That quantitative deficiencies in the activity of industrial and developmental research implies qualitative deficiencies in the technology of Canadian industries is, however, an empirical question. It is the concern of the next chapter to argue that through surrogates like direct purchase, Canadian industry is quantitatively technologized adequately, but that the character of and use of this technology limits its impact on productivity and trade in the world market. Attention will focus here on the role of subsidiaries of multinational corporations in the Canadian economy and polity. If the difficulty arises from the quality--character and use--of

Canadian industrial research and development, then redirection of existing funds or the addition of more funds into the present outlets, while effecting the quantity of industrial research and development done in Canada greatly, will not effect its quality and so will leave facing the same old problems which so worry advocates of science policy.

FOOTNOTES

1. F. Ronald Hayes, *The Chaining of Prometheus* (Toronto: University of Toronto Press, 1973), p. 61.

2. Placement of any item into the activity categories of basic, applied and developmental research is based upon a determination of ~~the in~~tentions of the performer or funder, or both, with emphasis to the funder. See Organization for Economic Cooperation and Development, *International Statistical Year for R & D in O.E.C.D. Member Countries in 1963-64*, Vol. II. *Statistical Tables and Notes* (Paris: O.E.C.D., 1968), p. 389. Cf. for example, H. G. Grabowski, *The Determinants and Effects of Industrial Research and Development* (Princeton, N.J.: Research Memorandum 82, Econometric Research Program, Department of Economics, Princeton University, 1966), p. 63 and National Science Foundation, *National Patterns of R & D Resources, 1953-71* (Washington, D.C.: National Science Foundation, 1970), p. 24.

3. Senate Special Committee on Science Policy, *A Science Policy For Canada*, Vol. I (Ottawa: Queen's Printer, 1970), p. 125. Cf. Lamontagne, chairperson, Opening Statement, *Press Conference on Volume II of the Report* (Ottawa: Senate Special Committee on Science Policy, 1972), p. 6 and P. Calamai, "Study would kill Research Council", *Edmonton Journal*, 18 January 1972, p. 1.

4. *A Science Policy for Canada*, Vol. I, p. 7, and as reported by the Canadian Press, "Senate Study hailed by Minister", *Edmonton Journal*, 20 January 1972, p. 2.

5. See, for example, *Press Conference on Volume II*, p. 6, this despite the admonitions of the O.E.C.D. to the contrary, see O.E.C.D., *Review of National Science Policy: Canada* (Paris: O.E.C.D., 1969), p. 21.

6. *The Stages of Economic Growth* (Cambridge: Cambridge University Press, 1960).

7. O.E.C.D., *International Statistical Year for Research and Development, A Study of Resources Devoted to R & D in O.E.C.D. Member Countries, 1963-4*, Vol. I, *The overall Level and Structure of R & D Efforts in O.E.C.D. Member Countries* (Paris: O.E.C.D., 1967), p. 8.

8. The Honourable Jean Sauvé, "Incentive for Innovation in Canadian Industry", Address to the Canadian Club (Toronto: 1973), p. 11. Cf. Government of Canada (The Gray Report), *Foreign Direct Investment in Canada*, p. 126.

9. *Press Conference on Volume II*, pp. 9-10 and J. Walker and P. Calamai, "Science Report Urges Industrial Revolution", *Edmonton Journal*, 18 January 1972, p. 2.

10. Aurele Beaulnes, of the Ministry of State for Science and Technology, "The Environment for Innovation in Canada", Address to the Annual Meeting of the Technical Section of the Canadian Pulp and Paper Association, Montreal, 1972, p. 9. Cf. Government of Canada, *Foreign Direct Investment in Canada*, p. 127.

11. Alister Grosart, "Canadian Science Policy", *Minerva*, IX (1971) 4, p. 540. Cf. his remarks in *Debates of the Senate*, Vol. 120, No. 15, 4th Session, 28th Parliament, 21 March 1972, p. 202.

12. Dominion Bureau of Statistics, *Federal Government Expenditures on Science, Fiscal Year, 1968-9* (Ottawa: Queen's Printer, 1971), p. 23. See also Scientific Activities, *Federal Government Costs 1958-9 to 1971-2* (Ottawa: Ministry of State for Science and Technology, 1971), p. 4.

13. *Press Conference on Volume II*, p. 6. See also Calamai, "Study would kill Research Council", p. 1 and "Curtailment of NRC is Recommendation"; *Toronto Globe and Mail*, 19 January 1972, p. B3.

14. J. Maddox, "American Science: Endless Search for Objectives", *Daedalus*, CI (1972) 4, pp. 129-30.

15. R. M. Nixon, *State of the Union Address* (Excerpts), United States Information Service, 20 January 1972, p. 5.

16. *Reviews of National Science Policy: Canada* (Paris: O.E.C.D., 1969), p. 21.

17. O.E.C.D., *Overall Level and Structure*, p. 58.

18. *Ibid.*, p. 43. Cf. National Science Foundation, *National Patterns of R & D Resources*, p. 5.

19. George Bach, *Economics* (Englewood Cliffs, N.J.: Prentice Hall, 1966), p. 263.

20. Amitai Etzioni, "Getting R & D Out of Orbit", *American Behavioral Scientist*, VIII (1964), pp. 6-10.

21. O.E.C.D., *Science, Economic Growth and Government Policy* (Paris: O.E.C.D., 1963), pp. 24-5.

22. *Silent Surrender* (Toronto: Macmillan, 1970), p. 139.

23. Science Council of Canada, *Issues in Canadian Science Policy (Sixth Annual Report)* (Ottawa: Information Canada, 1972), p. 38.

24. Explorations costs are included in totals used in Australia. See Department of Education and Science, *Project Score, Report 1. Research and Development Expenditure by the Commonwealth Government in 1968-9* (Canberra: Australian Government Publishing Service, 1973), p. 7.

25. W. Shapley, "Problems of Definition, Concept and Interpretation of Research and Development Statistics", *Methodological Aspects of Statistics on Research and Development Costs and Manpower* (Washington, D.C.: National Science Foundation and the American Statistical Association, 1959), p. 10.

26. *A Science Policy for Canada*, Vol. I, p. 1.

CHAPTER NINE

TECHNOLOGY, MULTINATIONAL CORPORATIONS AND POLICY

INTRODUCTION

A continuation of the analysis of Chapter Eight, this chapter takes as its main perspective at the outset the distinction between qualitative and quantitative deficiencies in Canadian industrial research and development. This is the distinction between the overall level of the activity of industrial research and development and the distribution of that activity in the pursuit of certain products. On the surface the investigations of Chapter Eight indicated that there are undeniable quantitative deficiencies. Now the question is whether or not that lack of industrial research and development has meant a corresponding lack of technology. If it has, then it would seem appropriate to consider policies designed to quantitatively improve the activity of industrial research and development. However, if not, then such policies would be less well advised. The answer given to the question of whether or not deficiencies in the activity of industrial research and development are related to deficiencies in technological products in Canadian industry is no. First the level of Canadian industrial research and development is underestimated by its failure to take into account exploration expenditures and the gain of additional investment is overestimated by virtue of a failure to document the existence of alternative investment opportunities. Moreover, the level is underestimated by the ommision of the intra-company technological transfer payments of the Canadian subsidiaries of multi-national corporations. Considerations of transfer payments leads to the conclusion that the technology is present. How it is created and how it is used, these are the difficulties. Neither of these difficulties will be overcome by increased funding in industrial research and development. Indeed they might be execerbated by such action. They arise from the presence of multinational corporations and are therefore the subject of economic, not science, policy. And economic, unlike science, policy is a political, not a technical, matter, a difficulty, not a puzzle or problem. Because this line of analysis directs attention to the effects of the purchase of the products of science by the subsidiaries of multinational corporations, it was reserved to this chapter in order to allow a fuller treatment of the origins and political context, as well as effects, of these subsidiaries in the Canadian political economy. This treatment divided into two parts, taking the last thing first, the consequences, which show the importance of the issue, and then second the origin and context. Part (1) examines some selected effects of multinational corporation subsidiaries in Canadian industrial research and development, concentrating on transfer payments. Part (2) takes up some aspects of the origin and development of these subsidiaries in the Canadian economy. Each part is itself divided into two parts.

1. THE EFFECTS AND ECONOMIC ROLE OF THE SUBSIDIARIES OF MULTI-NATIONAL CORPORATIONS

This part has five sections: (1.1) reminds us of the easy but unquantifiable technological spillover between Canada and the United States; (1.2) shows subsidiaries to be concentrated in the high growth sectors of the economy, which are the high technology sectors, too; (1.3) describes the extent of intra-company cross-national technological transfer payments; (1.4) discusses two additional effects of subsidiaries directly on the economy, rather than on research and development; and (1.5) summarizes this part.

(1.1) Border Spillover

What spills across the 49th parallel is not technology. The laws do not permit that, but rather information, which may be of one of two kinds: concerning applied and developmental research that stimulates ideas or concerning new technologies which stimulates a Canadian demand. The latter case is usually treated under the heading of advertising spillovers. The former is in the domain of information exchange. Geographically Canada is uniquely situated to enjoy advertising spillover from the United States in both print and verbal media. Such advertising is designed to stimulate a demand for a product which is available in the United States.

Information spillage is a worldwide phenomenon. It extends as far as the language of expression is advanced and comprehended. Still, Canada stands to be exposed to these technological ideas sooner and more extensively than any other country. American technical magazines are available more easily and widely in Edmonton than in Paris.

Together these technological stimuli with their underlying geographical foundation may also contribute to the second factor, which is direct importation. The market stimulation of American technology may easily lead to the importation of technology. Geographical proximity is the most obvious facilitating factor. In its wake others have followed.

(1.2) <u>High Technology Concentration</u>

The ownership of subsidiary companies by multinational corporations in Canada is concentrated in high technology industries. This is so because it is these kinds of undertakings in which multinational corporations have excelled and have built themselves into what they are. In the normal terms of economic accounting the principal high technology industries are chemicals, electronics and aviation.(1) As Table 9.1 and 9.2 show, in these areas there is a substantial presence of foreign owned firms. Twenty-four of twenty-eight chemically based firms; thirteen of seventeen transportation equipment companies; and fifteen of twenty-one electrical firms are owned by nonresident interests. In contrast, only three of the twenty-eight chemical; four of the seventeen transportation and six of the twenty-one electrical firms are Canadian owned.

If it is multinational firms that are highly technologized, then Canadian industry must be fully

TABLE 9.1

NUMBER OF FIRMS, BY INDUSTRY AND OWNERSHIP GROUP, 1970

Industry Group	Ownership Group			Canada	Total
	Private Non-Profit	United States	Other Foreign		
1. Mines and wells	1	2	1	3	7
2. Chemical based	1	20	4	3	28
3. Wood based	1	4	-	4	9
4. Metals	-	1	-	8	9
5. Machinery and Transportation Equipment	-	9	4	4	17
6. Electrical	-	11	4	6	21
7. Other Industries	3	2	2	2	9
TOTAL	6	49	15	30	100

SOURCE: Statistics Canada, *Industrial Research and Development Expenditures in Canada, 1970* (Ottawa: Statistics Canada, 1972), p. 20.

TABLE 9.2

FOREIGN OWNERSHIP AND CONTROL OF CANADIAN INDUSTRY, 1965

	Foreign Ownership %	Foreign Control %
Manufacturing:		
Beverages	28	19
Rubber	74	99
Textiles	22	22
Pulp and Paper	53	48
Agricultural Machinery	62	54
Automobile Parts	91	96
Transportation Equipment	61	80
Iron and Steel Mills	20	14
Aluminum	72	100
Electrical Apparatus	70	78
Chemicals	66	80
Other	52	59
Sub-total	54	59
Petroleum and Natural Gas	62	72
Mining:		
Smelting and Refining of Non-ferrous Native Ores	47	50
Other Mining	63	64
Sub-total	59	60
Total of Above Industries	57	63

SOURCE: A. Cordell, *The Multinational Firm, Direct Foreign Investment and Canadian Science Policy* (Ottawa: Information Canada, 1971), p. 85.

technologized too, because it is dominated by such firms. Certainly these firms do make substantial technological contributions, more than do Canadian firms, as shown in Table 9.3.(2) The full measure of this contribution can best be examined through investments in research and development. Industry in Canada:

> ". . . has access to many billions of dollars of R & D. This exceeds by a factor of perhaps fifty the total R & D done by Canadian industry."(3)

First, the subsidiaries do more research and development work than indigenous firms in the same field.(4) To this extent their presence seemingly elevates the Canadian picture. However, the levels of scientific investment in Canadian industry are lower than those of comparable firms in the United States from whence most Canadian subsidiaries are controlled, as seen in Table 9.4.(5) Accordingly, it has been argued that the levels of investment of these subsidiaries act not as an elevating, but rather as a depressing factor--rather than raising the floor, lowering the ceiling. The main point of the argument is the assertion that while foreign owned firms do more research and development than indigenous companies engaged in the same field,(6) they do less than their own parental counterparts, as shown in Table 9.5.(7) They do less and make up the difference with intra-company transfers. Were foreign-owned corporations not monopolizing the market for high technology in Canadian industry, it is conceivable that the rate of scientific investment in resident-owned corporations would be driven higher by the pressures of the world market,

TABLE 9.3

CURRENT INTRAMURAL R & D EXPENDITURES, BY OWNERSHIP GROUP, 1967-1972

	1967	1968	1969	1970	1971	1972
			in percentage			
Private Non-Profit	4	4	5	6	7	8
United States	45	47	48	43	41	39
Other Foreign	18	16	13	10	10	10
Canada	33	32	34	41	42	43
TOTAL	100	100	100	100	100	100

SOURCE: Statistics Canada, *Industrial Research and Development Expenditures in Canada, 1970* (Ottawa: Statistics Canada, 1972), p. 22.

TABLE 9.4

COMPARISON OF CAPITAL EXPENDITURES AND R & D EXPENDITURES BY INDUSTRY IN CANADA AND THE UNITED STATES, 1970

Industry	Country	Capital Expenditure as % of Sales	R & D Expenditures as % of Sales	Ratio of R & D to capital Expenditures
Electrical and Electronic	U.S.	4.5	8.50	1.80
	Canada	4.0	4.00	1.00
Chemical	U.S	7.1	3.70	0.52
	Canada	9.9	2.40	0.24
Manufacturing	U.S.	4.9	2.60	0.53
	Canada	7.0	0.87	0.12
All Business	U.S.	6.3	1.40	0.22
	Canada	13.9	0.47	0.03

SOURCE: Bourgault, *Innovation and the Structure of Canadian Industry*, p. 65.

TABLE 9.5 A COMPARISON OF R & D PER $1000 SALES IN CANADA AND THE UNITED STATES: MANUFACTURING INDUSTRIES BY SECTOR, 1967

Sector	CANADA Value[a] of Shipments (Sales)	CANADA Current[b] Intramural R & D Expenditures	CANADA R & D Expenditures per $1000 Sales	UNITED STATES Value[c] of Shipments (Sales)	UNITED STATES R & D[d] Expenditures	UNITED STATES R & D Expenditures per $1000 Sales
	$ Millions	$ Thousands	dollars	$ Millions	$ Million	dollars
1. Food and kindred products	7429.27	7807	1.051	82955	122	1.471
2. Tobacco products	493.26	m		4957	m	
3. Textile mill products	1404.939	3700	2.634)	19767)		
4. Knitting mills	325.534	m	)		39	.963
5. Apparel and related products	1176.755	m		20750)		
6. Lumber and wood products	1675.642	856	.511	10875)	11	.594
7. Furniture and fixtures	640.196	157	.245	7634)		
8. Paper and allied products	3231.176	18519	5.731	20927	74	3.536
9. Printing, publishing and allied industries	1297.275	m		21677	m	
10. Chemicals and allied products	2268.769	41095	18.113	42188	1113	26.382
11. Petroleum and coal products	1558.207	16629	10.672	21967	314	14.294
12. Rubber and plastics products	584.357	3543	6.063	12362	140	11.325
13. Leather and leather products	369.115	m		5146	m	
14. Non-metallic mineral products	1082.213	2711	2.505	14569	112	7.688
15. Primary metal industries	3052.537	20000	6.552	47023	181	3.849
16. Metal Fabricating industries	2732.066	4488	1.643	33191	124	3.736
17. Machinery industries	1517.875	13062	8.611	49077	1033	21.049
18. Electrical products industry	2312.519	83261	36.004	43606	2755	63.179
19. Transportation equipment industries	4720.876	43161	9.143	70539	4421	62.675
20. Miscellaneous manufacturing (includes instruments and rel. prod.)	1083.797	11591*	2.442	26673	407*	6.963
Totals	38955.389	270580	6.946	555863	10846	19.512

*In addition to R & D expenditures in the miscellaneous manufacturing sector, these totals include R & D expenditures in all the above sectors which are denoted with an "m". Hence the ratios "R & D expenditures per $1000 sales" have as their base, the sales of these sectors as well as the sales of the miscellaneous sector.

[a]DBS, *1967 Annual Census of Manufacturers*, Preliminary Bulletin, No. 31-208P, Table 2, pages 3-4. Value of shipments of goods of own manufacturers has been used as a proxy for sales.

[b]DBS, *Industrial Research & Development Expenditures in Canada, 1967*, No. 13-532, Table 4, page 31.

[c]U.S. Department of Commerce, Bureau of the Census, *Statistical Abstract of the United States, 1969*, Table 1109, pages 716-721. Value of shipments has been used as a proxy for sales.

[d]NSF, *Research & Development in Industry, 1967*, No. 69-28. Table 22, page 44.

Notes: U.S. figures for R & D include essentially the same costs as are included in the Canadian figures for current intramural expenditures. The only difference in the two sets of figures is that the U.S. figures include depreciation and overhead, whereas the Canadian figures do not.

So that the Canadian and U.S. figures would be comparable, depreciation and overhead were abstracted from the U.S. figures. In Table 22 of the NSF publication, R & D costs are broken down into wages, materials and supplies, and other costs (see sample questionnaire on page 98 and explanation of questionnaire on pages 103 to 105). Therefore, the figures for the U.S. were arrived at by subtracting other costs from total R & D costs.

SOURCE: Cordell, *The Multinational Firm, Foreign Direct Investment and Canadian Science Policy*, p.23.

forces against which these subsidiaries are protected by their parents' technology.

The available evidence for this claim is not direct. One part of it consists in an inference from two established facts: (1) that Canadian high technology industries are nearly exclusively the creatures of multinational corporations, as shown in Table 9.1; and (2) that the research investments attained in these industries are lower in Canada than in the United States. This is to be seen in Table 9.4. The inference is that the cause of the lower level must lie in the most significant part of the industry, which is the subsidiaries, not the indigenous firms.

Moreover, as significant as the contribution of these subsidiaries is, it is declining. This can be partially seen in Table 9.4. There the slight declines in research and development expenditures can be seen in the key high technology foreign dominated industrial fields of chemicals, electronics and transportation. Elsewhere decline is not the rule, as in metals or other industries. In Table 9.7 a decline, as measured by an index of research intensity, is present.

(1.3) Technology Transfer

Simultaneously, there has been an increase in intracompany transfer payments for both royalties and research and development. This is to be seen in Table 9.8. Together these two surrogate scientific investments add eight-four million Canadian dollars to Canadian research and development. That is doubtlessly an underestimation since charges within a

TABLE 9.6

CURRENT INTRAMURAL R & D EXPENDITURES, BY INDUSTRY GROUP
1965-1972

(in millions of dollars)

INDUSTRY GROUP	1965	1966	1967	1968	1969	1970	1971	1972
Mines	6.9	8.1	10.2	10.2	9.9	11.4	11.1	10.0
Chemicals	41.7	50.4	55.5	58.7	61.9	57.0	53.5	55.9
Wood	12.0	15.5	14.8	14.9	14.7	15.4	13.2	13.2
Metals	14.5	15.0	17.7	16.1	22.2	29.0	28.8	35.2
Transport	61.4	56.0	48.4	50.5	59.6	48.1	42.5	45.3
Electronics	58.5	69.0	82.9	82.2	89.7	92.5	98.1	92.0
Other	4.9	6.0	7.6	11.1	11.2	12.9	15.4	18.1
Total	199.9	220.0	237.2	243.7	269.4	266.4	262.4	269.9
Annual Change as percent		10	8	3	10	-1	-1	3

SOURCE: Statistics Canada, *Industrial Research and Development Expenditures in Canada*, 1970, p. 20.

TABLE 9.7

RESEARCH INTENSITY IN CANADA BY FOREIGN-OWNED SUBSIDIARIES, AS R & D EXPENDITURES PER $100 SALES

	1964	1967	1968
	(in millions of dollars)		
1. Total Sales	15,342	20,742	22,484
2. Current Expenditures on Research and Development			
-- Total	98	120	109
-- Abroad	-10	-14	-15
-- Canada	88	106	94
R & D Salaries	+90	+128	+128
Total R & D in Canada Current Expenditures	178	234	205
3. Research Intensity in Canada per $100 sales			
-- excluding salaries	0.58%	0.51%	0.42%
-- including salaries	1.16%	1.13%	0.91%

SOURCE: P. Meyboom, "Technological Innovation" (Ottawa: Economic Development Division, Department of Finance, 1970), p. 24.

TABLE 9.8

RESEARCH AND DEVELOPMENT TRANSFER PAYMENTS BY CANADIAN SUBSIDIARIES TO PARENT CORPORATIONS

Type of Charge	Year (in millions of dollars)	
	1969	1970
Royalties Paid	66	67
Charges for Research and Development	14	17

SOURCE: Department of Industry, Trade and Commerce, *Statistical Supplement to "Foreign Owned Subsidiaries in Canada 1964-1969"* (Ottawa: Department of Industry Trade and Commerce, 1972), p. 20.

company are generally less than the value on the open market.[8] This eighty-four million dollars alone represents a 30 percent addition to Canada's 1970 investment in research and development, as seen in Table 9.6.

The effect of these transfer payments on Canadian industrial and developmental research should not be minimized. In 1969 Canadian industrial research and development consisted of an investment of $344.6 million, in 1970 of $324.6 million. Adding intracompany transfer payments for research and development, these figures rise. In 1969 the subsidiaries of multinational corporations in Canada paid out $66 million in such transfers, in 1970 $67 million. (Here it can be noticed that the research of subsidiaries declined while transfer payments increased by half the amount of the decline.) If transfer payments are added to industrial research expenditures, that for 1969 is increased by 19.15 percent and that for 1970 by 19.55 percent.[9] Developmental research expenditures are elevated too, since most industrial research is developmental research. The effect of this addition can be seen in Table 9.9. Earlier, Table 8.7 related Canadian gross expenditure on industrial research to those of fourteen other countries. Those data were from 1965. All other things being equal, if the average transfer increase of 19.35 percent is made for Canadian figures in 1965, then the Canadian value for industrial research in 1965 ~~is incre~~ased from 0.449 percent of the gross national product to 0.530 percent.[10]

If the assumption is made that industrial research is

TABLE 9.9

CANADIAN INDUSTRIAL RESEARCH AS PERCENTAGE OF G.N.P. WITH TECHNOLOGICAL TRANSFER PAYMENTS ADDED

Year	Gross National Product	Industrial R & D	Technological Transfer Payments	Total	Total as % of G.N.P.
1969	71,390.0	344.6	66.0	410.6	0.57
1970	78,580.0	342.6	67.0	409.6	0.51

SOURCE: Statistics Canada, *Industrial Research and Development Expenditures in Canada 1970* (Ottawa: Statistics Canada, 1972), p. 15; Department of Industry, Trade and Commerce, *Statistical Supplement to "Foreign Owned Subsidiaries in Canada*, p. 20; and *International Financial Statistics*, XXIV (1971) 10, p. 76.

mostly developmental work, an assumption made with especial ease about technological transfer payments, then the Canadian value in Table 8.5 changes in the column for industrial research. It changes from 0.375 percent of the gross national product to 0.434 percent.

(1.4) Effects on Economy

The presence of subsidiaries of multinational corporations has two additional characteristics worth mentioning in passing. The first is in connection with Federal support of research and development and the second is in connection with the balance of payments.

There are six central government programmes pertaining to the support of industrial research. It was in 1961 that the Federal government became active in this regard. In 1972 it is estimated that these programmes contributed ninty-five millions of dollars.(11) This is about twenty-five percent of all Canadian industrial research for that year.

These programmes are designed to underwrite the development of research and development facilities, not to support on-going work.(12) Most likely to have already a facility is a larger company, and most larger companies are subsidiaries. Five qualified scientists and engineers is generally considered to be the minimum critical mass for an industrial laboratory. Fifty-one percent of industrial laboratories in Canada have fewer than five such persons on the staff.(13) Smaller companies are less likely to be in a position to forward an impressive application. After all, they cannot be explicitly

TABLE 9.10

FEDERAL SUPPORT OF INDUSTRIAL RESEARCH AND DEVELOPMENT

Programme	Estimated 1972 Expenditure (Millions of dollars)
1. Defence Industrial Research Programme	4.5
2. Programme for the Advancement of Industrial Technology	25.1
3. Defence Industry Productivity Programme	26.0
4. Industrial Research Assistance Programme	8.4
5. Industrial Research and Development Incentives Programme	31.0
Total	95.0

SOURCE: Pierre Bourgault, *Innovation and the Structure of Canadian Industry* (Ottawa: Information Canada, 1972), p. 58.

or implicitly understood to have the backing and resources of major world corporations in the way which a subsidiary can. Moreover,

> ". . . many small companies, mostly Canadian-owned, complain of having to incur the costs of going to Ottawa, of not knowing just where to go, and of the complexity and time needed to fill the forms, etc."(14)

A large subsidiary will have a liaison officer and even a vice president skilled in these arts. It can be seen in Table 9.11 that foreign owned firms receive the lion's share of research funds made available through the central government.(15) Thus foreign-owned firms spend 46 percent of Canada's total industrial research dollar while receiving 79 percent of the Canadian government's investments in research. Resident owned and non-profit institutions account for 54 percent of the total, but receive 21 percent of the government funds.

The second effect is on the Canadian balance of payments. Subsidiaries operate with the principal purpose of applying products devised elsewhere to the Canadian market by scaling down production techniques, by design modification and by advertising changes. The direction of such firms is solely to the domestic market. The research and development done by subsidiaries is not innovative. It is adaptive as Table 9.12 shows.(16)

> "In no case did we find a Canadian subsidiary that felt it had the freedom to enter foreign markets at will with a product which it thought could be produced in Canada and competitively exported."(17)

TABLE 9.11

SOURCES OF FUNDS FOR INTRAMURAL R & D, BY OWNERSHIP GROUP, 1970

Ownership Group	Sources of Funds					
	Canadian				Foreign	Total
	Reporting Company	Canadian Government	Other	Total Canadian		
	(in million of Dollars)					
Private Non-Profit	25.9	0.1	3.2	29.2	-	29.2
United States	85.0	23.4	1.6	110.0	13.0	123.1
Other Foreign	19.3	6.5	-	25.8	3.1	28.9
Canada	95.6	7.4	12.5	115.5	4.1	119.5
Total	225.8	37.4	17.3	280.5	20.1	300.7

SOURCE: Statistics Canada, *Industrial Research and Development Expenditures in Canada 1970*, p. 22.

TABLE 9.12

NATURE OF CANADIAN INDUSTRIAL RESEARCH PROGRAMMES

(Number of Companies)

Type of Programme	Country of Control			Assets in millions	
	United States	Other Foreign	Both	up to 4.9	5 and over
Adaptative	21	5	26	14	11
Innovative	5	3	8	5	3

SOURCE: A. F. Safarian, *Foreign Ownership of Canadian Industry* (Toronto: McGraw-Hill, 1966), p. 185.

The export performance of these companies is naturally limited. Examination of Table 9.13 shows the high technology foreign dominated industries of transportation, electronics and chemicals not to be export oriented. Hence, these companies and their industrial fields do not aid the Canadian balance of payments situation.

Further, they do it positive harm. These companies and hence their industrial fields import a good deal. For all foreign owned industries there is only a slight margin of exports over imports, as shown in Table 9.14. Since these firms dominate the main parts of Canada's industry, that means the overall importation situation is poor, especially in what should be the leading export fields of high technology. This is to be seen in Table 9.15.

> "In 1963, it was estimated that the balance of trade between Canadian affiliates and their American parents was some $1,063 million in favour of the United States."(18)

As much as 70% of the raw material consumption of subsidiaries consists of imports from parent corporations.(19)

How this happens is very easy to understand. Subsidiaries follow the design and production procedure of the parent corporation. These call for the use of certain materials. The parent corporation has become vertically integrated in its home market and controls these materials. The subsidiary then needs these same materials. Naturally it purchases them from the parent corporation, keeping all the business within the family. Hence it imports, and a look at Tables 9.16 and 9.17 shows that the degree of these parental imports is not small.

TABLE 9.13

EXPORT SALES AS PROPORTIONS OF TOTAL SALES BY INDUSTRY, 1968-1970

Industry	Export Sales as Proportions of Total Sales		
	1968	1969	1970
Mining and Primary Metals	48.1	43.7	47.6
Gas and Oil	13.1	13.8	14.5
Machinery and Metal Fabricating	12.5	13.7	16.4
Transportation Equipment	44.0	50.4	55.0
Electrical Products	13.4	11.7	14.0
Chemical Products	8.0	9.5	9.6
Food and Beverage	5.3	5.1	5.3
Pulp and Paper	57.1	57.7	55.7
Other Manufacturing	7.4	8.1	7.5
Wholesale Trade	49.5	38.5	45.5
Other non-manufacturing	1.0	0.6	0.5
Total	24.4	25.6	26.2

SOURCE: Department of Industry, Trade and Commerce, *Statistical Supplement to "Foreign Owned Subsidiaries in Canada 1964-1969*, p. 16.

TABLE 9.14

VALUES OF TOTAL EXPORTS AND IMPORTS BY THE SUBSIDIARIES OF FOREIGN OWNED INDUSTRY

Year	Exports (in millions of dollars)	Imports*
1968	*13,537	12,162
1969	14,832	14,007
1970	16,750	13,833

SOURCE: Department of Industry, Trade and Commerce, *Statistical Supplement to "Foreign Owned Subsidiaries in Canada, 1964-1969*, p. 15.

TABLE 9.15

PURCHASES ABROAD AS PROPORTIONS OF TOTAL PURCHASES

Industry	Year		
	1968	1969	1970
Mining and Primary Metals	21.7	19.4	19.7
Gas and Oil	24.5	25.5	24.5
Machinery and Metal Fabricating	45.9	47.9	45.1
Transportation Equipment	70.0	72.9	75.0
Electrical Products	32.5	32.1	33.2
Chemical Products	30.4	31.3	31.0
Food and Beverage	19.4	19.5	18.5
Pulp and Paper	7.0	8.3	7.9
Other Manufacturing	33.8	31.6	30.4
Wholesale Trade	24.5	28.1	23.3
Other non-Manufacturing	4.5	5.9	4.3
Total	36.8	38.7	36.9

SOURCE: Department of Industry, Trade and Commerce, *Statistical Supplement to "Foreign Owned Subsidiaries in Canada 1964-1969*, p. 16.

TABLE 9.16

COMPARATIVE IMPORT PATTERNS OF U.S.-CONTROLLED AND OTHER FOREIGN-CONTROLLED SUBSIDIARIES IN 1967

Source of Imports	Reporting Corporation Controlled in:			
	United States		Other Foreign Countries	
	Value	$ Millions	Value	$ Millions
Imports from U.S.	3124	87	178	38
Imports from Other Countries	467	13	294	62
Total Imports from All Countries	3591	100	472	100
IMPORTS FROM AFFILIATES BY U.S.-CONTROLLED AND BY OTHER FOREIGN-CONTROLLED CORPORATIONS				
Imports from Parent or Affiliates in U.S.	2253	87	41	15
Imports from Parent or Affiliates in Other Countries	332	13	228	85
Total Imports from Affiliates	2585	100	269	100
IMPORTS FROM UNRELATED COMPANIES BY U.S.-CONTROLLED AND BY OTHER FOREIGN-CONTROLLED CORPORATIONS				
Imports from U.S. Corporations	871	87	137	67
Imports from other Foreign Corporations	135	13	66	33
Total Imports from Non-Affiliated Corporations	1006	100	203	100

SOURCE: Bourgault, *Innovation and the Structure of Canadian Industry*, p. 93.

TABLE 9.17

IMPORTS FROM PARENTS AND AFFILIATES AS PERCENTAGES OF TOTAL IMPORTS

Industry	Year		
	1968	1969	1970
Mining and Primary Metals	70.2	77.2	78.3
Gas and Oil	85.7	88.6	84.3
Machinery and Metal Fabricating	78.1	79.8	79.6
Transportation Equipment	78.5	78.8	76.3
Electrical Products	64.1	72.4	68.0
Chemical Products	59.8	60.7	55.6
Food and Deveeage	44.7	45.7	43.8
Pulp and Paper	26.1	23.3	30.4
Other Manufacturing	69.0	70.3	70.6
Wholesale Trade	89.1	85.3	83.8
Other Non-Manufacturing	16.4	32.6	42.9
Total	74.9	76.2	74.0

Note: Imports cover merchandise and capital equipment items.

SOURCE: Department of Industry, Trade and Commerce, *Statistical Supplement to "Foreign Owned Subsidiaries in Canada, 1964-1969"*, p.18.

The country of control has a profound effect on where as subsidiary obtains supplies, as shown in Table 9.17.

(1.5) Summary

There is much research and development activity or its equivalent in Canadian industry. That, plus the spillover factors, make it difficult to view Canadian industry as under-technologized. It has technology. What it does not have is the freedom to exploit that technology. The source of the technology also controls it, jealously secluding it. It is the policies of multinational corporations that have led to the situation, not the lack of government poliicies for the support of science. It is the presence of government policies encouraging the presence of multinational enterprises. This is the issue.

> "Canadian industry, because of its structure, has been stripped of that incentive, and no amount of force-feeding of research will create the healthy and vigorous activity that is needed to build a Canadian controlled technology capable of supporting a secondary manufacturing industry."(20)

This problem of ownership rates more than the fifth place attention as assigned to it by the Ministry of State for Science and Technology recently.(21) And multinational corporations are a political, not exclusively an economic or scientific, phenomenon.(22)

2. THE ORIGIN AND POLITICAL BACKGROUND OF MULTINATIONAL CORPORATIONS

There can be few issues that command as wide and as intense a public attention in Canada as the multinational corporation. A handsome shelf of books has accumulated on this topic in recent years. Indicating the importance of the issue, two of these volumes are government reports, the first being the so-called Watkins Report while the second is the Grey Report.(23) What is more, two political movements have focused on this topic, encircling it in concentric bands of policy papers and background studies. Neither the Waffle group within the New Democratic Party nor the Committee for an Independent Canada meant that focus to be exclusive. Intentional or not, there can be little doubt that it was concern with this issue more than any other by which they were identified in the public's mind.

Consequently, public interest in and awareness of this issue have attained levels which make additional contributions here gratuitous. In the pages which follow no attempt is made to add to the store of public knowledge of multinational corporations. The aim is to interpret part of the phenomenon. To interpret it as a political issue primarily. The argument is that the multinational corporation as it has been and is being experienced in Canada is as much the result of political as of economic conditions. One main upshot results from this mode of interpretation. It is that the situation of multinational corporations in Canada is the result of choice and not necessity, and hence might be changed today. This argument points to different ranges of policy options than conventional analyses, which understand unalloyed economic necessity to have led to the development and maintenance of subsidiaries in Canada.

The argument in these pages is that political difficulties have led to the present economic situation. Normally the order attributed to these political and economic difficulties is just the reverse of this. The standard view is that economic necessities have led to the present political situation. Thus, one of the foremost exponents of the importance of multinational corporations, Kari Levitt, writes:

> "The most bitter harvest of increasing [economic] dependence and diminishing [economic] control may yet be reaped in the form of the internal political balkanization of Canada . . ."(24)

That there is internal political balkanization, and "piecemeal absorption into the American imperial system"(25) is not to be denied. What is to be denied is that the economic absorption is alone causing the political balkanization. To the contrary, the argument here is that Canadian political balkanization has also caused economic absorption. More specifically, it is argued that economic absorption resulted no less from political, than economic, balkanization. The *British North America Act* institutionalizes and thereby legitimates and extends the geographic and historical balkanization of the country. This condition in turn permits and indeed invites the penetration of the Canadian economy by multinational corporations.

> "It is wrong to seek economic or financial deficiencies in the Canadian environment to explain the ever-increasing American direct investment in Canada. Political and deficiencies, yes, for American investment has always been encouraged by Canada's political *cum* economic elite."(26)

The Canadian political culture is one in which the political authority relevant to the economy is fragmented into regions by both the spirit and the letter of the law.

It is the intersection of two well known and closely intertwined historical conditions that produce this fragmentation. They are (2.1) the colonial metropolitan-hinterlands division and (2.2) the cultural hetrogeneity of Canada, due to its two cultures. Together these conditions have divided the provinces and the country, making them rivals, competitors for scarce capital, rather than allies.

(2.1) <u>Cleavages I: Metropolis-Hinterlands</u>

The first is the metropolis-hinterland schism. Originally the whole of Canada was a colony, a hinterland, of a European metropolis. The purpose allowed to Canada was to supply the ill endowed metropolitan homeland with large quantities of staples. Developed in the hinterland was primary industry attuned solely to the metropolitan market.

Perhaps the first impression count most, and the first impression of Canada was as a staple storehouse. As that, Canada became known throughout the world, and what is more important, as that, Canada came to know itself. Canada is the storehouse and Canadians are those persons who hew the wood and draw the water in that storehouse to feed the industries of the metropolis.

Thus it was that first French and then English fishing fleets were drawn by the endless cod schools of the Grand Banks of Newfoundland.(27) Once drawn, these fishermen were forced to find techniques of taking and shipping cod on a scale large enough to permit the realization of a profit over the above the high fixed costs entailed by the operation of a fleet at so great a distance from home ports.

The jury is still out on the final evaluation of the theory of staple production as an explanation of the ~~de~~velopment of the Canadian economy. Whether adequate or not as a theory of economic development, the staple theory continues to offer a valuable perspective from which to interpret key aspects of Canadian economic history, including the institutions that produce and are produced by that history.(28)

That staple production has dominated the Canadian econmy is undeniable. Whether or not this dominance has enhanced or debilitated economic development, it has most certainly existed. From the standpoint of the present state of the Canadian polity, one of the principle features of the Canadian staple economy has been that it is capital intensive.

The necessity of extracting staples in maximum quantities is graphically portrayed in the nearly frantic transportation of animal furs by the Hudson Bay Company's expeditions. These expeditions carried no food and took no time to hunt for live game on the trail. Instead they lived from food supplied on contract by Original Peoples living along the way to York Factory.(29) Transportation more than anything else, has been the issue in the history of staple extraction. In short:

> "Reliance upon foreign capital is by no means new to Canadians. It is deeply rooted in the basic structure of our economy and, since before Confederation, has been an essential feature of our development. Spread over great geographical areas, the utilization of Canada's natural resources has taken tremendous amounts of capital management initiative and know-how to develop."(30)

This is the view of one Minister of Industry, Trade and Commerce.

The legacy of such a beginning is twofold. First was a lack of interest in the diversification of the economy of the nation. Second was the reliance on the metropolis for any capital or labour needs.

Canadians behaved in these ways so long that they started to think in these ways too. Accordingly, much of the inheritance of that legacy remains. Aspects of many government policies remain that are attractive to non-resident capital, for example, the tariff wall, the capital gains tax, and incentive grants. Most pervasively, there remains a certain sense of self-consciousness, even inferiority. Most Canadian business people are managers of what other people own, namely the subsidiaries of multinational corporations, and they are content with that.

Proof of a national inferiority complex is not far to seek. Suffice it to say here that the most telling consequence of this complex is that not even the Canadian government normally procures Canadian products in preference to foreign products.[31] Indeed, the Ministry of State for Science and Technology has had to delay its efforts by first advocating a buy Canadian programme within the federal government.[32]

A microcosm of this metropolitan-hinterlands relationship developed within Canada. It developed between the Central Canadian heartland and the vast periphery, where it is especially felt in the West, for reasons which will be treated in terms of geography. It is commonly said, with more than a modicum of truth, that all Canadians are united by one thing, hatred of Toronto.

(2.2) Cleavages II: Cultural Hetrogeneity

There is a second historical condition which effects industrial development. It is the original presence of two cultures within the Canadian nation, French and English. The tensions which produced this duality and the tensions produced by the duality have served to fragment political authority. A certain degree of decentralization of authority over especially social matters was built into the act of confederation, limiting central authority so that Quebec might enter Confederation without fear of losing its culture. Hence, the grants of authority to the provincial governments are considerable. One indication of the political power available in Canada is in provincial governments is the fact that more than one provincial premier with the potential for national party leadership has felt his political aspirations and ambitions to be fulfilled with provincial office.

The limitation of central authority was the desires of Canadiens as their means of protection as a minority in a majority of Canadians. And province-by-province all Canadians are a minority and have the same desire to limit the central government. It is still the Canadien province, Quebec, that advocates and explores provincial autonomy. Of course, this policy is one which is in the interest of more provinces than Quebec; more exploit it than speak of it. Especially attracted to decentralization are the wealthier provinces of Ontario, Alberta, and British Columbia. They, for economic, and Quebec for cultural reasons are happy to limit the central government.

If, as was said earlier, transportation is a critical aspect of Canadian history, it is so because of Canadian geography. It is transportation which is perpetually at a premium. So it was for the separate governments prior to confederation in 1867. Each was much preoccupied by matters of transportation and none too successfully. Each compiled large debts in this enterprise. It has been estimated that three-fourths of each colony's debt at confederation was the result of largely misbegotten rail and waterway construction.(33) These debts were an important issue in the negotiations that led to Confederation. They are specifically acknowledged in the Act.(34) Not only did the newly created state of Canada agree to take over these transportation debts, but it also agreed to do what they had failed to do--establish an eastern transport[illegible] route. Hence, in return for the cooperation of Nova Scotia and New Brunswick, the Confederation assumed the responsibility for the immediate construction of an Intercolonial Railway.(35)

Of course the most singular instance of the importance of capital and technology employed with both political inspiration and implication was the Canadian Pacific Railway. Although Canadians are seldom accustomed to thinking of it as such, the construction of the Canadian Pacific Railway is doubtlessly one of the great engineering achievements of the world's history. Few national railways have encountered conditions either of the variety or intensity, let alone both, as were encountered by the Canadian Pacific Railway in the way of, e.g., sheer distance, soil dynamics, grades, snowfall, temperature, flooding, forests and mountains.(36)

This brings us to a second important feature of Canadian geography. That is simply physical proximity to the United States. For it was the threat of gradual incursions by the United States into the prairies or on the West Coast that inspired Sir John A. MacDonald's first Canadian Government to embark on this engineering feat, so as to unify the country from sea to sea.(37) Naturally, then, the rail line had to follow an exclusively Canadian right of way. Following that route entailed much higher costs due to the considerable geographical obstacles involved. A route around the Great Lakes to the south would have been far cheaper, but it would not have been Canadian. The [illegible]tion that it be Canadian was stipulated by the govern[illegible]der this imposed political condition the venture held little or no appeal to private interests. Consequently, the central government undertood to carry a very high proportion of the total cost.

Prior to the building of the Canadian Pacific, another example of the political importance of transportation lies in the construction of the Rideau Canal (and the already mentioned Intercolonial railway). More recently, there is the example of the Trans-Canada Pipe Line.

Being politically inspired, these endeavours have naturally had political implications, for

> ". . . historically, fundamental political changes have been instigated in order to provide the institutional and political bases for new or improved transportation facilities."(38)

Without being unreasonable, one could say that New Brunswick and Nova Scotia entertained the idea of confederation and finally acceded to it for the purpose of getting the Intercolonial Railway built. Or it could be said that British Columbia joined confederation solely for the promise of the western rail line. British Columbia wanted into Confederation only because of the railway, and was wanted in by the other members, only with the railway which would breathe political life into the legal formalities of confederation.

In their political context, the transportation difficulties presented by Canadian geography yielded a further harvest of consequences.

First, once constructed, such a system as the Canadian Pacific Railway, represented a greater technical capacity than could be absorbed by existing traffic. Consequently, in order to ensure that the system operate at the maximum realizable level, it was decided to grant it a monopoly. Hence, the construction of other--potentially competitive or disruptive--railways was forbidden. The primary target of this exclusion was the everpresent temptation of North-South hookups with nearby centres in the United States. Hence, disallowance was invoked against the Manitoba railway of Premier Norquay in the 1880's.(39) Provinces were denied all legislative authority pertaining to the construction of transportation lines--steam, ship, rail or wire--extending beyond the borders of one province.(40)

This restriction focused trade and commerce, and with them public attention, along a continuous East-West axis, rather than allowing it to pass into a series of discrete North-South orbits.(41) Quite explicitly, the interests of the economic development of the West were sacrificed to the service of national unity.(42) Casualties in the struggle for nation building occur. This was one of them. As a result, Western Canada became, and largely remains today, a colony serving the aspirations of the Central Canadian heartland.

> "It was the fate of the West to become the colony of a colony which brought to its new imperial role neither imagination, liberality nor magnamity,"(43)

an effect magnified immensely by the low fertility of the soil of Western Canada, which fact alone would have caused it to be dependent on the support of the preoccupied but dominant metropolitan centre.(44) Hence,

> ". . . Western Canada has paid for the development of Canadian nationality, and it would appear that it must continue to pay. The acquisitiveness of eastern Canada shows little sign of abatement."(45)

Engineering and technology as embodied in the Canadian Pacific Railway have kept Canada whole. Canada has been kept whole at the expense of a near perpetual state of conflict. Even superb technology can only attenuate; not alter social reality.

Second, and as a consequence of the attempt to unify the country against the southern political menace, foreign corporate forces were actively recruited by the central government. It was these corporate organizations that recruited, assembled and directed the skilled and unskilled labour and the capital that the construction of the Canadian Pacific Railway required. At that time neither engineers nor capital were produced in adequate quantities by the inchoate economy of Canada. These were to come mostly from Britain.

Reliance by the Canadian hinterland on the British metropolis was by no means new upon that occasion. British corporate endeavours had long been a central feature of the Canadian experience: in a phrase, the Hudson's Bay Company. The rich harvest of staples available from the Canadian storehouse of natural resources attracted foreign capital with its attendant structures, while the need for capital at that time left Canadians with a receptive turn of mind. One indication of this receptivity is MacDonald's National Policy in its tariff aspects.(46) It built a high tariff wall which protected Canadian manufacturing, but which also did, and was meant to, encourage foreign capital to locate behind it.(47) This option was especially attractive to American capital, for behind that wall, one had protected access to the small Canadian market, but more importantly, one had favoured access to the whole Commonwealth.(48)

In the latter part of the nineteenth century British capital and business were challenged by newly emergent American enterprises in the world markets. Due to proximity and the tariff wall, much of the attention of these emerging corporations turned to Canada. Depleted and exhaustive by World War One, Britain redirected its financial interests to its own reconstruction. British capital withdrew from its world-wide activities to a noticeable degree. Fed, not depleted by the war, American business flourished and filled the vacuum British withdrawal left, especially in Canada.

The combined effect of these historical influences has been to fragment Canadian society and politics, and therefore in turn, economics. Certainly Canadian regionalism is remarkable.(49)

Essentially, it has been the purpose of this chapter to show that ultimately the determining factor in the political economy of Canadian industrial research and development is the subsidiaries of multinational corporations, and to show further that these subsidiaries are crucially situated in the whole of the Canadian political economy. Once these consequences were indicated, an attempt was made to sketch their origin and political context. This sketch began with the historical identification of Canada as a primary producer. It then pointed out the importance of transportation as a political difficulty and technical puzzle in Canada. It then dwelt on the fragmentation of central authority resulting from the bicultural nature of Canadian society. In short the several provinces were inclined by their own needs to compete with each other for external, scarce capital, and thanks to their autonomy they were and are still able to effect this inclination to a considerable degree. Chapter Ten turns to the more properly geographical background to the regionalized economy and then concentrates on how French-English tensions effect and are effected by the idea of a science policy.

FOOTNOTES

1. Government of Canada, *Foreign Direct Investment in Canada* (Ottawa: Information Canada, 1972), p. 131. Cf. O.E.C.D. *Gaps in Technology*, (Paris: O.E.C.D., 1970).

2. Meyboom, "Technological Innovation in Canada", p. 23 and O.E.C.D., *Reviews of National Science Policy: Canada* (Paris: O.E.C.D., 1969), p. 251.

3. Pierre Bourgault, *Innovation and the Structure of Canadian Industry* (Ottawa: Information Canada, 1972), p. 82.

4. Arthur Cordell, *The Multinational Firm, Foreign Direct Investment, and Canadian Science Policy* (Ottawa: Information Canada, 1971), p. 82. Cf. Government of Canada, *Direct Foreign Investment in Canada*, p. 122.

5. Government of Canada, *Direct Foreign Investment in Canada*, p. 123.

6. *Ibid.*, p. 54. Cf. A. F. Safarian, *Foriegn Ownership of Canadian Industry* (New York: McGraw-Hill, 1966), pp. 280-6; Safarian, *The Performance of Foreign Owned Firms in Canada* (Montreal: Private Planning Association, 1969), pp. 49-53 and O.E.C.D., *Reviews of National Science Policy: Canada*, p. 251.

7. Cordell, *The Multinational Firm, Foreign Direct Investment and Canadian Science Policy*, p. 82 ff.

8. *Ibid.*, p. 53. Cf. Task Force on the Structure of Canadian Industry, *Foreign Ownership and the Structure of Canadian Industry* (Ottawa: Queen's Printer, 1968), p. 96; Government of Canada, *Foreign Direct Investment in Canada*, p. 124; Bernard Bonin, "La firme plurinationale comme véhicule de transmission internationale de la technologie", *L'actualité economique*, XLVI (1971), p.715.

9. All computations made for transfer payments in the following paragraphs were made with a *DCALC programme which uses the computer as a desk calculator.

10. The original source for these data is O.E.C.D., *Reviews of National Science Policy: Canada*, p. 34 and other sources indicated for tables 8.5 and 8.7. Possible transfer payments by other countries is ignored.

11. Bourgault, *Innovation and the Structure of Canadian Industry*, p. 56.

12. *Ibid.*, p. 58.

13. Meyboom, "Technological Innovation in Canada", pp. 11-9 and Lamontagne, "The Sickness of Canadian Industry", p. 20.

14. Bourgault, *Innovation and the Structure of Canadian Industry*, p. 59.

15. See also Government of Canada, *Foreign Direct Investment in Canada*, p. 350.

16. *Ibid.*, pp. 122-3.

17. Cordell, *The Multinational Firm, Foreign Direct Investment and Canadian Science Policy*, p. 57.

18. Charles Taylor, "Nationalism and Independence", *Canadian Dimensions*, IV, 3; reprinted in *Canadian Dimension Kit #3: Canadian Nationalism*, p. 8. Cf. Eric Kierans, "The Economic Effect of the Guidelines", Address to the Toronto Society of Financial Analysis, 1966, p. 1.

19. Levitt, *Silent Surrender* , p. 125. Cf. Government of Canada, *Foreign Direct Investment in Canada*, p. 187.

20. Bourgault, *Innovation and the Structure of Canadian Industry*, 48.

21. "The Environment for Innovation in Canada", p. 17.

22. Robert Gilpin, "The Politics of Transnational Economic Relations", *International Organization*, XXV (1971) 3, pp. 398-9.

23. Task Force on the Structure of Canadian Industry, *Foreign Ownership and the Structure of Canadian Industry* (Ottawa: Queen's Printer, 1968) and Government of Canada, *Foreign Direct Ownership in Canada* (Ottawa: Information Canada, 1972).

24. Kari Levitt, *Silent Surrender* (Toronto: Macmillan, 1970), p. 142. According to Levitt, as a result of American investment "political unity" has "been eroded to a point beyond which lies the disintegration of the nation state." *Ibid.*, p. xix.

25. *Ibid.*, p. 142.

26. W. Pipe, *The Elephant and the Mouse* (Toronto: McClelland and Stewart, 1971), p. 40.

27. Donald Creighton, *The Story of Canada* (Toronto: Macmillan, 1959), pp. 14-5.

28. See particularly K. Buckley, "The Role of Staple Industries in Canada's Economic Development", *Journal of Economic History*, XVIII (1958) 4, pp. 439-50. Cf. H. G. J. Aitken, "Government and Business in Canada", *Business History Review*, XXXVIII (1969), pp. 4-21.

29. J. MacGregor, *A History of Alberta* (Edmonton: Hurtig, 1972), pp. 29-30. Cf. Harold Innis, *The Fur Trade in Canada* (Toronto: University of Toronto Press, 1930), pp.383-6.

30. The Honorable Robert Winters, "Foreign Investment and the Multinational Corporation", Address to Canadian Purchasing Conference, 42nd Meeting, Montreal, 1967, p. 5.

31. Two instances of Government purchasing policy favouring non-Canadian suppliers are easily documented. In 1970 Canada was buying up to 25 percent of its electrical transformer equipment abroad, while the Canadian transformer industry was cutback to 3/4 capacity. See Canadian Electrical Manufacturers Association, *Brief*, Anti-Dumping Tribunal 1970, Exhibit 1, 4, and 17. Another concerns a purchase by the Royal Canadian Mounted Police of a higher American bid over a lower bid by the National Cash Register Company of Canada. See National Cash Register Company of Canada, *Brief in response to Canada Tariff Board Notice R183*, "Computers and Related Telecommunications", 1971. Both cases are discussed in Bourgault, *Innovation and the Structure of Canadian Industry* (Ottawa: Information Canada, 1972), pp. 84-7.

32. The Honorable Jean Sauvé, "Incentive for Innovation in Canadian Industry", Speech to the Canadian Club, Toronto, 1973, pp. 11-2.

33. *The Rowell-Sirois Report, Book I*, D. Smiley, ed. (Toronto: McClelland and Stewart, 1963), pp. 45 and 218.

34. *British North America Act*, 1867-1965 (Ottawa: Queen's Printer, 1965), Sections 114-5.

35. *Ibid.*, Part X.

36. See Canadian Pacific Railways *Brief*, Senate of Canada, *Proceedings of the Special Committee on Science Policy*, 1st Session, 28th Parliament, No. 19, pp. 2961-6; E. Nyland *et al.*, *Response to the Lamontagne Committee* (Edmonton: Department of Physics, University of Alberta, 1973), p. 7; Innis, *A History of the Canadian Pacific Railway* (Toronto: McClelland and Stewart, 1923), pp. 247 and 243; and, especially, J. J. Brown, *Ideas in Exile* (Toronto: McClelland and Stewart, 1967), pp.108-18.

37. Innis, *A History of the Canadian Pacific Railway*, pp.44-5; Aitken, *The State and Economic Growth* (New York: Social Science Research Council, 1959), pp. 79-114; and V. C. Fowke, "National Policy and Western Development in North America", *Journal of Economic History*, XVI (1956) 4, pp. 461-79.

38. Consider J. McDougall, "Regulation versus Politics: The National Energy Board and the MacKenzie Valley Pipeline", Paper read at the Annual Meeting of the Canadian Political Association, Montreal, 1973, especially p. 3. Cf. Ministry of Energy, Mines and Resources, Government of Canada, *An Energy Policy for Canada* (Ottawa: Information Canada, 1973), p. 21.

39. Garth Stevenson, "Continental Integration and Canadian Unity", Background Paper, Committee for an Independent Canada, Toronto, 1972, p. 1.

40. *British North America Act*, Section 92, subsection 10, paragraph a.

41. T. Jackson, "Women in Politics: Pauline Jewett", *The Gateway*, LXIII (21 September 1972) 5, p. 8.

42. See, for example, Ramsay Cook, *Provincial Autonomy, Minority Rights and the Concept of the Compact Theory*, Study No. 4, Royal Commission on Bilingualism and Biculturalism (Ottawa: Queen's Printer, 1969), pp. 36-7.

43. W. L. Morton, "CLIO in Canada", *University of Toronto Quarterly*, XV (1946) 3; reprinted in *Approaches to Canadian History*, Cook, C. Brown and C. Berger, eds. (Toronto: University of Toronto Press, 1967), pp. 47-8. Cf. Innis, *A History of the Canadian Pacific Railway*, p. 294.

44. J. M. S. Careless, "Frontierism, Metropolitanism and Canadian History", *Canadian Historical Review*, XXXV (1954) 1; reprinted in *Approaches to Canadian History*, pp. 80-2.

45. Innis, *A History of the Canadian Pacific Railway*, p. 294.

46. See R. C. Brown, *Canada's National Policy* 1883-1900 (Princeton, N.J.: Princeton University Press, 1965).

47. Pope, *The Elephant and the Mouse*, pp. 17 and 39.

48. *Ibid.*, p. 12 and "Red Tape Hinders Technical Advance", *Edmonton Journal*, 25 April 1973, p. 19.

49. See Douglas Rae, *The Political Consequences of Electoral Laws* (New Haven: Yale University Press, 1971) (2nd. ed.), p. 199.

CHAPTER TEN

INDEPENDENCE, INTEGRATION AND SCIENCE POLICY

INTRODUCTION

Chapters Seven through Nine viewed the wider context of Canadian research and development. In so doing these chapters argued that the wider context added complexity to considerations of science policy. Specifically, it was argued in these chapters that an adequate analysis of problems in Canadian research and development should consider concentration on industrial research and development, high technology industries and hence subsidiaries of multinational corporations, which are mostly United States owned. Canada's admitted lacks in research and development were traced to the industrial-developmental categories. These categories were shown to be dominated by subsidiaries which control the high technology fields of endeavour. Once recognized, this causal analysis has severe policy implications. For example, it suggests that the diversion of more funds to industrial-developmental research, whether or not from basic-governmental research, would be ineffective since it would either go to the truncated element of the high technology fields in Canadian hands or to the subsidiaries, which not only do little research, but dedicate what little they do toward profit maximization within Canada, and not to international trading gains.

Now an added level of complexity is to be offered in this chapter. Chapters Seven through Nine showed that a Canadian science policy would be well advised to concentrate on industrial research and development and the subsidiaries of multinational corporations. These matters concern economic and foreign policy, basic policies of government which have wide ramifications. Indeed because of the continental rationalization of so much of the economy, it might be more useful to think of a good part of Canada's economic policy as foreign policy, and a good part of its foreign policy as economic policy, depending on emphasis. When the role of the subsidiaries of mainly United States owned multinational corporations is discussed, as particularly was the case in Chapter Eight, the emphasis is on foreign economic policy. Foreign economic policy in this case involves important aspects of Canadian independence.

Just as foreign economic policy can be given a domestic emphasis by conceiving it as economic foreign policy, so too Canadian independence as an internal correlate. Thinking of the subsidiaries of multinational corporations and industrial research and development raises key questions regarding Canadian-United States relations and Canadian independence. Around these relations much of the Canadian economy is tied. In its turn the economy raises questions of the relations of Quebec to Canada, as will be shown later in this chapter. In short, because of the interaction of the two, the issue of industrial research and development and the United States raises the question of Canadian independence while the question of the economy raises the questions of Canadian integration as between English and French Canada.

More than many countries, Canada has great difficulties in maintaining its independence and assuring its integration. Geographically independence is threatened by the centrifugal force of the United States. Historically, integration is threatened by the centripetal force of the Canadian cultural duality. Most nations root both independence and integration in a common history and a common culture. Neither of these represents a cohesive influence in Canada. Cultural duality exists from the outset. The historical moments which have welded together other nations have, more often than not, divided Canada, for example, wars. Wars in Canada have deepened cultural divisions, first in the decision to go to war and then in the decision to invoke conscription. Equally, the most romantic and legendary pages of Canadian history are divisive moments, for example, the Riel Rebellions or the MacKenzie-Papineau uprising.(1)

Canada lacks a common history largely because it lacks a common culture. As between the two founding cultures, events that have unified other nations have only divided Canada. A latent tension between these cultures remains today, unresolved by history. Latent, the tension is evoked, not quelled, by national symbols. Canadian currency and postage stamps accordingly picture not the creator of conscription, Robert Borden.

Devoid of a unifying history and culture, Canadians public life has been preoccupied with two difficulties. The first is the integration of the English and French cultures. The second is independence of the United States.(2) Together these difficulties produce great strains on the Canadian polity. Fundamental and yet unresolved, the difficulties are often ignored.(3) Yet they remain implicitly. Of course, while it is cold comfort, what may be surprising in this situation is not that it exists, but that Canada has survived it for so long. "There are two miracles in Canadian history. The first is the survival of French Canada, and the second is the survival of Canada."(4) It might seem more logical to see the French Canadian culture absorbed into the larger English Canadian culture, and in turn to see the remaining, single Canadian culture absorbed by the larger United States culture. It may be that the survival of each contributes to that of the other.

The intersection of independence and integration is pervasive and shows itself even in science policy. Science policy is not a technical problem or puzzle. It grows out of and is shaped by the two central issues of Canadian public life, independence and integration. To indicate the nature of the connection of science policy to integration the pages which follow in this chapter divide into four parts. (1) The first concerns the Canadian political culture, (2) the second the place of French Canada in the political economy, (3) the third the interactions of various ways of dealing with the difficulties of independence and integration and (4) the fourth offers a brief conclusion relating to science policy.

1. CANADIAN POLITICAL CULTURES

Balkanization was discussed in Chapter Nine in terms of independence regarding the subsidiaries of multinationsl corporations owned in the United States. Now it will be treated from the standpoint of integration, between English and French Canada. Balkanization is a complex phenomenon, having both geo-economic and socio-political causes and effects. Recently some have argued that the geo-economic is the more important dimension and is having serious socio-political effects.(5) Uncontested here, the latter claim is accepted, but not the former. To the contrary, here no choice is made between the geo-economic and the socio-political levels. Adequate evidence does not exist to sustain a judgement excluding one or the other level as less important. Since the geo-economic level has been explored by others, emphasis here will go to the socio-political dimension of balkanization relating to integration.

However hard to make analytically or empirically, the distinction between the geo-economic and socio-political dimensions is important. Each has different policy implications. Exclusive preoccupation with either risks ignoring part of the cause, consequence and cure. Emphasis in the geo-economic leads to policies designed to rectify economic puzzles, one of which policies might be science policy. Emphasis on the socio-political leads to policies designed to deal with political difficulties. The socio-political cannot be ignored although it is sometimes confused with the geo-economic. Both are important. What follows, in this part and throughout this chapter, is not so much an attempt to distinguish the two and emphasize the socio-political as it is an attempt to argue that the two can and should be distinguished, that the two interact and that the socio-political can and should be emphasized as much as the geo-economic. To actually make the distinction, document the interaction and develop the emphasis requires a separate study, though as will be seen here, such a study would be importantly related to this one.

When the polity is viewed as fragmented, then, of course, it, and not only the economy, must change, if there is to be integration. The Canadian polity can be viewed as fragmented in the basic sense that confederation was a union of previously separate, distinctive and independent colonies. Once confederated, the desires of the first generation of provincial politicians were to preserve and protect their separate provinces from each other. More importantly, this desire was manifested in the conditions of confederation themselves. The *British North America Act* goes out of its way to recognize and legitimate existing institutions, rather than to create all new institutions.(6) Moved in part by a desire to unite in face of possible American expansion, the colonies wanted some of the benefits of unity in respect of independence, without some of the costs in terms of integration. The *British North American Act* reconciled these desires to its nineteenth century conditions. It vested residual powers in a federal government in Section 91, but it specifically granted to the provinces in Section 92 powers most crucial to nation building and the development of a political culture, for example, the construction and direction of roads, hospitals and schools.(7) It was precisely because the importance of these activities to shaping and moulding citizenship were recognized that they were left to the provinces. Having a linguistically unique culture French Canada through the government of Quebec was perceived and perceived itself as having the most at stake in assuring provincial autonomy. But all provinces resisted the concentration of authority at the centre.

Resistance to centralization was a paradox. Respect for provincial autonomy meant that integration could proceed only under a decentralized government. Yet the original impetus to unity, independence from the United States, suggested centralization. The paradox was resolved by the construction of a federal system of government. Federalism favours decentralization.

> "It is generally understood that federalism places obstacles in the way of national economic planning and the regulation of the private sector."(8)

When viewed from without the Canadian federal government has few of the formal and informal powers over commercial and economic activity that demark other national governments.(9) The price of integration was met, at some risk to independence resulting from the weakened central government. Integration took priority in the final analysis at confederation and it has retained it since, as every national election campaign shows, explicitly or implicitly. Implicitly it is assumed that economic development increases integration.

Efforts to integrate Canadian society have been importantly, if not exclusively, economic. A pre-eminent example of an economic integrationist policy is the construction of the Canadian Pacific Railway. A transportation scheme, it was designed to facilitate interprovincial trade and communication. A number of complex policies were needed to make it as effective and efficient as possible, namely in a system of differential rates.

Railway building in the nineteenth century was tremendously expensive, especially across a continent and through a rigorous climate. Capital requirements exceeded indigenous sources. On an astronomical scale, capital was imported, and skilled labour too. Done in service of integration, these importations undercut independence, physically and mentally. Hence the secondary attention which has gone to independence has had as its first combatting the dependency effects of integration policies.

Giving priority to integration over independence is according to some critics a mistake. In the view of Kari Levitt, for example,

> ". . . the major national problem is not Quebec separation, but the problem of maintaining political sovereignty at a time when economic sovereignty is so gravely threatened."(10)

There is much purchase in Levitt's claim. It is true too, though, that the two, economic integration and political independence, are interrelated. One affects the other. Aiming to elevate economic integration has led to the invitation of foreign interest. "Sous le premier ministre Marchand [circe 1897], les capitalistes Americains sont invités a venir nous exploiter."[11] The result is balkanization.

Balkanization is contributed to by the provincial ownership of natural resources established in the *British North America Act*.[12] This is especially important in those western provinces entering confederation late, where these resources were as yet largely untapped. The combination of the desire for capital and the resources-based nature of the economies of the provinces oriented them to the large market for capital and resources in the United States.[13] Inescapably this leaves provincial governments speaking for the interests that control and/or consume their region's products. Provincial governments became partly the representative of American interests and markets.[14] A series of regional, resource-specialized economies, the provinces are linked southward with adjacent markets and linked east and west with each other. This can be seen in Tables 10.1 and 10.2. Provinces have little in common regarding economic policy across regions. Within regions where they have much in common, they are competitors, not allies, for capital and markets. External economic interests

TABLE 10.1

PERCENT MAJOR COMMODITY REPRESENTS OF REGIONAL EXPORTS TO UNITED STATES

Region	Commodity	Percent
Pacific	Timber	55.0
Prairie	Petroleum	59.0
Ontario	Automotive*	55.0
Atlantic	Timber	42.0
Quebec	Timber	24.0

*That Ontario's major American export commodity is not a resource, indicates the divergence of its interests in U.S.-Canada economic relations from that of the other four regions.

SOURCE: Garth Stevenson, "Continental Integration and Canadian Unity", Background Paper, Committee for an Independent Canada, Toronto, 1972, p. 9.

TABLE 10.2

AMERICAN IMPORTS OF SPECIFIC COMMIDITIES BY REGION

Commodity	Region	Percent
Automotive	Ontario	93.0
Petroleum	Prairies	89.0
Timber	Pacific	75.0
Aluminium	Quebec	73.0

SOURCE: Stevenson, "Continental Integration and Canadian Unity", p. 9.

often find it profitable to play one province off against another to get a better deal.(15)" Since the provinces are not allied, the role of the Federal government is limited.

One concrete sign of the dominance of the separate provinces over the central government is in fiscal resources, which are also crucial to economic planning and policy. Table 10.3 shows that the provincial share of the total of national tax resources has grown considerably. Simultaneously, demands for provincial expenditure in the traditional areas grows. Resource industries "require large scale spending by provincial governments on roads, electric power facilities, forest conservation," and education of the work force.(16)

The negative attitude to the Federal government and the hostility toward other provinces which results from this competition can be seen most clearly in the case of the French Canadian province of Quebec. There are also unique features of the case of French Canadian Québecois which warrant their separate attention. Quebec is important in its own right and as an example.

As for feelings to the central government, notice items three and four in Table 10.4. French and English Canadians alike hold it in low esteem compared to their provincial governments. There exists further differences in attitudes across regions within each culture as shown in Table 10.5. The pattern is indeed a mosaic.

The more unique features of the French Canadian attitude

TABLE 10.3

PROVINCIAL TAX REVENUES AS PERCENTAGE OF FEDERAL REVENUE

Year Ending	Percent
31 March 1958	31.0
31 March 1963	39.0
31 March 1968	71.0

SOURCE: *Canada Yearbook* (Ottawa: Queen's Printer, 1960), pp. 1085 and 1101; *Canada Yearbook* (Ottawa: Queen's Printer, 1965), pp. 975 and 992 and *Canada Yearbook* (Ottawa: Information Canada, 1971), pp. 1148 and 1163.

TABLE 10.4

POINTS OF PRIDE IN THE CANADIAN CULTURES

	English Canadian	(percentages) French Canadian
Geography	75.0	66.0
Economic Resources	67.0	44.0
Form of Government	27.0	13.0
A Region	37.0	96.0
Social Environment	30.0	21.0
Other	44.0	16.0
	*	*

Note: Totals do not attain unity because the responses are not mutually exclusive.

SOURCE: John C. Johnstone, *Young People's Images of Canadian Society* (Ottawa: Queen's Printer, 1969), p. 2.

TABLE 10.5

VARIATIONS IN ORIENTATION TOWARDS LEVELS OF GOVERNMENT BY LANGUAGE AND REGION

DIRECTION AND STRENGTH

NEGATIVE NEUTRAL POSITIVE

A Federal Government		
- 19.7	French	- Quebec
-0.8		- Non-Quebec
+9.2	English	- Atlantic
+9.0		- Quebec
-2.6		- Ontario
-2.2		- Prairies
-5.7		- B.C.
B Provincial Government		
+16.3	French	- Quebec
+5.2		- Non-Quebec
+8.7	English	- Atlantic
-0.7		- Quebec
+8.7		- Ontario
+5.1		- Prairies
C Municipal Government		
-1.6	French	- Quebec
-4.4		- non-Quebec
-17.9	English	- Atlantic
-8.3		- Quebec
-6.1		- Ontario
-2.9		- Prairies
-17.6		- B.C.

20 10 -0+ 10 20 30

SOURCE: Johnston, *Young People's Images of Canadian Society*, p.19.

come out in Table 10.6. It is one which is more fatalistic and less achievement oriented. While subjectively these attitudes may follow from such basics as religion, they have a basis in objective economic reality, as the next part shows. Good grades in school and hard work have in the past brought fewer rewards to French Canadians than to English Canadians.

2. QUEBEC IN THE CANADIAN POLITICAL ECONOMY

There can be no doubt. It is the economic issues which underlie and buttress unity that preoccupy Canadian politics. For instance, even in the relatively favourable year of 1968, the major post election academic survey found economic issues to be those important for identifiers with all parties.(17) As true as this may be for all Canadians, it is particularly true for French Canadians. Editor of *Le Devoir*, Claude Ryan, wrote, and was quoted approvingly by the leader of the Parti Québecois, "Economic policy, is in our times, the very essence of governmental action at every level."(18) For French Canadians "Canada has value . . . . only insofar as it constitutes a protection . . . for their culture."(19) The economic stagnation alleged to ensue from Quebec separation is less a determinant in an already stagnant economy, leaving open the question of "pourquoi l'unité politique si la cohesion économique n'existe plus?"(20)

To the French Canadian the economy and its attendent economic policy provide the nurture of their culture and

TABLE 10.6

FACTORS PERCEIVED AS AFFECTING PERSONAL SUCCESS IN THE CANADIAN CULTURE

Factor	Percentage Citing Factor		
	English Canadian	French Canadian	Other Canadian
Good grades in school	95.0	69.0	94.0
Hard work	94.0	47.0	90.0
Good personality	85.0	69.0	77.0
University Education	80.0	49.0	83.0
Knowing the Right People	50.0	51.0	61.0
Being bilingual	39.0	75.0	45.0
Coming from right family	23.0	27.0	27.0
Coming from right religious group	11.0	32.0	35.0
Being born in Canada	10.0	22.0	2.0
Having Parents with Money	6.0	11.0	11.0

SOURCE: Johnstone, *Young People's Images of Canada*, p. 8.

society. Such a feeling may have characterized French Canadian thought for some time, but it was importantly changed in the early 1960's, for until that time the claims over the economy made by governments of Quebec had been limited to protecting existing culture. It was because these rearguard actions were unsuccessful that the Lesage government undertook to claim economic authority, not to protect the pale remnant of the culture but rather to restore that remnant to its former flower. Lesage and la révolution tranquille sought to preserve the culture and the language by reaching out to new areas of jurisdiction, for example, claiming control over immigration as a labour matter. Québecois "are now moving with the conviction that their survival as an ethnic entity depends on gaining a deciding voice in the economy."(21)

If the diminution of French Canadian culture is due to economics, then it is due to politics, for economics is partly shaped by politics. Today

> ". . . the French Canadian nationalist is convinced that the existing political order is responsible for retarding his progress and must therefore be modified in some way."(22)

The movement is toward a "wider use of state powers to achieve French Canadian aspirations."(23)

That Quebec should have economic grievances against Canada is not surprising. Fully eighty per cent of the province's economy is controlled from outside its borders.(24) Moreover, "in the past French Canada has benefited substantially less than the English speaking population from participating in the Canadian state."(25) This can be more specifically illustrated by certain census findings.

Table 10.7 gives an occupational categorization of the Quebec labour force in 1931, 1951 and 1961. As can be seen from the table, the proportion of the total labour force in middle class white collar occupations has been increasing, while the proportion represented by primary and unskilled labour has decreased since 1931.

Though the Quebec bourgeiosie enlarged, it was not extended to Québecois as rapidly as it was to Quebeckers. English Canadians more than French Canadians were recruited and mobilized upward. In Table 10.8 there is represented the under and over representation of persons of British and French ancestory. Clearly,

> ". . . for French there was some increase from one generation to the other in the white collar group, but the increase [between generations] was not as great as it was for the British."(26)

This can be seen from Table 10.9 where a comparative picture of the occupational distribution of the English and French labour forces of Quebec is shown. There is a trend of embourgeoisement for both groups, but much more slowly for Québecois.

"Ethnic origin . . . continues to be an important differentiation of social-economic data" in Canada.(27) This can be seen more clearly from data compiled by the Royal Commission on Bilingualism and Biculturalism.(28) These findings have attained a wider circulation and need only to be

TABLE 10.7

OCCUPATIONAL LEVELS OF FRENCH AND BRITISH MALE LABOUR FORCE IN QUEBEC, 1931, 1951, 1961

		Percentage of total Quebec labour force
1931		
Professional and financial		6.2
Clerical		4.7
Personal Service		3.8
Primary and unskilled		19.6
Agricultural		[illegible]
All others		[illegible]
	Total	100.0
1951		
Professional and financial		6.0
Clerical		6.4
Personal Service		3.4
Primary and unskilled		13.4
Agricultural		16.6
All others		54.2
	Total	100.0
1961		
Professional and financial		7.8
Clerical		7.8
Personal Service		4.5
Primary and unskilled		10.4
Agricultural		9.1
All others		60.4
	Total	100.0

SOURCE: *Census of Canada, 1931*, Vol. 7, Table 49; *Census of Canada, 1951*, Vol. 4, Table 12 and *Census of Canada, 1961*, Vol. 3.1-15, Table 22.

TABLE 10.8

PERCENTAGE OVER- OR UNDER-REPRESENTATION IN OCCUPATIONAL LEVELS OF FRENCH AND BRITISH MALE LABOUR FORCE IN QUEBEC, 1931, 1951, AND 1961

	Percentage over- or under-representation	
	British	French
1931		
Professional and Financial	+5.0	-0.9
Clerical	+7.1	-1.4
Personal Service	+0.5	-0.5
Primary and unskilled	-7.5	+0.3
Agricultural	-10.6	+4.8
All others	+5.5	-2.3
	0.0	0.0
1951		
Professional and Financial	+6.1	-1.2
Clerical	+6.3	-1.1
Personal Service	-0.2	-0.2
Primary and unskilled	-6.1	+1.1
Agricultural	-7.9	+2.5
All others	+1.8	-1.1
	0.0	0.0
1961		
Professional and Financial	+7.1	-1.5
Clerical	+5.2	-0.7
Personal Service	-1.4	-0.4
Primary and unskilled	-6.0	+1.1
Agricultural	-4.4	+1.6
All others	-0.5	-0.1
	0.0	0.0

SOURCE: *Census of Canada, 1931*, Vol. 7, Table 49; *Census of Canada, 1951*, Vol. 4, Table 12 and *Census of Canada, 1961*, Vol. 3.1-15, Table 22.

TABLE 10.9

ENGLISH CANADIAN AND FRENCH CANADIAN ETHNIC ORIGINS AND SELECTED MALE OCCUPATIONAL CLASSES, 1931, 1951 AND 1961

	English Canadian	French Canadian
1931		
Professional and Financial	6.4	4.0
Clerical	5.6	3.0
Personal Service	3.5	3.2
Primary and Unskilled	13.3	21.0
Agricultural	27.9	34.1
All others	43.3	34.7
Total	100.0	100.0
1951		
Professional and Financial	7.5	4.4
Clerical	7.7	5.1
Personal Service	3.2	3.2
Primary and unskilled	11.6	16.3
Agricultural	13.9	19.1
All others	56.1	51.9
Total	100.0	100.0
1961		
Professional and Financial	10.6	6.7
Clerical	8.2	6.7
Personal Service	3.4	4.1
Primary and unskilled	7.7	12.8
Agricultural	10.7	10.8
All others	59.4	58.8
Total	100.0	100.0

SOURCE: *Census of Canada, 1931*, Vol. 7, Table 49; *Census of Canada, 1951*, Vol. 4, Table 12 and *Census of Canada, 1961*, Vol. 3.1-15, Table 22.

referred to here. In income the average Canadien earns 20% less than the average Canadian. In all provinces the Canadien is 17% under the provincial average. This difference is greatest in the province of Quebec. There, the French Canadien average is 35% less than that of the English Canadian. English Canadians are 40% above the Quebec average, while French Canadians are 12% below it.

The most highly educated English Canadians are the Quebeckers. Québecois are much less educated, and benefit economically less from an equivalent education. The Commission calculated that a Bachelor of Arts degree incremented the salary of a Jewish Canadian $4171, an English Canadian $4007, an Italian Canadian $3695 and a French Canadian $3290.

The closer we move to the centre of French Canada, the greater becomes the differentiation in favour of Canadians. Overall the differentiation is figured at 8%. Within the province of Quebec it is placed at 16%, and in the city of Montreal at 22%.

By the same token, because of the fact that 80% of Quebec commerce is controlled from non-Quebec sources, French Canadian firms exercise only a small economic role. They are limited to local business. Exports from majority owned French Canadian firms composed only 4.5% of Quebec's exports.

English Canadian ownership is concentrated in middle-technology and middle-profit industries. Subsidiaries of multinational corporations dominate the high technology, high profit industries. Left to French Canadians are the low technology and low profit endeavours. This differential concentration shows itself in worker productivity. A worker in a subsidiary produces at the rate of $12,200 a year, a worker in an English Canadian firm at $8,400 a year and in a French Canadian firm at $6,500. Naturally wages will not exceed productivity.(29) In short,

> "Our examination of the social and economic aspects of Canadian life (based on 1961 census figures) shows that there is an inequality in the partnership between Canadians of French origin and those of British origin. By every statistical measurement which we used, Canadians of French origin are considerably lower on the socio-economic scale. They are not as well represented in decision-making positions and in the ownership of industrial enterprises, and they do not have the same access to the fruits of modern technology. The positions they occupy are less prestigous and do not command as high incomes; across Canada, their average annual earnings are $980 less than those of the British. Furthermore, they have two years less formal education. Quebec manufacturing firms owned by Francophones produce only 15% of the provincial output."(30)

In a large part, the plight of French Canadians must be admitted to be the result of institutional failure in Quebec,(31) but it is a failure convenient to external interests and either or both anticipated by willing Quebec authorities or encouraged by those interests.(32) Essentially the failure lay in the Quebec educational system, and secondarily with the unemployment and welfare mechanisms.

Its educational system was directed to traditional pursuits of little value in the industrial society enveloping Quebec. "French Canadian education was never geared to the provision of industrial skills at the managerial or technical level."[33] Québecois had few resources with which to compete in the free market. Undeveloped welfare and unemployment measures left little protection to the casualties of industrialization.

Instead of being public responsibilities, education and welfare were long left to the Roman Catholic Church of Quebec. And the Church left them in their nineteenth century forms, so that Catholic Quebec was endowed with a large and unskilled labour force, a labour force strictly dependent on the Church. This made Quebec attractive to entrepreneurs who saw advantages in a complacent work force. This became Quebec's main selling point in industrial recruitment, as the Duplessis government preserved the disorganized state of the Quebec labour force with padlock legislation.[34] Even today, Québecois are under-unionized.

It is no coincidence then that first among the reforms of the Lesage government was education, beginning with the Royal Commission of Parent and leading to the creation of the CEGEPS. Modernizing the educational system alone would not have been enough, of course. Its trained products must be employed. Only then can Québecois talent be fully developed and matured. For this reason, under the leadership of René Levesque, the minister responsible for natural resources, the Lesage government nationalized approximately seventeen hydro companies which had been serving Quebec. Thereby created was Hydro Quebec to serve as an employer and developer of a Quebecois technocracy. While the evidence from the 1971 census data is not yet in compatible form to that used in Tables 10.7-10.9, there can be no doubt that the Lesage efforts were successful, so that the 1961 trends of Québecois embourgeoisement have continued.

However the problem is far from solved. La révolution was doubtlessly more successful at elevating the skills and expectations of Québecois through education than at meeting them in the economy. After all, only 20% of the province's commerce is controlled within the province.

In Quebec there would seem to be a disjunction between the population pyramid and the opportunity pyramid.(35) The population pyramid refers to the quantitative and qualitative features of the people of Quebec, their number by level and kind of education, skill, and abilities. The opportunity pyramid is the socially available complex of outlets available to that population, the number of technical, managerial positions, books and magazines to be read or published by and in one's own language, the positions available in advanced education, seats in a library, or conditions of employment. Where the opportunity structure mirrors the population structure the talents of people are fully employed, thereby fully meeting the ambitions and aspirations which led to and follow from those talents. Where the opportunity structure fails to do this, the aspirations of people exceed their expectations.

Of course, no where are these two structures perfectly congruent. So long as their discongruence is marginal, it is all to the good. Marginal discongruence is stimulating. The population is led by its aspirations to alter the opportunity structure. However ill defined, it is clear that there are thresholds at which such incongruities become dysfunctional. Then they are perceived as repressive.

There is a mismatch between the Québecois population and the opportunity structure available to it. Aggregatively, the intensity and diversity of the opportunity structure available for Québecois aspirations is poorer than that of English Canadians. This would be true for one reason, if no other. That reason is that Québecois are confined to one province whereas Canadians have nine provinces across which to seek their opportunity. Unlike most other Canadians, hope does not spring eternal for them in the prospect of migrating to Toronto. To do so they would have to cross a cultural barrier no other Canadian is asked to traverse.

In the comparative returns on a Bachelor of Arts degree we saw earlier one indication of the disadvantage of the Québecois opportunity structure, though we saw also in Tables 10.7 to 10.9 that the structure is changing.

Still, this much seems clear. The opportunity structure of Québecois generated by the present role of development is inadequate compared to the aspirations which have been aroused and nurtured. The Quiet Revolution has turned into a revolution of rising expectations. One sign of this is the fact that the most tempestuous cauldrons in Quebec society are the very CEGEPS where these aspirations have been and are being extended.

The main indicator that a revolution of rising expectations has been released lies in the Parti Québecois. The Quiet Revolution began to create a French Canadian middle class in Quebec. That beginning has not yet been completed in over ten years. A certain number of Québecois have come to experience and to appreciate the challenges and rewards of middle class society. At the same time these Canadians see these experiences not offered to most of their fellows, and they see many of its extremes beyond the training and skills available to themselves. It is the Parti Québecois which is squarely aside the crest of this revolution of rising expectations.

The Parti Québecois offers a substitute opportunity structure to the inchoate French Canadian bourgeoisie much less satisfactorily than did Hydro-Quebec for their elder siblings. Members of the Parti Québecois are by and large younger, more educated, more likely to be bilingual, more likely to be in the professions and living in a city than members of any other political party in Quebec. This can be seen in Table 10.10. Those most like the Canadian middle class in skill and desire feel the effects of the cultural and linguistic barrier most.

The "Parti Québecois party [sic] strength appears to be concentrated primarily in the Montreal area and among the young middle class."(36) The party is found appealing to these people "as a way of escaping their predicament," in the

TABLE 10.10

SELECTED SOCIAL CHARACTERISTICS OF A SAMPLE OF QUÉBECOIS BY PARTY OF PREFERENCE

	Union National	Liberal	Party Québecois
Age			
18-24	20.0	23.0	40.0
Education			
Post Secondary	14.0	23.0	45.0
Occupation			
Professional	20.0	20.0	46.0
Sex			
Male	22.0	25.0	31.0
Language			
Bilingual	18.0	23.0	29.0
N = 428			

SOURCE: Selected from Jane Jenson and Peter Regenstreif, "Some Dimensions of Partisan Choice in Quebec, 1969", *Canadian Journal of Political Science*, III (1970) 2, p. 310.

present by offering an alternative opportunity structure and in the future by influencing certain social changes.[37]

The desire of the bourgeois revolution of the Parti Québecois is to further the development of Quebec, to expand the opportunity structure open to Québecois, a goal which can be (1) incrementally assuaged by government efforts at co-optation or, (2) by independence.

Quebec is not the least economically developed region in Canada. To the Maritimes must go that honour. However, Quebec is the most entrapped economy. The limits of a Québecois's world is the French language.

3. INTEGRATION, INDEPENDENCE AND QUEBEC ECONOMIC ASPIRATIONS

Québecois, especially in the Parti Québecois, wish wholeheartedly for continued and increased economic expansion. The importance of foreign capital has been emphasized by Jacques Parizeau, economic critic for the Parti Quebécois.[38] Members of Parti Québecois

> ". . . veulent que la moyenne bourgeoise québecoise remplace jusqu'a un certain point la bourgeoise canadienne-anglaise et négocie de nouveaux rapports l'exploitation avec les capitalistes américains,"[39]

thinking that they can get a better deal than has been gotten for Québecois by Ottawa.[40] One area of priority in these negotiations would be capital investments in research and development. All scientific expenditures in Quebec amount to only 0.7 percent of the gross provincial product, as far from the Canadian national figure as that figure is from that of the United States.[41]

Inside or outside of confederation, Quebec still wants capital, more than it generates. The capital is wanted in such things as scientific investments to permit Quebec and Québecois "to catch up with English Canada through encouraging American investment in Quebec."[42] Substantial and rapid economic development is impossible without non-Canadian investment.[43]

> "Les Québecois sont en général favorables a une plus grande présence du Québec a l'etranger. Ils pensent de plus que c'est l'aspect économique qui est le plus important dans les rélations internationales du Québec et qu'elles deviquient se faire surtout avec les Etats-Unis."[44]

Even while continually eager for non-resident investment Québecois want to safeguard control over their economy. And this is threatened by foreign investment. But there is no contradiction. Québecois nationalists claim that non-resident capital can be in the form of loans not equity, just as was the early foreign capital that financed American development. These controls would be effective only if they were not thwarted by central government policies to the contrary or undercut by the conditions offered by the other provinces. The latter is almost inevitable short of the interdiction of the central government. Were Quebec alone to apply such criteria, capital would flee to more relaxed conditions elsewhere, a Brinks job on a large scale.[45] The former has occurred on occasion in the past, perhaps one illustration of which would indicate some of the myriad of issues at stake.

In 1966 the Liberal government of Quebec was eagerly involved in encouraging the development of Quebec business. To redress a balance of payments deficit the Secretary of the Treasury of the United States, Henry Fowler, took steps to discourage investments abroad. This action met the approval of Canadian Finance Minister Mitchell Sharp. It did not meet the approval of Quebec Finance Minister Eric Kierans. In an unusual move, Kierans contacted Fowler directly. Kierans charged that the restraint on the in flow of American capital would upset the equilibrium of the Canadian capital market. It would do so by obliging the subsidiaries of multinational corporations to seek financing in Canada and not from parent corporations. Canadian banks would be attracted by the superior guarantees and track records of the American owned firms so that funds would not be available to Quebec firms. Fowler's guidelines in effect made the subsidiaries policy instruments of Washington and not merely profit-seeking extensions of their companies, because they were put to work in deepening ties of dependence, Kierans claimed. Coincidentally, Fowler said the United States firms abroad "have not only a commercial importance . . . but a highly significant role in United States foreign policy."(46)

Even if Canadian capital were available in adequate supply to service the Quebec market, it is not at all clear that it would actually be put to work there. Canada now may well generate ample capital to be sure. But Toronto or Westmount capital may consider East Montreal an unattractive and unstable prospect, due partly to first hand experiences and partly to an overactive imagination, while foreign capitalists would not be so detered, having neither vantage point. Moreover, the prospect of being dependent on Canadian capital probably appeals less to Canadiens than does American capital, American capital has not yet pulled a Brinks job in Quebec, but English Canadian capital has. With capital dependency goes political domination, as Canada is learning in respect to the United States, and Quebec has long known in respect of Canada. No matter how delicately it is put, "la domination politique et la domination économique sont inextricablement liées" as a young Pierre Trudeau once observed.(47)

While Quebec has not been the least beneficiary of the economic development made possible by foreign capital, Ontario has certainly been the greatest beneficiary as noted in its distinctive concentration in manufacturing in Tables 10.7 and 10.8 Ontario has been very well situated for connections with the United States in view of its proximity to the heartland of the continent. United States capital found its way from Chicago and New York to Toronto sooner and more easily than to Halifax or Vancouver, just as products from Ontario had a comparatively easy route to Chicago and New York.

Ontario, or more precisely Southern Ontario, offers the highest degree of industrialization in Canada. It therefore supports what is the most diverse and intense opportunity structure too. All roads lead to Toronto and with good reason.

> "Basically the Quebec argument is that Canada's economic policies have traditionally favoured Ontario to the detriment of the other provinces."(48)

Ontario's economic development has reached matured backward linkage effects to secondary industry and forward linkages to tertiary sectors. It has given rise to manufacturing and service industries as those who cut timber, buy clothes; and those who make the clothes, check books out of the library. The congruence of the Ontario population pyramid to its opportunity structure is doubtlessly the best in Canada. Even if it falls on hard times, it falls more gently. What is more important, in hard times those excluded can hope to gain entry to or advancement in the opportunity structure later, unlike those in the Québecois structure.

Being as well off as it is, Ontario is now in a position to contemplate the termination of incoming capital. Few sacrifices would fall to Ontario now. It is in a position to afford independence and perhaps even to find it profitable. It is not surprising that so many of the landmarks of the renewed interest in Canadian independence have arisen in Ontario, specifically the Waffle faction of the New Democratic Party and the Committee for an Independent Canada. In Ontario too, there has been a Royal Commission on book publishing and it can be used to illustrate how independence can profit Ontario. Now that a colony of writers of critical self-sustaining mass has arisen on Ontario, they could capture the whole of the Canadian market without American competition under the justification of nationalism, or what is good for Ontario is good for Canada. As Robert Stanfield has said,

> "Je n'ai rien contre ce nationalisme canadien, mais je dis que dans la circonstances il éxprime plus une préoccupation des milieux d'affaire du entre du Canada et surtoit de l'Ontario qu'un sentiment d'indépendence nationale parmi les Canadiens, d'un ocean a l'autre."(49)

Certainly it is Ontario, more than, say, Alberta, that favours the screening of additional foreign investment.

At the root, the question is constitutional. Now in its unique position Ontario can afford to prefer centralization. Quebec resists centralization, preferring decentralization to avoid the particular kind of centralization favoured by Ontario.(50)

Independence to a degree freezes Canadian economic development, social integration and hence unity. At their present levels this may be an acceptable tradeoff to many provinces. The Canadian economic level would be frozen in whatever proportion it was to the United States at that point. This would be an inferior, but easily tolerable level on average. But it would also and in the same way freeze Quebec's inferiority vis-a-vis the remainder of the country. This is not tolerable to Québecois.

Defending Canadian sovereignty by making war on multinational corporations could be enough to solidify Quebec's backward status in Confederation. "The trouble comes from Quebec, and from nowhere else."(51)

4. SCIENCE POLICY AND CANADIAN-QUEBEC DIFFICULTIES

Quebec favours decentralization as the best means available to it to expand its economy so that it can attain levels of the distribution of goods and services attained elsewhere in Canada. Some years ago Senator Lamontagne wrote that "l'abondance constitue sans doute le plus vieux rêve de l'humanité."(52) He argued further that science and technology are the uniquely modern mechanisms by which to expand production and attain abundance. Through the effects of mobilized science the Senator seems to have hoped then and now . . . in our terms . . . to separate the issues of independence and unity so that they do not come into contradiction. Policies can be implemented to control foreign investment while research and development can accelerate so as to make the difference to Quebec. If science and technology increase production then "égalité culturelle et 'statut particulier'" can be attained for Quebec.(53) To use science policy as a surrogate for an economic policy is the plan. Senator Lamontagne is, of course, not alone in seeing science and technology as a means to save Quebec without destroying confederation: a considerable number of other French Canadians agree.(54) Instrumentally presented science has often been touted the saviour of humanity, could not so great a force as this be harnessed to save Quebec?(55)

Since Confederation Canadian public life has been torn between the centrifugal force of the American presence and the centripetal influence of its cultural duality. Two men have recently enacted the Canadian scenario for these difficulties. They are Maurice Lamontagne who "fathered the Royal Commission on Biculturalism and Bilingualism" and Walter Gordon who "initiated the task force on Foreign Ownership and the Structures of Canadian industry."(56) The solutions of each floundered on the rocky shores of minority government, which is itself part of the problem. Senator Lamontagne now seems to be looking elsewhere, beyond political constitutional means to find a way to economically integrate Canadian society. He seems to be looking to science and technology.

FOOTNOTES

1. Charles Taylor, "Nationalism and Independence", *Canadian Dimension*, IV, 3; reprinted in *Canadian Dimension Kit #3*, p. 4.

2. Ramsay Cook, *The Maple Leaf Forever* (Toronto: Macmillan, 1971), pp. 4 and 4(.

3. As with French-English relations characterized by Hugh MacLennan as *The Two Solitudes* (Toronto: Popular Library, 1944).

4. F.R. Scott, "Canada et Canada francais", *L'espirit* (August-September 1952), p. 178. The pervasiveness of the survival theme finds importance in Margaret Atwood's study of Canadian literature, *Survival* (Toronto: McClelland and Stewart, 1970).

5. Kari Levitt, *The Silent Surrender* (Toronto: Macmillan, 1970), p. 142.

6. *British North America Act* (Ottawa: Queen's Printer, 1967), Sections 64, 84, 93.1 and 93.2, 96, 104, 124 and 137.

7. *Ibid.*, Sections 91 and 92.

8. Garth Stevenson, "Continental Integration and Canadian Unity", Background Paper, Committee for an Independent Canada, Toronto, 1972, p. 3.

9. Robert Gilpin, "Science Policy for What: The Uniqueness of the Canadian Situation", paper read at a Science Council of Canada Seminar, Ottawa, 1971, p. 14.

10. Levitt, *The Silent Surrender*, p. 55.

11. Léandre Bergeron, *Pétit manuel d'historie du Québec* (Montréal: Éditions Québecois, 1971), p. 176.

12. *British North America Act*, Sections 109 and 92.5.

13. Whether either capital or labour now need to be imported is an important question. See Thomas Powrie, "What Does Foreign Capital Add?" *Canadian Forum* (January-February, 1972), pp. 34-7 and David Shaw and T. Roo Archibald, *Canada's Capital Market* (Toronto: Toronto Stock Exchange, 1972) and M. W. Jackson, "The Ph.D. Quagmire", *The Gateway*, LXIII (20 March 1972) 44, p. 5.

14. Stevenson, "Continental Integration and Canadian Unity", p. 5.

15. Levitt, *Silent Surrender*, p. 170; W. Pope, *The Elephant and the Mouse* (Toronto: McClelland and Stewart, 1971), p. 20; and W. L. Morton, Letter to the Editor, *Toronto Globe and Mail*, 14 December 1970, p. 6.

16. Stevenson, "Continental Integration and Canadian Unity", p. 13.

17. John Meisel, *Working Papers on Canadian Politics* (2nd ed.) (Montreal and London: McGill and Queen's University Press, 1973), p. 19.

18. Claude Ryan, "Le Québec dans le Canada de demain". *LeDevoir*, Supplement 30 June 1967, pp. 1 and 27. Cf. René Levesque, *An Option for Quebec* (Toronto: McClelland and Stewart, 1968), p. 24.

19. Jacques Morin, "French-Canada: The American Empire and the Future of Canada", *Canadian Dimension*, IV, 4; reprinted in *Canadian Dimension Kit #3: Canadian Nationalism*, p. 33. Morin is presently leader of the Parti Quebecois legislative caucus.

20. Jacques Parizeau, "Préface", Levitt, *La capitulation tranquille*, trans. A. d'Allemagne (Montréal: Reedition-Québec, 1972), p. xi.

21. Edward Corbett, *Quebec Confronts Canada* (Baltimore: Johns Hopkins Press, 1967), p. 221. Cf. Richard Jones, *Community in Crisis* (Toronto: McClelland and Stewart, 1967), p. 129.

22. Jones, *Community in Crisis*, p. 124.

23. Kenneth McNaught, *The Pelican History of Canada* (Toronto: Penguin, 1969), p. 306.

24. Jones, *Community in Crisis*, p. 139.

25. Meisel, *Working Papers in Canadian Politics*, p. 212.

26. Yves de Jocas and Guy Rocher, "Inter-generation Occupational Mobility in the Province of Quebec", *Canadian Journal of Economics and Political Science*, XXIII (1957) 1, p. 96.

27. K. J. Krotki, "Consequences of the Demographic Wave in Western Canada", *Perspectives on Regions and Regionalism*, B. Y. Card, ed. (Edmonton: University of Alberta Bookstore, 1969), p. 108. Cf. Krotki and E. Lapierre, "La fécondite au Canada selon la religion, l'origine éthnique et l'état matrimonial", *Population*, XXIII (1968) 5, pp. 815-34.

28. These findings are taken from a discussion of the Report in Lysiane Gagnon, "Growing Poor in Quebec", *Making It*, Cy Gonick, ed. (Toronto: McClelland and Stewart, 1972), pp. 345-59. Shortly, a summary remark is quoted from the report itself.

29. *Ibid.*, p. 352.

30. *Report of the Royal Commission on Bilingualism and Biculturalism, Book Three* (Ottawa: Queen's Printer, 1969), p. 61.

31. The plight of French Canadians is best conveyed not in census data but rather in novels, notably those of Marie-Clare Blais and Gilbert Roy.

32. Charles Taylor, "Nationalism and the Political Intelligentsia", *Queen's Quarterly*, LXXII (1965), p. 152.

33. John Porter, *Vertical Mosaic* (Toronto: University of Toronto Press, 1965), p. 92.

34. See Corbett, *Quebec Confronts Confederation*, p. 25. Cf. Pierre Trudeau, and F. R. Scott, ed., *La grève de l'amiante* (Montréal: Les éditions Cité Libre, 1956), at pp. 13-4.

35. For an elaboration of these concepts see K. J. Krotki, "The Social, Economic and Demographic Consequences of the Divergences between the Age Pyramid and the Opportunity Pyramid", paper read at the Annual Meeting of the Canadian Sociology and Anthropology Association, Winnipeg, 1970, pp. 4-5.

36. R. J. Van Loon and M. S. Whittington, *The Canadian Political System* (Toronto: McGraw-Hill, 1971), p. 278.

37. Jane Jenson and Peter Regenstreif, "Some Dimensions of Partisan Choice in Quebec, 1969", *Canadian Journal of Political Science*, III (1970) 2, p. 310. Cf. Hubert Guindon, "The Social Evolution of Quebec Reconsidered", *Canadian Journal of Economics and Political Science*, XVII (1960) 4, pp. 533-51.

38. Parizeau, "Preface", p. vii.

39. Bergeron, *Pétit Manuel d'histories du Québec*, p. 235.

40. Corbett, *Quebec Confronts Confederation*, p. 226.

41. Parti Québecois, *Les dossiers du 4iéme congrés national du Parti Québecois*, n.d.), p. 61.

42. Robert Gilpin, "Science Policy for What", Paper read at a Conference sponsered by the Science Council of Canada, Ottawa, 1971, p. 2.

43. *Ibid.*, p. 5. Cf. W. Griffith, "Quebec in Revolt", *Foreign Affairs*, October 1964, p. 31.

44. M. Henri Gariepy, "Les Québecois favorisement une plus grande présence du Québec a l'etranger", *Le Droit* 30 July 1973, p. 19. See also Levitt, *Silent Surrender*, p. 147.

45. The so-called Brinks job occurred the day before the Quebec provincial election of April 1970. In it the Brinks company was conscipicuously visible in transferring Royal Trust funds out of the province with the implication that this was motivated by fear of a separatist victory, and that if there were a separatist victory this would be only the beginning of the flight of English capital from the province.

46. Corbett, *Quebec Confronts Confederation*, p. 223.

47. "A propos de 'domination économique'". *Cité Libre* (May 1958) 20, p. 8.

48. Corbett, *Quebec Confronts Confederation*, p. 226.

49. Quoted in *Le Devoir*, 28 September 1970, p. 3. Cf. Meisel, *Working Papers in Canadian Politics*, p. 201.

50. See the three part article of Parizeau, "Gouvernements provinciaux et decentralization constitutionales," *Le Devoir*, 18 November 1967, pp. 5 and 6; 20 November 1967, pp. 5 and 6; and 21 November, p. 4.

51. Lévesque, *An Option for Quebec*, p. 76.

52. Lamontagne, "Les teches d'un Etat moderne dans une societé d'abondance," *Le Devoir*, 23 September 1967, p. 5.

53. Lamontagne, "Egalité culturalle et 'status particulaier'," *Le Devoir*, 25 September 1967, p. 5.

54. Many of the more prestiguous advocates of science policy in Canada are Canadiens, including Senator Lamontagne and Minister Sauvé, to name only two.

55. See, for example, Pierre Vallieres, *The White Niggers of America*, J. Pinkham, trans. (Toronto: McClelland and Stewart, 1971), p. 58.

56. Cook, *The Maple Leaf Forever*, p. 47.

CHAPTER ELEVEN

PUBLIC LIFE AND SCIENCE POLICY IN CANADA

In the previous pages it has been argued that the meaning of politics has come to be focused more and more exclusively around matters of material well being. A good society is regarded as one which is materially comfortable. Politics is the instrument of bringing about and protecting that comfort. Material comfort is in the interest of all, and all would be wise therefore to cooperate in its attainment. Cooperation would be more efficient and more effective for all concerned. Moreover, with the use of technology the material requirements of all can be met. No conflicts will arise.

On this view happiness rests in some large part on wealth. Science is indirectly involved in this because it is supposed that the products of science--from a theory to an apparatus--increase productivity and hence economic well being. The products of science are valued for instrumental purposes determined by the larger context.

Against this analysis it has been argued in this essay that there are several distinct levels of inquiry. One is puzzle-solving which seems to be apropos of technology. A second is problem-solving which seem to be apropos of science and economics, and third, difficulties which seem to be apropos of politics. To equate politics with economics is to sacrifice and ignore important and inescapable dimensions of social life. Important and sacrificed is serious consideration of non-material values and justifications. Inescapable but ignored is the possibility that some are going to ask for more than their share. That there is not a technological solution to either of these difficulties does not permit us to conclude that the claims are unimportant or that they do not exist. They are important and ever present, as the fact of war reminds us. Rather the inevitability of difficulties permits us to view a totally realized or aspired technological vision with caution. Any approach to policy which does not maintain this scepticism is doomed to being misleading and superficial.

Preoccupation with the material concerns of what is here being called economics is preferred because it is less likely to lead to explosive conflict. Any dispute over material values can be easily overcome by the production of more things. This cannot be so for the non-material values of politics.

Technological politics is oriented to materialistic values. It aims to increase the sum total of goods, thereby benefiting all, gradually. It aims not at resolving conflict but at finding ways of preventing conflict from arising. The irresolvable difficulties of politics become then soluble problems.

Gradually, but surely, "the role of politicians and bureaucrat has become almost indistinguishable,"(1) in Canadian

Liberal governments, and most Canadian governments since the social impact of science have been Liberal. The Liberal approach to government is technocratic and managerial.(2) Politics becomes administration, not decision, and administrators are above politics. It is by no mean coincidence that the Liberal Party draws many of its ablest representatives from the public service, especially but not exclusively its leaders. So pervasive and persuasive is the reduction of politics to administration in Canada that one of the most astute observers of Canadian public policy recently felt it necessary to say explicitly in the title of a work that policy and policy making in the Federal Government is political.(3) At one time no one needed to be told that policy was political, but apparently this is necessary now.

In contrast, the politics is potentially redistributive. It is potentially redistributive because it is oriented to the values of the public. It directs neither confidence nor commitment to any substitute for redistribution. If the public wishes to redistribute existing wealth, that is that.

Science policy enters upon these troubled waters as a small auxiliary craft to economic policy. If the first belief is that happiness emerges from wealth, then here the second belief is that wealth emerges from knowledge. Hence, the focus on science as knowledge. This presupposition is twofold. (i) Presumed first is that technological research yields economic wealth. (ii) Presumed second is that science yields technology. These two presumptions were challenged throughout these pages in various ways, serving to establish at least that the presumptions are presumptions, not incontrovertible truths.

Particularly important in undermining the credibility of these two presumptions was an examination of the relationships between the activity and the products of science. Even if the products of science paid off in technology and eventually wealth, securing those products through policy is unlikely. Policy is instrumental. The view policy oriented persons take of science is coloured by that instrumentalism. The activity of science is much more than instrumental. Operation of the basis of an exclusively instrumental preoccupation would be inefficient and ineffective.

At this point attention turned to some specific aspects of the present Canadian situation. Pre-eminent amongst these aspects is the penetration of the Canadian economy by the subsidiaries of multinational corporations, most headquartered in the United States. Contrary to some leading critics, it was argued that it is political factors in Canada that allowed this economic penetration and subsequent domination. Attention was drawn to the mandate of provincial jurisdiction over resources permitted in the *British North America Act*. It was argued that the political design of authority set out in the *British North America Act* for the purposes of drawing the several provinces together was one that in fact allowed each of them considerable autonomy, especially concerning the economic matters that come to count greatly, natural resources.

It becomes clear that science policy is seen by some as a surrogate for the unified economic policy the *British North America Act* makes difficult. The term "science policy" is a misnomer.(4)

Hence, many Canadians see the best way for Canada to escape American economic domination and the inferior status it enforces to be in successfully developing a Canadian technology. Equally, many Québécois see the best way for Quebec to escape Anglo-Canadian domination and the inferior status it enforces to be in successfully developing a Quebec technology. With a Canadian and with a Quebec technology, reliance on American capital and know-how could be ended in the name of independence, without threatening unity, because the technologies would accelerate economic growth. Hence, "it is hardly an exaggeration to say that . . . science policy takes in every activity of government . . ." *including* "French-English relations."(5)

In short,

> "The development of channels of escape from a permanent branch-plant relationship with our great neighbour forms the heart of contemporary Canadian planning in science and much else. The primary formula offered is to tighten our belts and gain independence through acceptance, if necessary, of a lower standard of living. James Coyne, Walter Gordon and Melville Watkins have been among the advocates of this course in Canada. From the upshot of their proposals and those of others, it is evident that no Canadian national party believes it could carry the country on curtailment. We have, therefore, sought a second string solution, namely, the strengthening of technology in order to eventually make our branch plants independent and establish a viable economy."(6)

Accentuation of Canadian independence strengthens Quebec dependence.

Circumstances have confined Canadian integration efforts to the short-term. Construction of lasting social and economic development has been elusively beyond the grasp of the Federal Government constitutionally within Canada and much of it simply beyond the border physically.(7)

Because Canadians do not wish to be Americans they have held themselves together in a delicate balance between English and French.

Indeed the balance between French and English is so delicate that only of inaction can we be sure that it will not jeopardize the balance. Canada's most successful modern politician, MacKenzie King, is celebrated in the popular wit as a leader who kept from acting when lesser lights would have.

Inaction may have protected Canadians from each other for the purposes of integration. It certainly has not protected them from the influence of the United States at the expense of independence. Indeed the only alternative to being absorbed Americans seems to be to become more economically like them voluntarily, so as to be competitive.(8)

Before recognizing and resolving th[illegible]ssues, talk of the planning of science is wasted, for unt[illegible] issues are resolved, planning is impossible. To [illegible]s a sign of weakness, not of strength.(9) It is [illegible] solution to this weakness, to advocate Canadian industrial specialization as

Senator Lamontagne and Minister Sauvé have done.[10] Canadian industry is already specialized, in natural resources. Nor is it a proper diagnosis to point to the small size of the Canadian domestic market as an explanatory factor as Minister Sauvé has done.[11] Many viable European economies serve smaller markets.[12]

There is a certain degree of merit in these points to be sure, but even that much is a product of the underlying political reality. That reality is Canadian constitutional particularism. This is a weakness that must be first dealt with, perhaps beginning with the issue of individual and group rights.[13] Before Canada can have a national science policy, there must be once again a resolve to have a nation.

FOOTNOTES

1. John Meisel, *Working Papers on Canadian Politics* (2nd ed.) (Montreal and London: McGill-Queen's University Press, 1973), p. 231.

2. *Ibid.*

3. G. Bruce Doern, *Political Policy-Making* (Montreal: Howe Research Institute, 1973).

4. Doern, "The Senate Report on Science Policy", *Journal of Canadian Studies*, VI (1971) 2, p. 47.

5. F. Ronald Hayes, *The Chaining of Prometheus* (Toronto: University of Toronto Press, 1973), p. 54.

6. *Ibid.*, p. 100. See Robert Presthus, *Elite Accommodation in Canadian Politics* (Cambridge: Cambridge University Press, 1973).

7. Gad Horowitz, "Conservativism, Liberalism and Socialism in Canada", *Canadian Journal of Economics and Political Science*, XXXII (1966) 2, reprinted in H. Thorburn, *Political Parties in Canada* (Toronto: Prentice-Hall, 1966), p. 96.

8. N. Lithwick, "Technology and Progress", *Science Forum 26*, V (1972) 2, p. 10.

9. Robert Gilpin, "Science Policy for What?" Paper read at a Conference sponsored by the Science Council of Canada, 1971, p. 12.

10. Specifically on natural resources see especially G. V. LaForest, *Natural Resources and Public Property under the Canadian Constitution* (Toronto: University of Toronto Press, 1969), or Anthony Scott, *Natural Resources* (Toronto: McClelland and Stewart, 1955).

11. The Honourable Jeanne Sauvé, "Notes for a Speech to the Canadian Club", Toronto, 1973, p. 13.

12. Peter Meyboom, "Technological Innovation in Canada" (Ottawa; Economic Development Division, Department of Finance, 1970), pp. 29-30. Cf. Pierre Trudeau, *Federalism and the French Canadians* (Toronto: Macmillan, 1968), p. 21.

13. See Andre Siegfried, *The Race Question in Canada* (Toronto: McClelland and Stewart, 1907) and *The Tremblay Report*, David Kwavnick, ed. (Toronto: McClelland and Stewart, 1953).

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