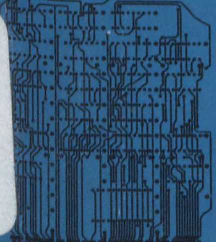
The Canadian Computer/Communications Task Force

Background Papers

5 Canadian Policy Options in Computer/Communications

6 Working Paper on Strategic Options



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Background
Papers

5

The
Canadian
Computer/Communications
Task Force

Background
Papers

5 Canadian Policy Options in Computer/Communications

(A Study of the Effect of Canadian Policies
in the Participation of
U.S. Industry in Canada 1970-1985)

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Menlo Park, California 94025

August, 1971

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Purpose of Report

This report describes the results of a four-month study of the likely consequences of certain hypothetical future policies of the Canadian government with respect to the organization of computer/communications and control of data banks used in Canada. Information about such consequences was obtained from top executives of the U.S. data processing industry and some large U.S. companies, having affiliates in Canada, who answered a highly structured, anonymous questionnaire on the impact of government policy on their industries in Canada. Information was also obtained from academicians in the United States and Canada.

The broad conclusions with regard to consequences of computer/communications policies were as follows. First, large Canadian industries, for the most part, will be unaffected by any choice from among the policy options considered in this study. Second, a policy of *status quo (i.e., laissez faire)* will result in the highest domestic sales for the Canadian data processing industry but also the highest imports of data processing services from the United States. In comparison, creation of a Crown Corporation for computer/communications would produce the next highest sales, while a middle policy of a government-supported and -regulated cartel would have the lowest sales. Third, no matter which of these three options were adopted, Canadian imports of data processing would exceed exports. Finally, the middle policy was found to be less desirable on the whole than either the *status quo* or the creation of a Crown Corporation. This last conclusion was based, however, on one specific definition of the middle policy and may not be applicable to other possible compromise policies.

With regard to the consequences of policies on data banks, there was no consensus either that licensing would be in Canada's interest or as to what its economic effects would be, although it was clear that licensing would reduce the percentage of "critical" data banks under foreign control. Both options examined here (licensing and *status quo*) were considered by our respondents to have severe disadvantages, suggesting that, whichever option is ultimately selected, serious efforts will be necessary to forestall detrimental side effects.

Canadian Policy Options in Computer/Communications

The respondents expressed unanimous preference for the *status quo* policy on computer/communications, but were evenly divided in their preferences as to policies on data banks.

Preface

This study was primarily an experiment in policy formulation. The experimental nature of the study was due to the inclusion of: (i) a deliberate effort to collect quantitative data about consequences of several policy options, as well as preferences among these options; (ii) an attempt to use an explicit value model, in which considerations of several indicators, including those of national identity, are "traded" for economic advantages; and (iii) portrayal, again in quantitative terms, of the risk inherent in choosing a policy in the face of uncertainty. These three attempts were reasonably successful.

Unfortunately, perhaps because of the unusual nature of the undertaking, we found it very difficult to obtain respondents willing to engage in a study that may have appeared to some to be an unnecessary, trivial, difficult, or possibly even injurious exercise. Most people are not accustomed to debating hypothetical consequences of hypothetical policy options — the prevailing custom being to take a position, explain one's value model (for example, that government intervention is undesirable), then further one's interests through the workings of the political process. The type of dialogue represented in our study appeared, we are sure, to some of our potential respondents as a change in well-understood ground-rules, and they were not sure whether the change would be for the better. Whatever its cause, the reluctance to participate is clearly illustrated by these uninspiring statistics: of the 252 potential respondents who were asked to participate, eighty-six agreed to do so; of those who agreed twenty-three (or 28 percent) returned filled-in questionnaires (twelve questionnaires were returned unfilled). By contrast, however, most filled-in questionnaires were answered fully and thoughtfully.

The authors wish to acknowledge the assistance and co-operation of the members of the Canadian Computer/Communications Task Force, who helped to focus the inquiry and reflected to the Institute's research staff the concerns and aspirations of Canadians. We wish to single out the Director General of the Task Force, Dr. Hans J. von Baeyer, and our project monitor, Mr. Ray H. Taylor, who were intimately involved in the progress of the study. We also acknowledge the professionnal assistance of Prof. I.A. Litvak and Prof. Christopher J. Maule of Carleton University, as well as that of Prof. James N.

Rosse of Stanford University, who helped in the initial organization and final consolidation of the study.

Part A

Introduction

1. Background

In September 1969, Canada's former Minister of Communications, the Honourable Eric Kierans, announced the formation of a "telecommission" to undertake a series of studies on telecommunications[1] preparatory to formulating the Canadian government's policy on communications. At the conclusion of these studies in November 1970, a special Task Force on Computer/Communications was set up to continue the investigations in more depth and to make recommendations for technical, financial, and institutional policies to ensure the orderly and efficient growth of computer/communications systems in Canada.

To help in obtaining information about the likely impact of Canadian policy options on U.S. industry's future participation in and contributions to the Canadian economy, the Task Force engaged the Institute for the Future, a U.S.-based, nonprofit research organization that has conducted studies on the future of telecommunications in the United States.[2]

2. Organization of the Report

In Part B of this report we provide a brief description of the study's objectives, an outline of its procedure, and a summary of its conclusions. Part C presents a detailed analysis of the methodology by which we reached these conclusions. It includes descriptions of the following: the theoretical framework in which the policies were compared, the correspondence

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1 Department of Communications. *Instant World: A Report on Telecommunications in Canada* (Ottawa, Information Canada, 1971), provides a summary of these studies.

2 Among these studies are: Baran, Paul and Lipinski, Andrew J., *The Future of the Telephone Industry, 1970-1985*, Report R-20, Institute for the Future (September, 1971); and Lipinski, Andrew J., *The Future of Communications Regulation as It Affects the Data Processing Industry*, Institute for the Future (forthcoming).

between components of this framework and the study's activities, the procedure by which estimates of policy consequences were obtained and processed, and the method by which the value model was constructed and used to evaluate the forecasts of policy consequences. Part D contains the conclusions based on the assumed value model, the sensitivity of the conclusions to uncertainty and the weighting of net exports, the effects of the policies on selected economic indicators, and a summary of the respondents' preferences.

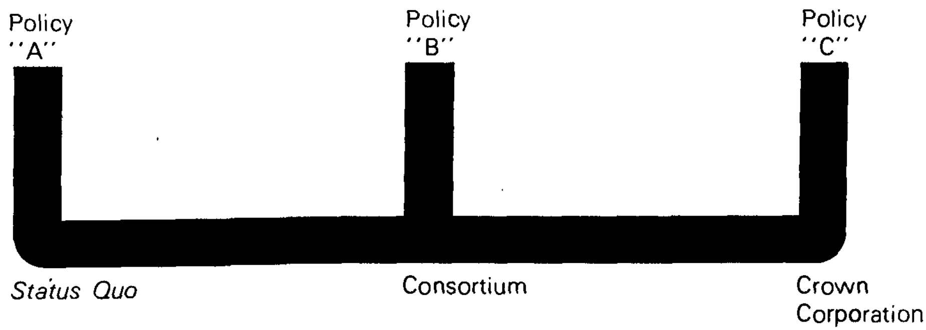
3. Policy Options

Two sets of Canadian policy options were postulated in the present study, one set dealing with the future organization of the computer/communications network and the other with operation of data banks.

With regard to the former, we hypothesized a range of policies, from a very relaxed policy of inaction (*i.e., status quo*) to a "strict" policy of outright Crown Corporation ownership of both computers and data communication networks (see Figure 1). We also assumed a "middle" policy, in which a consortium, composed of present carriers and some data processors, would offer data processing services. The government would regulate entry, tariff structure, and rate of return to the members of the consortium. This middle policy represents a sort of benevolent, government-supported cartel, as typified by the Japanese approach. Initially, we did not think it was important that the hypothetical Policy B be very close to that which may eventually be recommended by the Task Force — what mattered was that it be somewhere between the two extreme policies. For example, we assumed that if the eventual policy were to be more lenient, our results could be interpreted by assuming outcomes somewhat to the "left" of Policy B.

The expectation that the outcomes of Policy B would lie somewhere between those of Policies A and C was not supported by the study results. The estimated values for several desirable outcomes, such as investment and employment, were higher for Policies A and C than for Policy B. Therefore, the exact definition of Policy B may be more important than it at first appeared.

Figure 1
Range of Computer/Communications Policy Options to Be Examined



For the second set of policy options (*i.e.*, with respect to regulation of data banks), we postulated on the one hand a *status-quo (laissez-faire)* policy and, on the other hand, a policy of regular licensing of data banks used by companies located in Canada.

A brief but precise description of these policies, as presented to the participants in the study, follows.

Set 1: Organization of Computer/Communications Network

Policy A. Approximately the present situation, in which computer utility services (i.e., services offered to the general public, and not computer services within an organization) may be provided by companies freely entering the market from either within or outside Canada. Telecommunications are provided by many common carriers, including two large regulated consortia in competition with each other, which may themselves offer computer utility services.

Policy B. A loosely knit system of computer utilities, with the federal government regulating entry, prices, and rate of return, and establishing software and hardware standards for the system. Government involvement would be basically that of a catalyst and a regulator, giving encouragement, possibly in the form of subsidies, for the development of socially desirable systems, and exercising its current and newly acquired controlling and regulatory powers over the data processing industry in areas of public interest. To encourage the lowest cost to the user by utilizing possible economies of scale, the common carriers would be encouraged to offer, via subsidiaries, data processing services. These subsidiaries, as all other data processing companies, would be regulated by a newly-formed agency. The new regulatory agency would regulate prices, entry, and rate of return of data processing companies. Each data processing company connected to the associated networks would advertise and sell its own services and computer power.

Policy C. An integrated Trans-Canada data-communications network, possibly owned and operated by a Crown Corporation.[3] This corporation may initially lease communications lines from the common carriers, but would possibly aim for a wholly owned, separate digital communications network. In either case, computers and terminals connected to the system would be owned by the Corporation, and terminals and storage space leased to users. Ownership of information and, hence, privacy of data banks on the system would remain with those organizations responsible for maintaining the data banks. Advertising, selling of services, and supply of computational services and of computer power (defined as a supply of operating-system but not user software programs) would be done by the Corporation. However, it would be at liberty to buy software and hardware from whatever sources it deemed necessary, possibly within some framework of regulatory control.

Set 2: Operation of Computerized Data Banks

Policy D. The present situation, in which virtually no regulatory provisions exist for the establishment and operation of computerized data banks. The exceptions concern government-collected data, the disclosure of which to third parties is prohibited by statute.

Policy E. The situation in which governmental authorities license the establishment and operation of computerized data banks that store personal and Canadian resource information. The legislation relating thereto would provide for limitations as to use and access, regular inspection, and penalties for circumvention of the legislation.

[3] U.S. equivalent to "Crown Corporation" might be a federal commission, such as the Atomic Energy Commission.

Part B

Summary and Conclusions

1. Objectives

The main objective of the study was to develop forecasts of key parameters, such as investment, sales, and employment, that would describe the extent to which U.S. industry will participate in the future development of the Canadian data processing and information industries. These forecasts were to be (i) conditional on a few selected Canadian policies with respect to the organization of computer/communications and (ii) probabilistic, that is, the forecasts were to be shown as probabilities that a given value of a key parameter will be exceeded, given a specific policy.

A subsidiary objective of the study was to develop a framework for comparing the effectiveness of various policies toward achieving a state of affairs that Canadians might consider ''best''.

2. Method of Approach

To develop the forecasts mentioned above, the Institute's staff elicited and processed expert opinions by means of a structured, written questionnaire. The expert panel comprised representatives of the U.S. time-sharing, computer, data processing, and data-dependent industries, and members of the academic community.

The Institute and the Task Force jointly determined the key indicators necessary to evaluate the success (or failure) of any policy with respect to computer/communications. These indicators fell roughly into two classes: those concerned with economic well-being and those related to the perception of Canadian identity. The economic indicators were the annual new investment, annual sales, overall employment, imports of data processing services to Canada, and exports of data processing services from Canada, of given industries. The indicators of Canadian identity included: employment of Canadian college graduates in computer-related fields, the percentage of data processing companies in Canada effectively controlled by U.S. parent companies, and the percentage of all data banks storing information on Canadian citizens or critical resources that are located in the United States or controlled by U.S. interests.

After discussion with the Task Force, the Institute's staff hypothesized the policy options and framed questions incorporating these options and key indicators. Since the future value of a key indicator is an uncertain quantity, the Institute attempted to describe this uncertainty by asking for the 10-, 50-, and 90-percent probability levels for each indicator. At these levels there is a 10-, 50-, or 90-percent chance, respectively, that the actual future value of the indicator will be less than or equal to the assigned value. The probability distributions obtained in this manner were then processed by computer to obtain group probability distributions for each indicator, conditional on the policy option, and these results were then analyzed by the Institute.

The analysis of the information obtained from the panel proceeded in three stages. First, in consultation with the Task Force, we constructed a "value model", based on a number of assumptions about the preferences Canadians would have about future policy outcomes. This model was designed to permit aggregation of the forecasts into an overall measure of the desirability to Canada of each option. Second, we used the model to convert the consequences of each policy into the desired aggregate evaluation for that policy. Finally, we tried altering some of the assumptions on which the model was based and computed revised desirability ratings, to determine whether the choice among policy options would be influenced by such changes in assumptions.

Details of this rather complex analytic procedure are presented in Part C, and its results are shown in Part D. A summary of the key results follows.

3. Overall Conclusions

The overall conclusion of the study is that the effect of Canadian policy decisions with respect to computer/communications, viewed by managers of U.S. companies, will be such that: (i) no one policy with respect to computer/communications appears clearly better than any other so far as the effect on large Canadian industries is concerned, and (ii) with regard to the data-processing industry, a policy of *status quo* will result in largest sales, $316 million in 1985, accompanied (perhaps unfortunately) by largest imports of data-processing services from the United States — 1985 figure, $145 million. Depending on how undesirable a negative balance of trade in data-processing services is considered, either the policy of establishing a Crown Corporation or that of maintaining the *status quo* would be best. Thus, if Canadians are largely indifferent to the importation of data-processing services, then a policy of *status quo* would serve them best; if the converse is true, then a Crown Corporation would be a more suitable alternative. For example, if Canadians were willing to "trade" less than seventy cents of domestic sales for one dollar of net exports, they would prefer *status quo*. For any higher rate of exchange, such as dollar per dollar, Crown Corporation would be preferable.

In terms of aggregate utility, both Policy A and Policy C rate fairly high, having roughly comparable mixtures of advantages and disadvantages. Only Policy B, that of a government-sponsored and -regulated consortium of carriers and data processing suppliers, receives a significantly lower utility rating, largely because this policy appears likely to stifle U.S. investment in and development of Canadian computer/communications activities.

As to the effect of licensing of data banks, the percentage of data banks containing critical information about Canadian citizens or Canadian resources that are either located in or effectively controlled[4] by the United States would decrease if they were licensed. However, the respondents did not agree on whether licensing was in fact the best policy. We report later on these disagreements.

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4 By *effective control* we mean control of pricing, marketing, and development strategy, irrespective of the percentage of ownership.

Part C

Study Procedure

1. Theoretical Framework

In this part, we describe how the information gathered in our study was designed to contribute to a much larger undertaking — the process of policy formulation. The final objective of policy formulation is to make a decision, or decisions. In this case, it is a decision as to what should be done about the future of computers and communications in Canada. To arrive at a successful policy (by making good decisions), the policy-maker needs a great deal of detailed and reliable information.

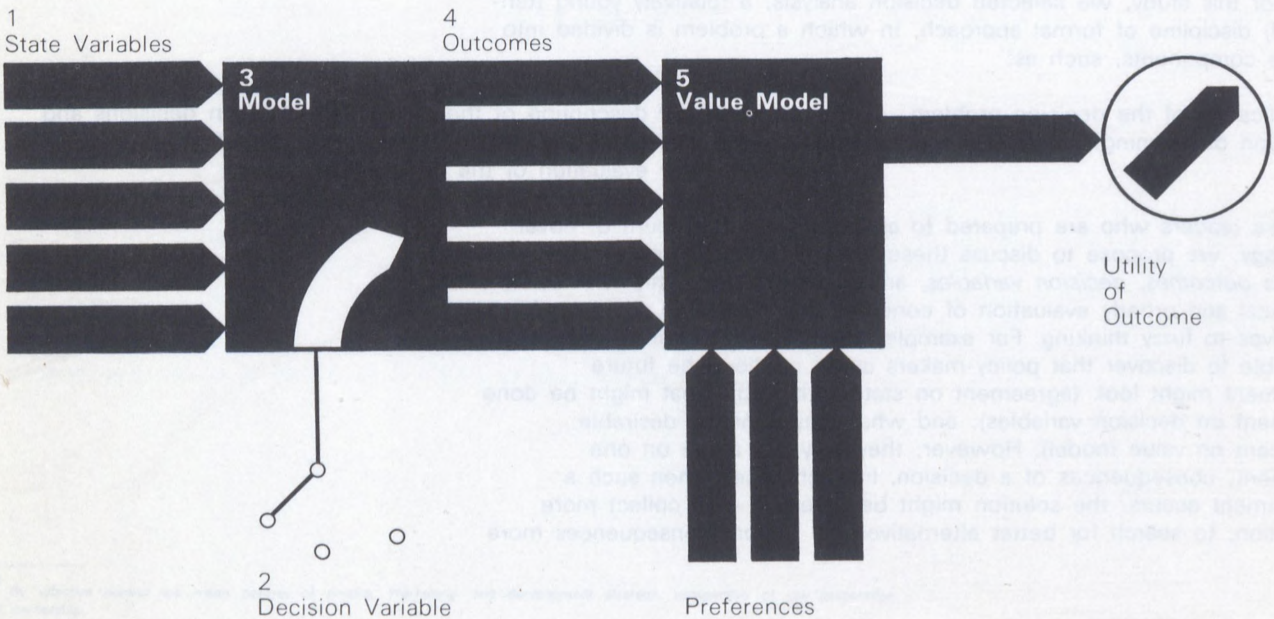
There are advantages to using some logical framework for dealing with information about the future environment and current preferences and aspirations. Such logical frameworks can, of course, be organized in many ways. For this study, we selected decision analysis, a relatively young (ten-year-old) discipline of formal approach, in which a problem is divided into separate components, such as:

- Identification of the decision problem
- selection of meaningful consequences of the decision
- description of the interaction between decisions and consequences
- evaluation of the consequences

For those readers who are prepared to absorb a certain amount of novel technology, we propose to discuss these features in more detail, using such terms as *outcomes, decision variables,* and *state variables*. This will facilitate a methodical and orderly evaluation of concepts that otherwise often lend themselves to fuzzy thinking. For example, by using a structured approach, it is possible to discover that policy-makers agree on how the future environment might look (agreement on state variables), what might be done (agreement on decision variables), and what they consider desirable (agreement on value model). However, they may not agree on one component: consequences of a decision. In each case, when such a disagreement occurs, the solution might be different — to collect more information, to search for better alternatives, to explore consequences more thoroughly, or to compromise divergent preferences. That is why we propose to ''detour'' from the main subject for a while. However, a reader who is familiar with the concepts or who would rather not go any deeper into this theoretical background may proceed directly to Part D, ''Study Flow''.

According to the conventions of decision analysis, decision problems can be conveniently separated into components as shown in Figure 2. The main components include two models: one describing the interaction of state variables and decision variables, and the other a value model that describes the preferences of the decision-maker.

Figure 2
Basic Problem Structure for Decision Analysis



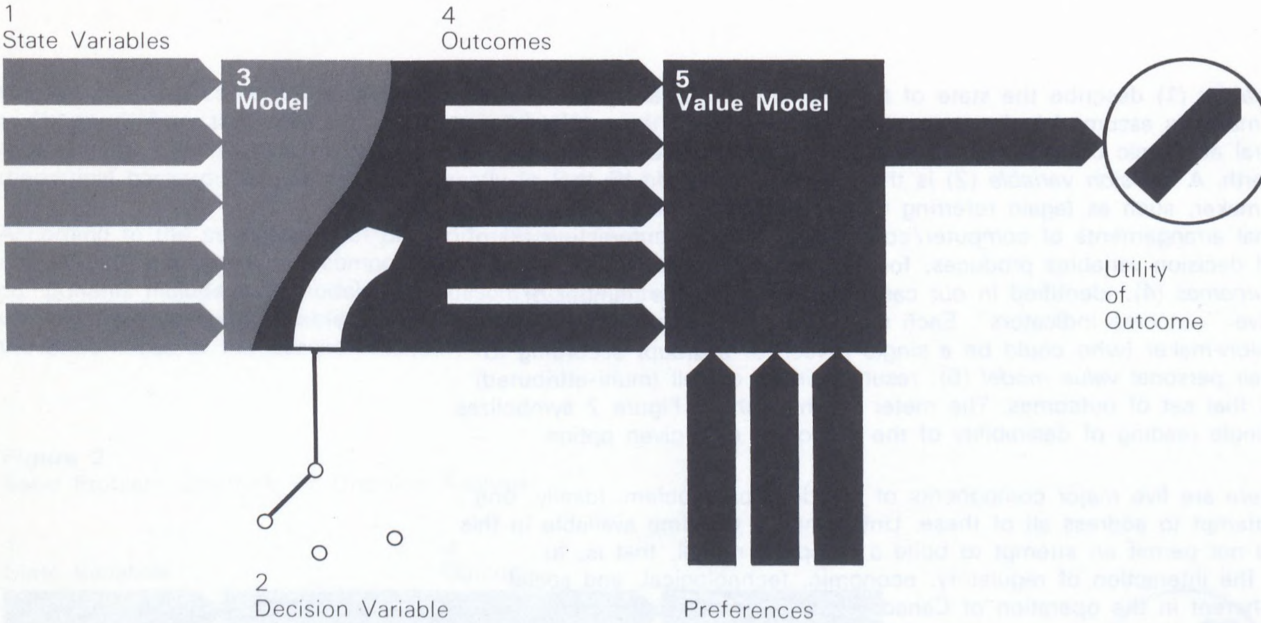
State variables (1) describe the state of the environment, over which the decision-maker is assumed to have no control; in our case, these might be the general economic climate, Canadian trade patterns with other countries, and so forth. A *decision variable* (2) is the "switch" operated by the decision-maker, such as (again referring to the problem at hand) different institutional arrangements of computer/communications. The interaction (3) of state and decision variables produces, for each decision option, a particular set of *outcomes* (4), identified in our case by the levels of a number of quantitative "outcome indicators". Each set of outcomes is then evaluated by the decision-maker (who could be a single person or a group) according to his or their personal *value model* (5), resulting in an overall (multi-attributed) *utility*[5] of that set of outcomes. The meter on the right in Figure 2 symbolizes such a single reading of desirability of the outcomes of a given option.

In all, there are five major components of the decision problem. Ideally, one should attempt to address all of these. Unfortunately the time available in this study did not permit an attempt to build a complete model, that is, to describe the interaction of regulatory, economic, technological, and social forces inherent in the operation of Canadian computer/communications. However, even if more time were available, it is doubtful that a credible model could be made, given the complexity of communications in Canada and the dynamic development of the computer industry. Therefore we compromised, as shown in Figure 3, and went directly from decisions to outcomes, deciding to bypass explicit consideration of components (1) and (3) of the problem — simplifying the analysis, but paying a price for it.

What was the penalty? By omitting state variables (1) and modelling (3), we asked for estimates regarding the outcomes of different policies directly and relied on each respondent's mental modelling of the future and his implicit choice of state variables. Thus we determined each respondent's uncertainty regarding the outcomes of, say, Policy A, but we could not determine whether the respondent's mental model of future interactions was the same as when he considered the outcomes of Policy B. We assume that it was. As a result, we are able to discuss the risk of adopting a "wrong" policy, but in

[5] The term *utility* is used here in the classical economics sense, that is, as a measure of the desirability or "goodness" of the outcome.

Figure 3
Simplified Problem Structure



more cautious terms than if we had developed a single model and a uniform set of state variables.

In Part D. we supply an example (using our own estimates of Canadian value preferences as embodied in weighting factors attached to the various outcome indicators) of what the utility of a policy might be if the value of every indicator, such as sales or investment, ''landed'' on the low side or on the high side. This then enables us to determine whether the best policy, chosen on the basis of the expected values of the indicators, is still the best policy when the value of every indicator falls either on the low or on the high side. Such a determination shows the risk involved in choosing the best policy.

Government policy with respect to computer/communications will have both measurable and intangible consequences. A convenient approach, used here, is first to analyse separately the measurable consequences; next, to determine the best policy; and then to inject the intangible consequences as a final check, to see whether, in view of these, one would wish to review the earlier conclusions which were based on the examination of the tangible consequences alone. This statement may give the impression that it is a straightforward procedure to arrive at a recommendation of policy by examination of measurable consequences. As we shall see, this is far from being the case. Depending on the weight attached to the values of measurable indicators of policy consequences, different policies appear to be the best.

2. Study Flow

The activities undertaken in this study were specifically designed to correspond with the components of the simplified decision-problem framework previously described. First, with the help of the Task Force, we selected hypothetical computer/communication and data-bank policies for examination (see Part A, pp.5-8), corresponding to the options of the *decision variable* "switch". Second, we obtained expert forecasts of the consequences likely to follow from each policy; these forecasts – most of which were expressed in terms of the future course of economic and other trends – correspond to the *outcome* indicators. Third, we constructed a simple *value model* which expressed our own estimates of Canadian *preferences* regarding the outcomes. Finally, by means of this model, we calculated a measure of the overall *utility* of each policy and tested the sensitivity of the computed utility to alterations in the assumptions which had gone into construction of the value model.

3. Estimation of Policy Outcomes

(a). Policy Indicators

One way to approach policy determination is first to attempt to list as many relevant outcomes as possible and then to evaluate the desirability of the individual outcomes which are judged likely to follow from each of the available policy options. This approach, although sound in principle, soon raises a question as to how many and which outcome indicators would be evaluated. A policy may affect many factors – for example, it may affect social stability, economic well-being, and technological innovation. Each of these factors can in turn be subdivided into more detailed and meaningful indicators. How is one to avoid being bogged down in details?

As mentioned previously, we found that a convenient and practical approach is suggested by the discipline of decision analysis, which emphasizes the concept of the value of information to the decision-maker. The suggested approach is to ask the decision-maker (or a surrogate decision-maker): "What is the minimum number of indicators you would need to observe in order to determine whether a policy option that was carried out was a success, and what measures would you like to see used as indicators?"

To introduce the time horizon over which a policy is to be effective, one "places" the decision-maker in the future, for example, in the year 1985, by prefacing the above question with: "If you were called upon in 1985 to determine the consequences of a policy option implemented now, what indicators and measures would you need to decide whether the policy had been, in fact, a success?"

Let us now review the indicators adopted for this study and the reasons that led to their adoption.

Using as a rough guide the problem mentioned in the introduction to this report (*i.e.*, recognition by Canadians that economic well-being is not necessarily synonymous with cultural, economic, and national independence), we selected, after discussion with the members of the Task Force (as surrogate decision-makers), two groups of indicators: those dealing primarily with economic well-being, and those bearing on the perception of Canadian identity. The first group of indicators consisted of:

- Total new investment
- sales
- employment
- imports (to Canada)
- exports (from Canada)

These economic factors were for a given industry in Canada (*e.g.*, automobile) and aggregated the contribution of Canadian companies with the contribution of affiliates of U.S. companies operating in Canada. Thus, for example, "total new investment" aggregated investment of Canadian companies with the investment (in Canada) of U.S. affiliates.

The second group of indicators was:

- Employment of Canadian graduates specializing in computer/communications oriented disciplines
- percentage of data processing companies in Canada effectively controlled by U.S. parent companies
- percentage of all data banks storing information about Canadian citizens or critical resources that are located in the United States or controlled by U.S. interests

Our selection of indicators was, obviously, a matter of judgment. To obtain an idea of what indicators our respondents would have chosen, later in the questionnaire we asked them to name the measurable and the intangible effects arising from the adoption of the policy they considered worst. In Part D, "Detailed Findings", we will describe their selection of indicators.

(b) Time-Frame

Government policies take time to evolve. The useful life of a policy ends when new developments, such as in technology or economics, make it obviously inapplicable, as evidenced by the dissatisfaction of the public whom it affects. Only then does a new policy formulation begin. We selected 1970-1985 as the time-period of our study — to us, a probable time-span of the new policy. Thus, the indicators selected for use in examining policy outcomes should continue to display a "value" throughout the 1970-1985 period. The format of the questionnaire by which we sought to determine such values is shown in Figure 4. In this sample, we ask the respondent for his estimate of the trend of annual sales of "his" industry in Canada, assuming that Policy A (*status quo*) will be adopted. The respondent is asked to indicate his uncertainty by drawing the upper and lower limits of the future sales. He has been informed that we will interpret this range as his assignment of 80-percent probability that the sales will lie in the range drawn, 10 percent that they could be even higher, and 10 percent that they could be even lower.

One important consequence that follows from the fact that we obtain estimates over the time-period 1970-1985 is that there is a possibility that

Figure 4

Sample Questionnaire Format

Respondent Code No. 853

Economic Implications — Your Industry

Annual Sales Given Option A

Page No. 5

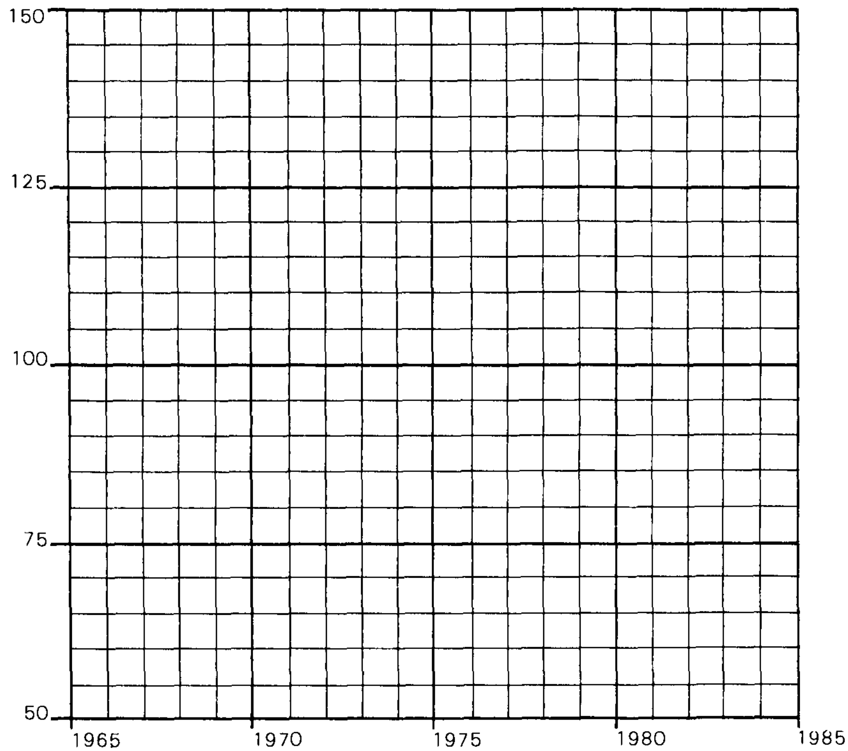
8111 02 01

Please Estimate:

If the annual sales in 1970 were 100:

Please project the future annual sales, assuming that the Canadian government will adopt policy option A, *i.e.*, no significant change from the organization of computers and communications industries and interfaces that exist today.

For 1970-1985 please draw 3 projections (10, 50 and 90 percent probability):



What key developments, if any, have you assumed in making this forecast?

one policy may be "better" for 1975 and another better for 1985. In addition, because of the probabilistic nature of these estimates, the definition of *better* is, itself, probabilistic; that is, there may be an 85-percent chance that in a given year Policy C will be superior to the other policies, while there may be a 15-percent chance that Policy B will be superior. We will explain this second consequence in more detail in Part D under "Sensitivity of Policy to Uncertainty".

(c) The Respondents

One of the most important, and yet sometimes neglected, aspects of information is its credibility. It is not enough to gather information since if information is not credible to the decision-maker, he will consider it useless and reject it. Thus, sources of information and the method of processing information should be carefully considered because both can impair or enhance the credibility of the information. All information about the future is really opinion, some better substantiated than others, but finally only opinion. The question, then, is: whose opinion?

When discussing the future, all of us tend to take into account opinions of people we consider informed, intelligent, and representative of divergent points of view. Before we assign a weight to expert evidence, we want to know who the expert is and why we should trust his opinion. In this study, expert respondents were drawn from three communities: executives of the largest U.S. companies that have affiliates in Canada, executives of U.S. data processing companies (whether or not they had operations in Canada), and university professors or consultants, whom we embrace in one designation, "academicians". Members of this last group were from both Canada and the United States. Sometimes, executives to whom questionnaires were sent "subcontracted" them to others in their organizations. Thus several people may have contributed to one questionnaire. At the end of the questionnaire, we asked each respondent whether he had obtained assistance. We found that 64 percent of the total panel of respondents answered the questionnaire by themselves; 36 percent obtained help, either from within the United States, from Canada, or from both countries.

(d) Calibration of Respondents

Expert opinion is used by decision-makers every day; the decision-maker commonly modifies his choices on the basis of expert opinion. The underlying process, even though not necessarily formalized, proceeds along roughly these lines:

> My own (the decision-maker's) opinion about the probability of any particular future value (of something) is modified to the degree that my expert adviser would have been likely to tell me what he did tell me, if that particular value were true.

If it sounds complicated, it is. It is the underlying principle of the process of changing opinion, first explicated by Thomas Bayes, an English clergyman, in 1763. The key element is:

> How likely is it that my expert adviser would have told me what he did, if the real future value were such and such? For example, if it were to rain tomorrow, how likely is it that he would have predicted rain?

The best-understood method of evaluating an expert's degree of clairvoyance is to measure his past "batting average". For example, how often did the forecaster predict rain, when it actually rained? How often did he predict sunshine? Within each organization, every manager mentally collects these batting averages of experts whom he consults. Unfortunately, batting averages of our respondents were unavailable. Lacking that information, we substituted the following criteria of a respondent's expertise: (i) self-ranking of the respondent's familiarity with each particular topic (elicited in the questionnaire), (ii) our judgment with respect to the respondent's care in answering and to his understanding of the probability estimates as evidenced by his replies, and (iii) an evaluation of the consistency of his estimates with respect to each other. The scale adopted for evaluating the expertise of a respondent contained five categories of familiarity, each category separated by a factor of two, as shown in Table 1. The net effect was to take an expert respondent sixteen times more seriously than a respondent who considered

Table 1
Respondent Familiarity Scale

Expertise	Ranking
Expert Knowledge	16
Quite Familiar	8
Familiar	4
Casually Acquainted	2
Unfamiliar	1

himself, or was judged as, unfamiliar. This is explained in more detail in the paragraphs which follow.

The final calibration of respondents was made in a conference of the research team and its consultants.

(e) Computation of Group Probability Functions

Encoding of Individual Probability Assignments: In the questionnaire, we called on the panelists to make projections of a number of trends. In previous forecasting studies, we have usually obtained trend projections of this sort by asking each participant for a single estimate of each variable at each of several points in time, that is, by asking him to sketch a simple curve extrapolation. Here, however, we attempted to reflect each panelist's uncertainty by requesting not one but three estimates for each variable (V) at each point in time. These three estimates V_i ($i = 2,3,4$) were defined as those values of V for which the respondent judged that the probability (p_i) of V being less than or equal to V_i was 0.1, 0.5, and 0.9, respectively. These estimates could then be interpreted as points on a cumulative probability distribution approximating the respondent's complete judgment regarding the value of the given variable at the given point in time (see Figure

5(a)). The end-points of this function (V_1 and V_5, for which the probability $p_1 = 0$ and $p_5 = 1$ were not specified, so we had no information about the "tails" of the cumulative probability function (mass function).

Completing the Density Function: Next, to facilitate later processing, we found it convenient to translate the mass function into its derivative, the probability density (density, for short). We approximated the missing information about the tails, that is, regions of 0-10 percent and 90-100 percent, by extrapolating the slope of the mass function until it intercepted $p = 0$ and $p = 1$ at $V = V_1$ and $V = V_5$, respectively. Such an extrapolation is illustrated in Figure 5(b), and the corresponding density function is shown in Figure 5(c).

Average Density Function as an Indicator of Group Uncertainty: The average of the density functions of a group of respondents (obtained by adding the individual densities and dividing by the number of respondents) provides us with an indicator of the range of opinions. Refer to Figure 6(a) for a typical result. The mass function can then be reconstructed from the density curve by integration (Figure 6(b)).

Weighted Average: If information regarding relative expertise or any other measure of confidence in individual experts is available, it is possible to weight the individual distributions accordingly prior to summing up. For each trend estimate, we weighted the respondents according to the expertise scale discussed previously under "Calibration of Experts", and then used these weights to multiply the respondents' probability density functions. Thus, an expert's estimates carry sixteen times more weight than do the estimates of a respondent who was calibrated as unfamiliar. In the processing of the estimates, the weighted density functions were summed, normalized to unit area, and converted to a group mass function to facilitate the interpretation of the group estimates. The resulting group mass functions for each trend estimate are given in Appendix A.

Derivation of the Probability Density Function

Figure 5(a)

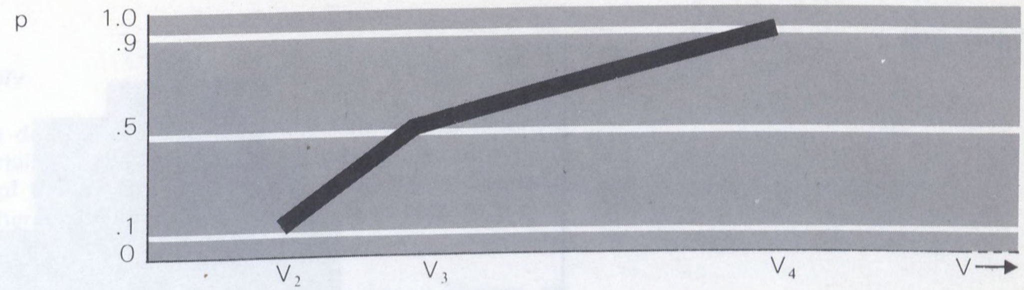


Figure 5(b)

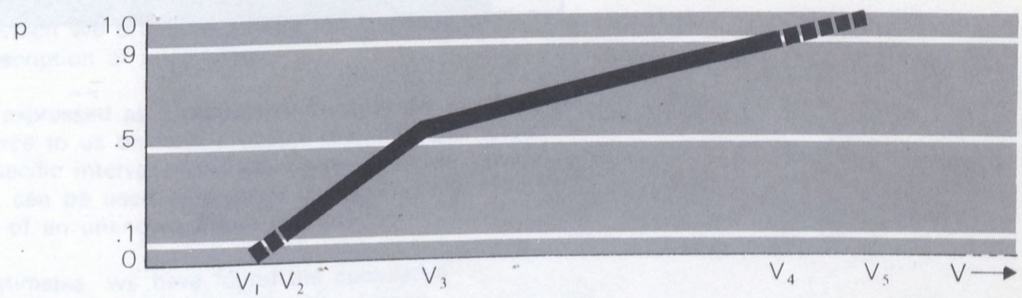
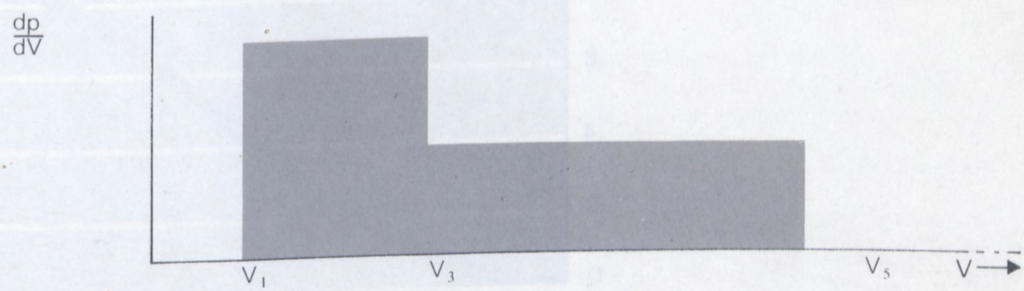


Figure 5(c)



Derivation of Cumulative Probability
(Mass) Function

Figure 6(a)

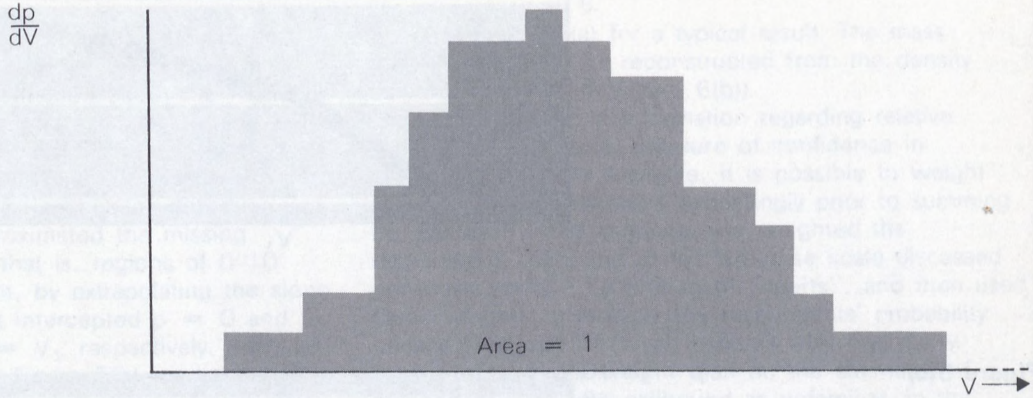
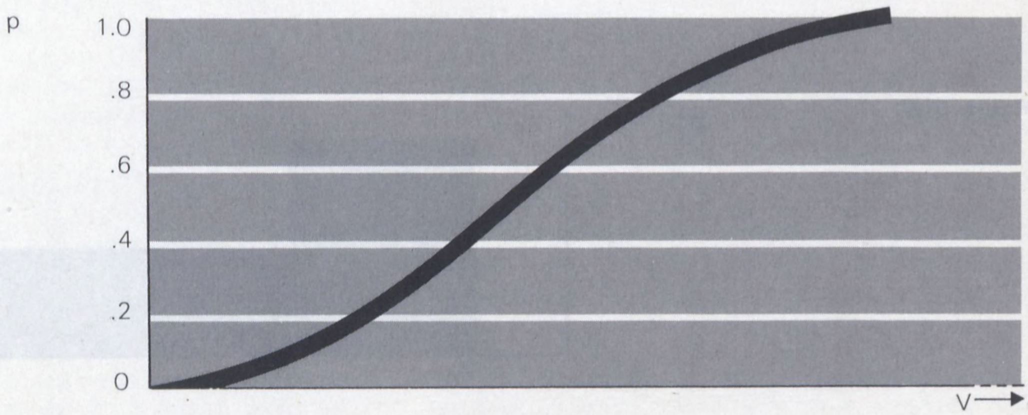


Figure 6(b)



(f) The Language of Uncertainty

To assist interpretation of the detailed findings presented later in this report, a word or two about the uncertainty of the findings is in order. This study concerns a particular aspect of the future of data communications in Canada. Somehow, the uncertainty inherent in this future must be dealt with in the study's findings.

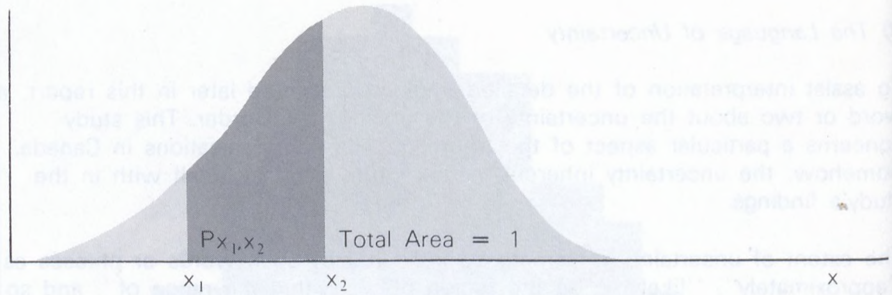
The extent of uncertainty is sometimes indicated by such words or phrases as "approximately", "likely", "in the region of", "within the range of", and so forth. Somewhat more information is conveyed by attaching a plus or minus range to the number, indicating a specified lower and upper bound (*e.g.*, 100 ± 5). The third alternative, which we prefer, is to use the language of probability explicitly in the description of uncertainty.

Wherever a group opinion is expressed as a probability density, the opinion is tantamount to the groups advice to us on how probable it is that the actual future number will lie in a specific interval of values. Figure 7 shows how a probability density distribution can be used as a guide to apportioning probability to different ranges of an unknown future quantity.

For elicitation or display of estimates, we have found the cumulative probability function, which is the integral of the probability density distribution, more useful. The value of the cumulative probability at a point x_o is the probability that the actual value of x will be less than or equal to x_o and corresponds to the area under the probability density to the left of x_o. Figure 8 shows the cumulative probability function corresponding to the density distribution given in Figure 7.

In this report, whenever a single number is used, it is intended to represent the expected value (mean or average) of a group opinion of respondents obtained by weighted addition of their individual estimates. One of the axioms that a careful and logical decision-maker is presumed to accept is that of *substitutability*: that is, faced with such a lottery as described by the

Figure 7
An Estimate of x Expressed as Probability Density on x



(P_{x_1,x_2} = area under the curve between x_1 and x_2 = probability assignment that the actual value of x will lie in the range x_1 - x_2.)

distribution of Figure 7, he would exchange it for its expected value. The expected value $\bar{x}$ is defined as

$$\bar{x} = \int_{-\infty}^{\infty} x \quad f(x)dx \text{ where } f(x) \text{ is the density function.}$$

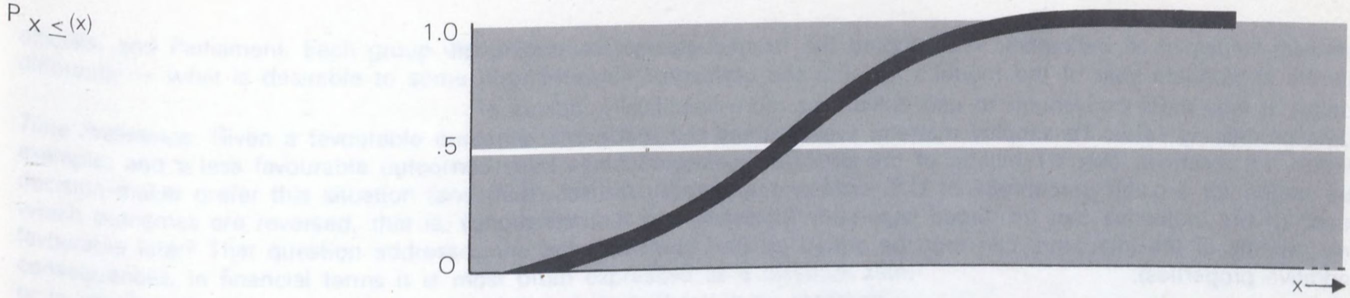
Therefore, when our respondents give a range of values for a given quantity (*e.g.*, sales) as a first approximation, we should be willing to exchange their uncertain estimate for one certain value, equal to the expected value.

4. The Value Model

(a) Basic Requirements

In this section, we discuss the problem of constructing a framework of preferences — technically, the establishment of a *value model*. For

Figure 8
The Cumulative Probability Function on x



completeness, we shall first identify the key elements of such a value model even though in the course of this study we took some liberties with it and, by eliminating some components (time and risk preferences), transferred a greater burden onto the shoulders of the eventual decision-maker.

Trade-Off Functions: The indicators of policy consequences used in this study have different dimensions: dollars, number of Canadian graduates, and percent of U.S. control of the data processing industry. Combining them in one measure of value is a problem of deriving a multi-attributed utility. This problem is yielding slowly to a theoretical approach and even more slowly to a practical approach. It is a problem that decision-makers (in fact, all of us) face every day, yet somehow we all seem to be able to make such simple decisions as choosing between three apples and four bananas, and four apples and three bananas. In examining consequences that display each indicator as a time series, this trade-off can be performed in the appropriate year in the future, or the values of each indicator can be replaced by an equivalent present value and the trade-off can then be performed using the present values of all indicators. We adopted the former approach — trading off in the appropriate year of the model's run. For the common "currency" of utility, it was most convenient to use dollars, or more specifically, dollars of data processing sales. To simplify matters, we assumed that trade-offs are linear, for example, that $1 million of the data processing industry's sales can be traded for a given percentage of U.S. control at any level of sales, that each of the indicators can be traded separately for sales, and that the money equivalents of the indicators can then be added up (*i.e.*, the utility has additive properties).

We addressed the problem of trade-offs thus: How much of a decrease in sales of the data processing industry in Canada is the decision-maker willing to accept in order to obtain a given decrease in the percentage of U.S. control? For example, suppose that to decrease U.S. control from its present level, the decision-maker wanted to adopt Policy C (Crown Corporation). Such a policy would result in the provision of many non-remunerative services (such as educational), thereby ultimately crowding out the profitable ones. By first calculating the sum of the money equivalents (utilities) of the economic indicators, the decision-maker could compare the overall economic effect of each policy. If the money equivalents are equal, the decision-maker is assumed to be as happy (or unhappy) with the old (larger) sales and U.S. control as he is with the new (smaller) revenues and decreased U.S. control. This trade-off obviously has limits, because we cannot conceive of a decision-maker who would be happy to have the data processing industry be totally Canadian-controlled if it would in the process become very small.

A similar trade-off was performed between sales and number (or percent) of Canadian graduates, and so forth for the other indicators. Then the individual dollar amounts were added, resulting in one utility (in the classical, non-risk sense) of each policy for the years 1975, 1980, and 1985.

Of course, the measures of aggregate utility which were thus obtained do not reflect possible disagreements among the real-world groups which might be involved in the choice of a policy for actual implementation. The trade-offs are the essence of the political bargaining process: they would be judged differently by the data processing industry, the computer industry, public officials, and Parliament. Each group views identical consequences differently — what is desirable to some is undesirable to others.

Time Preference: Given a favourable outcome in the first five years, for example, and a less favourable outcome in the next five years, would the decision-maker prefer this situation (and, if so, to what extent) to that in which outcomes are reversed, that is, less favourable first and more favourable later? That question addresses the importance of future consequences. In financial terms it is most often expressed as a discount rate, or in psychological terms as the degree of impatience. There is no standard answer to such a question of discount rates, and it is difficult to elicit them. However, assuming that this were done, the utility values (expressed in dollars) in each year would be used, with the help of the discount rate, to compute the present (decision time) value of the utility. In this study, we show the utility of different policy options as the function of time (while time preferences are left out).

Risk Preference: Policy formulation should recognize risk inherent in a policy. The best efforts of decision-makers, however well intentioned at the time, sometimes turn out to be disastrous. Would the decision-maker prefer to "play it safe", choosing a modest policy, or would he rather "go for broke", in an all-or-nothing, success-or-failure policy? Decision-makers, particularly those operating with large resources, tend to be cautious and risk-averse. This observation applies to industry as well as to the government.

Powerful political forces are at play in policy formulation, which means that the decision-makers are likely to proceed cautiously. Therefore, one might be tempted to translate the dollar value of future outcomes into its utility — not the utility in the classical sense, but the von Neumann-Morgenstern utility that reflects risk aversion.

To illuminate the pitfalls that might be incurred by adopting a policy that ultimately will be recognized as undesirable, we computed the economic penalties involved in case the outcomes of a given policy were to turn out differently from the expected values. Risk preference, however, was not explicitly incorporated into the value model used here.

(b) Allocation of Value Weights

Summarizing the discussion of the preferences or the value model, it is possible, although difficult, to reduce information contained in the description of the several outcomes for each year into one overall number by using successively:

- Trade-off functions
- time preference
- risk preference

Whose preferences and trade-off functions should be taken into consideration? The final decision-maker is the Parliament of Canada, representing the people of Canada. We assumed that a participant in policy formulation (the Task Force, for example) would like to know the preferred policy given trade-off tables that, in our estimation, might be close to those assigned by the Canadian government and how the desirability of the preferred policy will change, depending on the weights assigned to different indicators. The Task Force might, therefore, assign different trade-off functions to represent its impression of what is best for the data processing industry.

We would now like to describe our attempt to arrive at one number that incorporates a feeling of an overall usefulness of:

- Annual total investment
- annual (domestic) sales
- employment opportunities
- employment opportunities for Canadian university graduates specializing in computer/communications-oriented disciplines
- imports to Canada
- exports from Canada
- U.S. control of data processing companies in Canada

Before proceeding, however, it should be pointed out that the structure of the data processing industry creates a difficult problem in evaluating consequences of changes in the organization of computer/communications. Briefly, data processing can be (and is) performed ''inside'' many companies in Canada, as well as ''outside''. If it is performed outside, it is expressed in revenues of the data processing industry; but if it is performed as an inside computation service in any of the companies that can afford their own computation services, it is an element of internal production costs. If the

Canadian government reorganizes the structure of the computer/communications network, the industrial user has two choices: he can accommodate himself to the changes, or he can switch more of his external data processing requirements to inside processing. When our respondents estimated the effect of future organization of the data processing industry on the operations of Canadian companies, we specifically asked them to bear in mind the possibility of changing the ratio of external to internal data processing.

The problem raised by this dual nature of data processing is that there are no existing forecasts for the future amount of internal data processing and we collected forecasts for the external data processing only. However, this is not as bad as it seems. For a decision-maker who is detached from the external data processing industry, the choice appears to be: "Would I rather have the data processing services performed outside or inside Canadian companies?" So long as the services are performed, he may not particularly care where they are performed. Of course, there will be users, particularly small-sized companies, who may be inconvenienced (or hurt economically) by not having such an option and having to rely possibly on a Crown Corporation for their services. The decision-maker will have to consider such users as well. Even then, many business companies offer computer services and software support which a small company might use.

Because of the possibility of transfer from external to internal data processing (or *vice versa*), the utility of the outcome must address the *differential* desirability of having more data processing performed outside than inside. The desirability of external data processing stems from the belief that innovation and flexibility would be enhanced, and that small Canadian companies would thus find available a range of data processing services that they could not otherwise afford. We assumed that the total amount of data processing at a given time (that is, the outside plus the inside data processing) will be approximately constant, for the following reasons: (i) as suggested by our data, large companies are indifferent to the manner in which computer/communications will be organized, and (ii) the competitive pressures would probably disallow drastic differences in the amount of data processing, either external or internal, performed as a part of their day-to-day operations between companies competing in Canada, or between Canadian companies competing with U.S. and other foreign companies in the world market.

If the differential desirability were zero, that is, the decision-maker were indifferent whether data processing services are performed outside or inside, such assessment would be reflected in a zero weight attached to the corresponding indicator. Then, regardless of the value of the indicator, we would have no reason to prefer one policy over another. As a common denominator, we assumed that the decision-maker values differential sales of $1 million as one unit of utility, and we express all our calculations in terms of such differential sales. We do not use sales directly as one of the indicators of utility — rather we infer the utility value of all the other indicators in terms of the utility of differential sales.[6]

In this study, six indicators having dimensions of three types (dollars, persons employed, and percent effective U.S. ownership) were used to derive a measure of utility. First, we established, where possible, the 1970 dollar values for some of the indicators. Table 2 shows the dollar values used to convert the normalized forecasts used by our respondents to the estimated dollar amounts.

Using the annual domestic sales as a yardstick (or a common denominator), we established, outcome by outcome, their utility in dollars. Domestic sales were chosen because: (i) they are a relatively unambiguous measure, and (ii) they happen to be one of the indicators for which we had a 1970 estimated value. In the following sections, we explain how we assigned utility values, in terms of sales, to the other indicators. The assumed utility values are only an approximation to the actual utility values that Canadian decision-makers might assign. They were arrived at in a conference of the project staff and our consultants. Table 2 summarizes the estimated 1970 values of the indicators and the weighting factors chosen for use in our utility calculations.

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6 Sales were not used because it would result in employment being given double weight. Refer to "Employment Opportunities", page 36, for an explanation of this concept.

Table 2
Summary of Utility Weights
Assigned to Policy Outcome Indicators

Indicator	1970 Value ($ Millions)	Weighting Factor
Annual Total Investment	16.25	4.4
Employment Opportunities	65	1.0
Employment Opportunities for Canadian University Graduates in Computer/Communications	65	1.05
Imports to Canada	15	−1.2
Exports from Canada	5	1.2
U.S. Control of Data Processing Industry	70%*	− $1.8 million/change (%) × value of sales compared with value of sales under Policy A

Source:
Conference between Institute for the Future research team and members of the Canadian Computer/Communications Task Force.

* 70% U.S. control of the commercial data processing services industry represents a hypothetical, best-guess estimate derived at an early stage in Task Force deliberations. Apart from the difficulty of defining "control", other problems arise concerning the bases upon which the degree of control may be measured. Such factors as market share, equity, number of companies and availability of technology are all relevant, and each may result in widely-varying estimates (see Table 3).

Most of the pertinent information remains unavailable, but more recent Task Force estimates suggest that the figure of 70% may be somewhat high. Indeed the group estimate provided by the panel in this study was considerably lower (48%).

Annual Total Investment: The objective was to establish an utility in dollars of annual total (differential) investment, which, in the mind of the decision-maker (the Canadian government), would substitute for \$1 million of domestic differential sales. Typically, the data processing industry writes off equipment in about four years, mainly because of technical obsolescence. Therefore, one additional dollar of investment ought to result, a short time later (depending on delivery of equipment and other factors), in \$4 of additional sales. We assigned a small penalty (10 percent) to express the effect of delayed sales. It happens, however, that the absolute number of investment dollars is roughly one-fourth of the amount of sales. Hence other things being equal, numerical values expressing the utility of annual sales and annual investment ought to be roughly interchangeable. But other things are not equal. As indicated in Part D, regarding the intangible effects of policy, there is a commonly-held belief that innovation, *per se*, is important because a lack of it will blunt the competitive edge of the Canadian industry *vis-à-vis* its competitors in the United States and abroad. Because new investment is directly associated with innovation, we allocated to investment an additional weight of 20 percent (*i.e.*, we multiplied investment by 1.2).

Summarizing the above considerations as an equation, we have an overall weighting factor multiplier for investment dollars as a product of three factors:

$$\text{Weighting factor for investment} = (\$\ \text{sales}/\$\ \text{investment}) \times (\text{discount factor}) \times (\text{innovation factor}) = 4 \times \frac{1}{1.1} \times 1.2 = 4.4$$

Employment Opportunities: Once we made the assumption that the overall amount of data processing performed in Canada would be approximately independent of the ultimate Canadian government decision with regard to computer/communications, it followed that, in parallel with internal and external sales, we should consider the differential desirability of having the Canadian labour force for data processing employed within the data processing industry *per se*, rather than in Canadian companies. We estimated that sales are roughly proportional to the number of people employed. Thus, neglecting possible economies of scale (which we leave to a possible future, finer modelling effort), when both sales and employment are expressed on a normalized scale (having the value 1 in 1970), the constant of proportionality is unity. Both consider the differential advantages of external data processing. Therefore (neglecting exports), one unit increase in sales is the same as one unit increase in employment, the argument being that very soon (because of competitive pressures) additional employment will result in additional sales; that is, one unit increase in employment produces one unit increase in sales. Therefore, we assigned a scale factor of 1.0 to employment opportunities and, because we express all indicators in dollar terms, a 1970 ''value''[7] of $65 million to employment in 1970.

Employment Opportunities for Canadian University Graduates: Here the approach is similar to the general employment situation discussed above, modified by the assumption that Canadians would be willing to pay an additional premium (*i.e.*, a premium beyond the differential desirability of external data processing) for the employment of Canadian university graduates within the data processing industry — in the belief that the graduates' capability for innovation will be better utilized in the external data processing environment than inside companies. Therefore, instead of a weighting factor of zero (which would signify indifference), we assigned to this indicator a weighting factor of 1.05. To express it in the common currency of sales, we assigned a value of $65 million to the indicator in 1970, resulting in an initial utility of 1.05 X 65 = $68.25 million.

Net Exports: To account for Canada's (i) sensitivity to the international trade balance, (ii) desire to export sophisticated technological products as well as raw materials, and (iii) recognition that export of data processing services could mean acknowledgment of the competitive posture of the Canadian information industry, we allocated a weight of 1.2 to net exports. That is, because of the three factors enumerated above, we assumed that Canadians would be willing to ''trade'' $1.2 of domestic sales for $1 of net exports. By assigning a weighting factor of -1.2 to imports, we converted the sum of exports and imports into net exports.

U.S. Control of Data Processing Companies in Canada: Our respondents indicated that Policy C (*i.e.*, Crown Corporation) would have the effect of reducing external data processing but would, of course, result in Canadian control of the industry.

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7 We set ''value'' off by quotation marks to avoid its interpretation as payroll, in which case the industry would always be in the red!

The trade-off of sales for increased percentage of Canadian control is the central problem of Canadian economic, national, and cultural independence: How much are Canadians willing to pay to remain independent? All we can hope to do, as in the other examples, is to show how such trade-offs might be derived and, having been derived, how they might be aggregated.

Rather than postulating a price that Canadians might be willing to pay for increased Canadian control of the data processing industry, we determined, on the basis of the respondents' estimates, the price that they probably would have to pay. We chose to use estimates for the year 1980, in effect "averaging" over the 15-year period 1970-1985. In 1980, under Policy A, external data processing sales are expected to be $239 million, of which 54 percent will be Canadian controlled.[8] Under Policy C, however, external data processing sales will amount to only $192 million, of which 84 percent will be Canadian controlled. Since we assumed that the total data processing sales will remain constant, an additional effect of Policy C would be thus to drive $47 million of data processing sales inside large companies, where the average Canadian control will amount to 40 percent, that is, equal to the present overall Canadian control of Canadian industry.[9] To summarize, the consequences of policies A and C in 1980 are:

- Policy A: External data processing sales of $239 million; Canadian control of data processing industry relatively unchanged from 52 percent to 54 percent.
- Policy C: External data processing sales of $192 million; Canadian control of external data processing industry increases from 52 percent to 84 percent, an increase of 32 percent.
- $47 million (roughly one-fifth of $239 million) of data processing sales driven internal; Canadian control of that portion of data processing decreases from 52 percent to 40 percent.

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[8] This estimate of 54% Canadian control in 1980 should be compared with the panel's estimate of the present level; namely 52% rather than with the initial Task Force estimate of 30% (see note, Table 2, p.35).

[9] The estimate of 40-percent effective Canadian control of Canadian industry is an assumption made by us, based on several opinions and with the help of some statistics such as those shown in Table 3

We determined the trade-off between the percentage of Canadian control and differential data processing sales by noting that the difference, in 1980, in external data processing sales between Policy C and Policy A is -$47 million. In exchange for this amount of lost sales of the external data processing industry, Canadians gain 32 percent control, but only over 85 percent of its size compared with its size under Policy A. We bring in this second consideration (*i.e.*, reduced size) in recognition of the fact that the utility of control vanishes when there is no industry to control. Thus, for Policy C, four-fifths of the possible external data processing sales would be 85-percent Canadian controlled, while one-fifth, that is, the amount of data processing driven "inside", would be 40-percent Canadian controlled. However, because we were concerned only with external data processing in this study, this last consideration should carry no weight.

We use this weighting factor of $\frac{47}{32 \times .8}$, that is, -$1.8 million per one-percent change of the entire external data processing industry, to calculate the price (in terms of domestic sales) Canadians will have to pay under each of the policy options and thereby to obtain the level of Canadian control associated with that policy. Whether such a price is worth paying is for Canadian decision-makers to judge – we simply report that this is the price that might have to be paid. We believe that this may be reasonably realistic – a 32-percent increase in Canadian control of external data processing by 1980 may be worth a loss of one-fifth of its sales.

(c) Computational Procedure

Where applicable (*i.e.*, except for employment), the value of each indicator was computed for 1975, 1980, and 1985, and then multiplied by the appropriate weighting factor. The desired aggregate utility measure was obtained for each year by simply summing the individual results of these computations. An example is shown in Table 4.

Table 3
Ownership of the Canadian Computer Services Suppliers (excluding those which are also hardware suppliers) (1969)

	Canadian*		Foreign**		Total	
	Amount	% of Total	Amount	% of Total	Amount	% of Total
Companies (Number)	26	65%	14	35%	40	100%
Assets ($ Millions)	$60,868	68%	$29,210	32%	$90,078	100%
Sales ($ Millions)	$17,346	33%	$34,799	67%	$52,145	100%
Profits ($ Millions)	–$ 2,474	—	$ 1,667	—	–$ 807	—
Equity ($ Millions)	$32,144	65%	$17,226	35%	$49,370	100%

Source:
Private communication.

* Having 50% or more of common shares owned by Canadians.

** Having 50% or more of common shares owned by non-Canadians.

Table 4
Example of Aggregate Utility Computation, for Data Processing Industry Under Policy A (1970 normalized values for the indicators are assumed to be 1.0)

Indicator	1970 Value ($ Millions)	Weighting Factor	1970	1975
Annual Total Investment	$16.25	4.4	1 × 16.25 × 4.4 = 71.5	1.74 × 16.25 × 4.4 = 124.4
Employment Opportunities	65.0*	1.0	1 × 65 × 1.0 = 65.0	1.84 × 65 × 1.0 = 119.6
Employment Opportunities for Canadian University Graduates in Computer/Communications	65.0*	1.05	1 × 65 × 11.05 = 68.3	2.01 × 65 × 1.05 = 137.2
Imports to Canada	15.0	−1.2	1 × 15 × −(1.2) = −18.0	5.59 × 15 × (−1.2) = −100.6
Exports from Canada	5.0	1.2	1 × 5 × 1.2 = 6.0	1.91 × 5 × 1.2 = 11.5
U.S. Control of Data Processing Industry	70%**	−$1.8 million / change in % × value of sales compared with value of sales under Policy A	0% × (2.0) × $\frac{65}{65}$ = 0	+5% × (−1.8) × $\frac{170}{170}$ = −9.0
Total Utility			192.8	283.1

* Employment values for 1970 are made equivalent to sales value for 1970.

** We "overrule" the respondents' estimate for 1970 percentage of U.S. control (the expected value is 48%, although the distribution is very broad, indicating a high degree of uncertainty) with our own best estimate of 70%. However, we have tried estimates from 48% to 80%, and the conclusions of the study do not change. We use the respondents' estimate of the future trend of the percentage (*i.e.*, changes in U.S. control from one period to the next); in this case, uncertain as the respondents are, they are our best source of information.

Part D

Detailed Findings

1. Policy Evaluation for Data Processing Industry

(a) Determination of the Best Policy

In this study, we explored the effects of specific policies regarding computer/communications on the Canadian data processing industry in greater detail than the effects on other industries. This was done for several reasons: (i) the data processing industry is the one that will be most affected by a choice of policy; (ii) the results of our study indicate that there appears to be no clear "best" policy for industries other than data processing; and (iii) there were enough respondents answering for the data processing industry to enable us to construct group probability distributions with respect to the key indicators by which the desirability of a given policy option could be evaluated.

Using the value model described in Part C, we calculated the utility of Policies A, B, and C for the years 1975, 1980, and 1985, on the basis of the expected values of the policy indicators and the scale factors we assigned to each indicator. In all three years, Policy C had the highest utility.

(b) Sensitivity of Policy to Uncertainty

Each of the forecasts for the indicators used to evaluate a given policy option was expressed as a probability distribution rather than a single trend projection, thereby acknowledging that our respondents were uncertain as to the future values of sales, investment, and so forth. To assess the significance of this uncertainty, we attempted to ascertain whether the policy that is considered best, given the expected values of future indicators, remains the best policy if all values fall on the low side, or if all values fall on the high side. In fact, one might expect that it is likely that they will all do so simultaneously; for example, general economic conditions would affect all the indicators in a similar way. Therefore, in addition to checking the sensitivity of policy, these low and high forecasts represent a real situation that may develop.

The conclusion of this analysis of sensitivity was that a choice of policy, with the particular weights we assigned to the indicators, is not very sensitive to uncertainty. For example, when net exports are weighted (*i.e.*, considered more desirable) by a factor of 1.2 (*i.e.*, 20 percent more important than domestic sales), as they were in computing the values in Table 5, then Policy C appears to be the best in terms of highest utility for both the forecasts based on the expected values of the indicators and the forecasts based on the 90-percent probability values (both the "so-so" and the "very good" forecasts). Only when 10-percent probability values are assumed (decidedly a pessimistic future) does Policy B become preferable to Policy C. This is equally true for calculations performed for policy effects in 1975, 1980, and 1985.

Table 5 shows the risk inherent in adopting a given policy based on the particular weights we assigned to the indicators. If the decision-maker adopts Policy C, then, calculating the range of estimates for which utility of Policy C is highest,[10] we find that there is roughly an 85-percent chance that Policy C will indeed turn out to be the best policy in all three time-periods (*i.e.*, assuming that the future values of the indicators will lie somewhere between the "so-so" and optimistic estimates). However, if the pessimistic estimates turn out to be true (a 15-percent chance), then Policy B is best, but the difference in utility between Policies B and C is small.

(c) Sensitivity of Policy to the Weighting Factor Assigned to Net Exports

In addition to determining the sensitivity of the best policy to uncertainty, we checked the sensitivity of the best policy to the weights assigned to the key indicators in the value model. We calculated the utility of each policy for several different values of the weighting factor assigned to net exports — a factor that, in our opinion, dominates the judgmental criteria of what is a "good" policy.

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10 We calculated the range of estimates for which Policy C is best by interpolating the utilities of Policies B and C between the probability estimates given in Table 5. At approximately a 15-percent probability level, Policy C becomes worse than Policy B

Table 5
Sensitivity of Policy to Uncertainty

		Utility for Estimates Based on:		
		10% Probability *	Expected Values	90% Probability *
1975	Policy A	215	283	444
	Policy B	**250** **	265	345
	Policy C	184	**372**	**692**
1980	Policy A	233	404	642
	Policy B	**295**	314	444
	Policy C	241	**521**	**1,200**
1985	Policy A	251	540	873
	Policy B	**297**	373	589
	Policy C	244	**604**	**1,393**

* Probability that the value of each indicator will be less than the value stated here.

** Bold-faced numbers identify policy having the highest utility.

If Canadian decision-makers were completely indifferent to the difference between exports and imports (expressed as a weight assignment of zero to these indicators), then Policies A and C would be almost as good in terms of having the highest utility. However, should the decision-makers attach some importance (or weight) to the difference between exports and imports (*i.e.*, net exports) in terms of domestic sales (corresponding to an increase in the weighting factor), then Policy A would decrease in utility quite rapidly and Policy C would become the best policy. The explanation is that the magnitude of imports under Policy A is much larger than under Policy C and that the utility of these imports is assumed to be negative (because exports are good).

In Table 6, we illustrate the sensitivity of policy to the weighting factor for net exports. With an increase in the weighting factor, there is a rapid decrease in utility for Policy A, whereas only a slight decrease for Policy C. The changeover at which Policy C becomes better than Policy A occurs at different values of the weighting factor in each of the three time-periods considered. What is clear, however, is that if net exports are weighted greater than 0.7 times domestic sales, then Policy C is the best policy in the entire 1970-1985 period. For smaller weight assignments, some time preference must be assumed as Policy A is best for 1985 whereas Policy C is best for 1975 and 1980.

2. Measurable Effects of Computer/Communications Policies

(a) Data Processing Industry

Table 7 summarizes the economic effects of the alternative computer/communications policies on the data processing industry. In addition to these economic forecasts, Policy A is expected to result in a 6-percent decrease in U.S. control, Policy B in a 21-percent decrease, and Policy C in a 36-percent decrease (from an estimated 70-percent effective control in 1970). The overall outcomes of the policies can be summarized as: Policy A will lead to maximum growth but also largest imports and largest degree of U.S. control; Policy B will lead to extremely slow growth but low imports and a lower degree of U.S. control; and Policy C will lead to only moderate growth but minimal imports and least U.S. control.

Table 6
Sensitivity of Policy to Weighting of Net Exports

		Weighting Factor Assigned to Net Exports					
		0.0	0.2	0.6	0.8	1.2	2.0
1975	Policy A	372	357	327	313	283	223
	Policy B	281	278	273	270	265	253
	Policy C	**386** *	**384**	**379**	**377**	**372**	**362**
1980	Policy A	**538**	516	471	449	404	315
	Policy B	337	333	325	321	313	299
	Policy C	537	**534**	**528**	**526**	**521**	**510**
1985	Policy A	**705**	**677**	**622**	595	540	430
	Policy B	400	395	386	382	373	354
	Policy C	623	620	614	**611**	**604**	**592**

* Bold-faced numbers identify policy having the highest utility.

The distributions from which the expected values in Table 7 are derived are characterized by great uncertainty. Typically, the 90-percent probability estimate is several times the 10-percent estimate. Thus, respondents appear to assign 80-percent probability (that is, 90 percent minus 10 percent) that the future values will be somewhere within a range of two to one, three to one, and sometimes as much as six to one with respect to the 10-percent estimate. Figure 9 shows a typical group distribution of estimates, in this case for future sales of the data processing industry.

Table 8 translates the percentage figures of Table 7, where applicable, into the effect in 1985 of Policies A, B, and C, measured in millions of dollars. These calculations are based on 1970 estimated values.

(b) Other Canadian Industries

One should bear in mind that the data we collected suffer from two severe limitations: (i) very few highly placed executives were willing to participate in the inquiry, and (ii) they "spoke for" or had opinions about very few key industries in Canada. Nevertheless, with the above caveats in mind, the findings indicate that the effects of policies for computer/communications on large Canadian industries are expected to be small, with a few exceptions.

Table 9 supports these conclusions in more detail. The values shown are percentage changes in indicator values that would be caused by a substitution of one policy for another, whichever substitution creates the largest difference in the value of the indicator. Next to each number we indicate the best and the worst policy option.

Once again, the reader should bear in mind that these findings merely give a flavor of what a full-scale investigation of the effects on various industries might yield. But even the flavor conveys the message: The effects of Canadian decisions with respect to computer/communications on industry will be uneven — relatively large on some industries and small on others — and a policy that would be beneficial for some would be bad for others. The overall conclusion is that there is nothing in the findings (limited as they are) that clearly indicates that one policy option is uniformly better than another for Canadian industries other than data processing.

Table 7
Measurable Effects of Computer/Communications Policies on Canadian Data Processing Industry

Indicator	Percent Change in 1970-1985 Period		
	Policy A	Policy B	Policy C
Annual Total Investment	163%	64%	86%
Sales	387	158	244
Employment Opportunities	254	94	232
Employment of Canadian University Graduates in Computer/Communications	304	100	235
Imports to Canada	866	93	35
Exports from Canada	141	28	−3

Table 8
Estimated Economic Effects in 1985 of Computer/Communications Policies on Data Processing Industry (millions of dollars)

Indicator	1970 Value	Policy A	Policy B	Policy C
Annual Total Investment	$16.25	$ 42.7	$ 26.7	$ 30.2
Annual (Domestic) Sales	65.0	316.6	167.7	223.6
Imports to Canada	15.0	144.9	29.0	20.3
Exports from Canada	5.0	12.1	6.4	4.9
Net Exports	−10.0	−132.8	−22.6	−15.4

Figure 9
Example of Panel Uncertainty:
Estimated Future Sales of Canadian Data Processing Industry (1970 — 100)

Group Probability Estimates for 9 Respondents

The unshaded region corresponds to the interval between the 10 and 90% probability estimates.

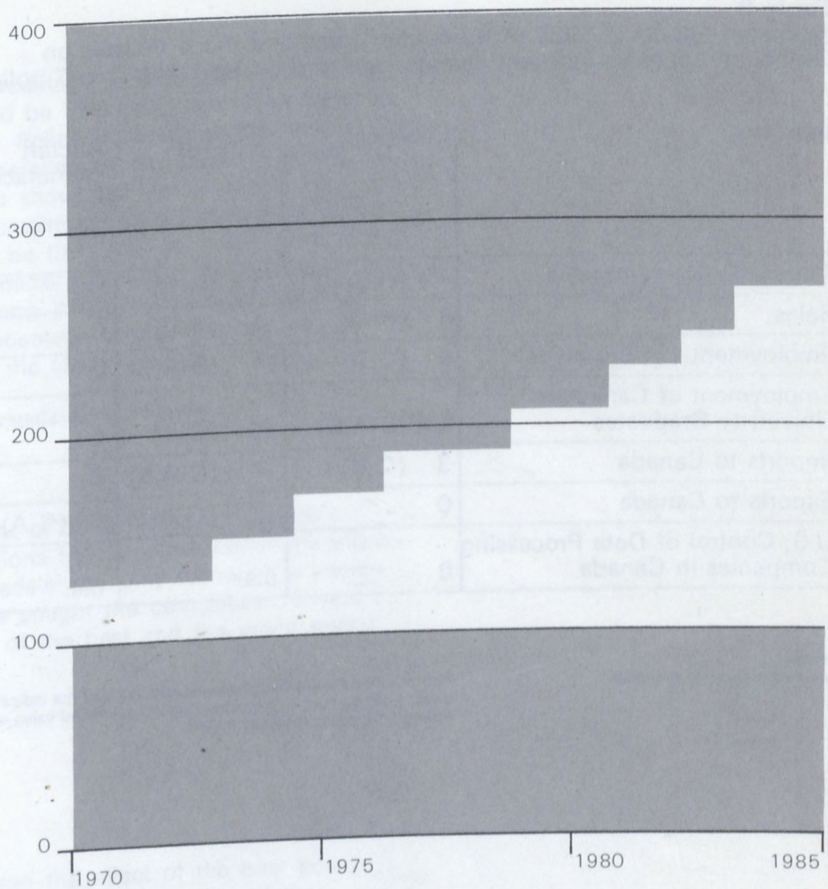


Table 9
Estimated Effects in 1985 of Computer/Communications Policies on Canadian Industries (percent change caused by substituting "best" policy for "worst")

Indicator	Chemical	Computer	Aircraft Manufacturing	Pulp and Paper	Automobile	Communications	Electronic Components Manufacturing
Annual Total Investment	4% (A,B-C)*	24% (A-B)	0%	0%	0%	10% (A-B)	21% (B-A)
Sales	8 (B-C)	9 (B-C)	0	0	0	10 (A-B)	23 (B-A)
Employment Opportunities	4 (C-B)	1 (B-A,C)	0	0	0	7 (A,B-C)	n.a.
Employment of Canadian University Graduates	1.5 (C-A,B)	20 (C-A)	0	0	0	1 (A,B-C)	n.a.
Imports to Canada	3 (C-B)	4 (C-A,B)	0	0	0	30 (B-A,C)	n.a.
Exports to Canada	0	7 (C-A,B)	20 (C-A)	0	0	n.a.	n.a.
U.S. Control of Data Processing Companies in Canada	0	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.

Note:
n.a.=estimates not available.

* This notation means that the estimated value of the indicator under Policies A or B is greater than the estimated value under Policy C by the percentage stated.

3. Measurable Effects of Data Bank Policies

Respondents were asked to estimate the percentage of data banks containing personalized or critical information that would be effectively controlled by or in the United States, under two policy options: Policy D (no licensing) and Policy E (licensing). The forecasts of these percentages are given in Figure 10 in terms of expected values. These estimates show that, for all industries considered, the percentage of data banks containing critical information in the United States under Policy E is expected to be the same as or less than that under Policy D. For the automobile and chemical industries, the difference between the two policies to Canada's economy is expected to be very slight, in that it does not appreciably affect the percentage of data banks (used by those industries) controlled by or located in the United States.

4. Respondents' Preferences for Computer/Communications Policies

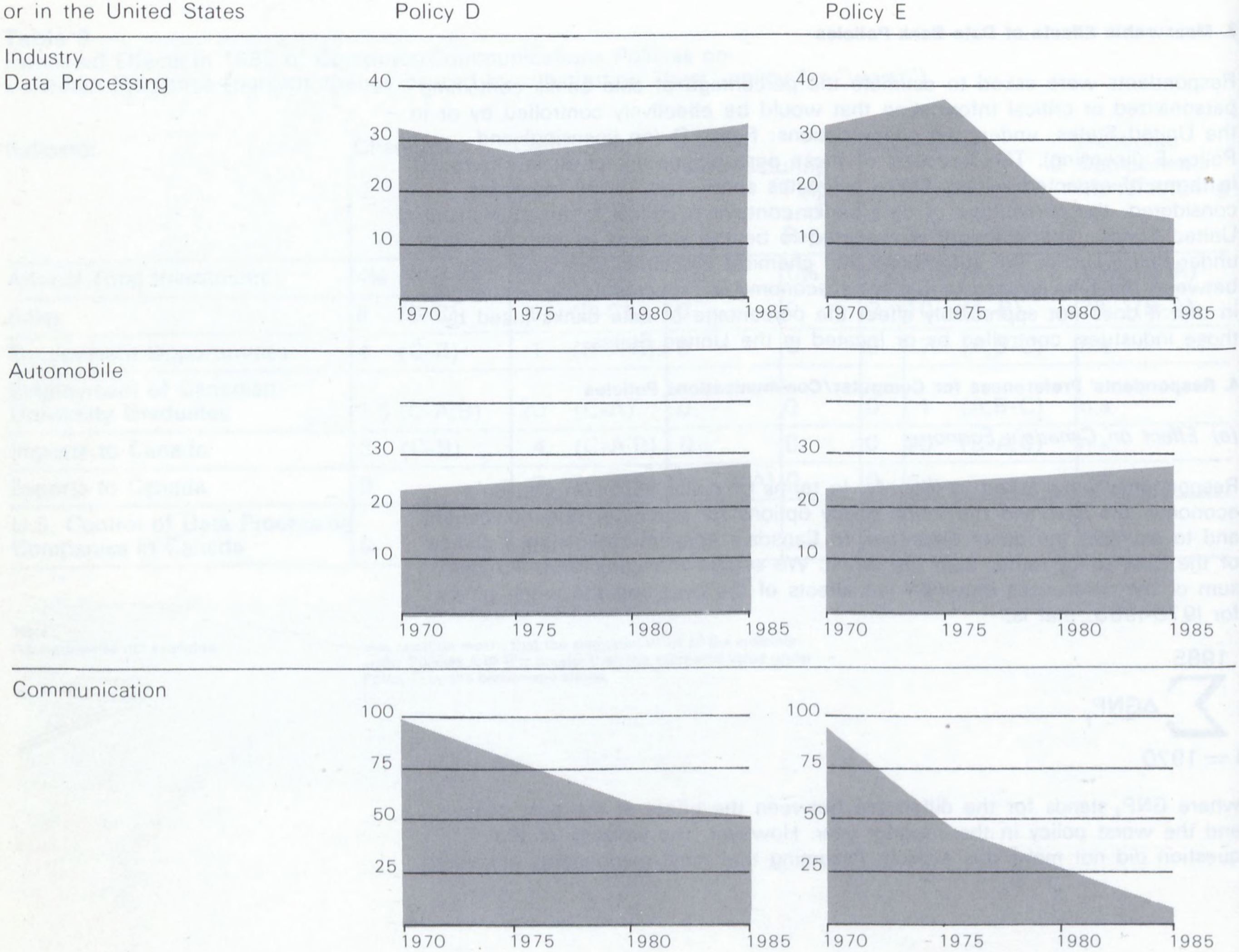
(a) Effect on Canada's Economy

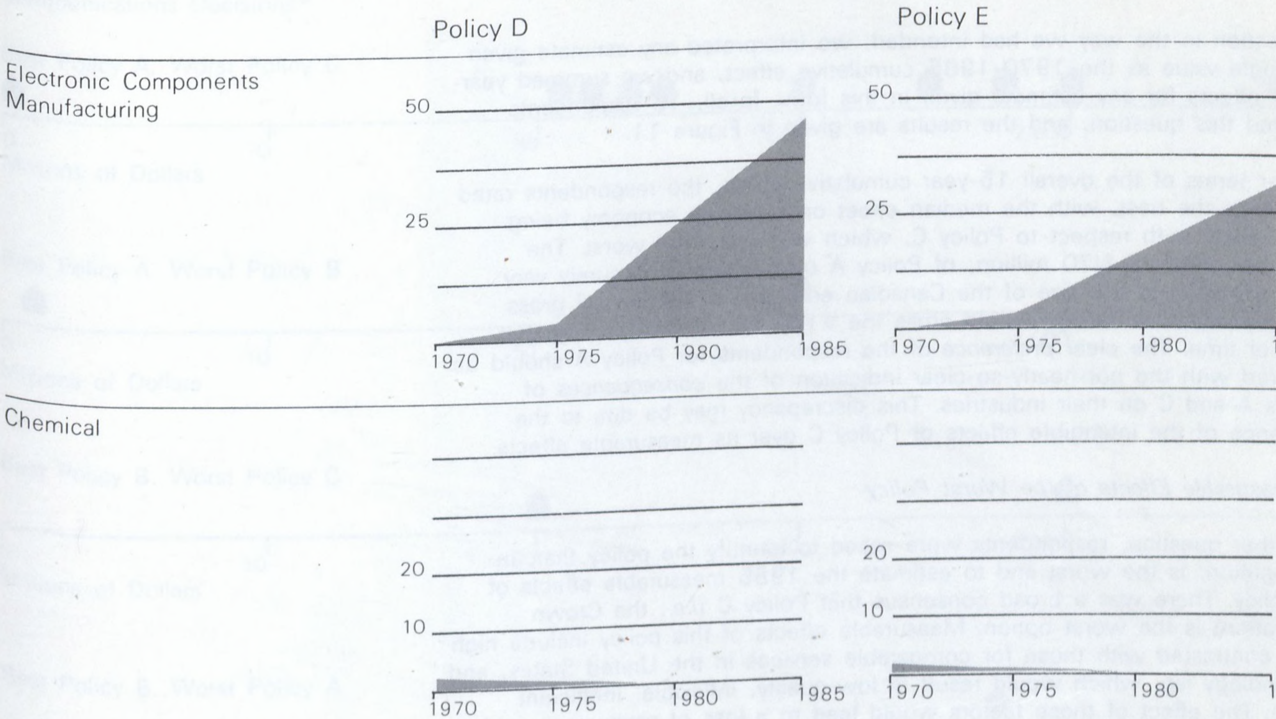
Respondents were asked to identify, in terms of dollar effect on Canada's economy, the best and the worst policy options for computer/communications and to estimate the dollar difference to Canada's economy following a choice of the best policy rather than the worst. We sought the cumulative 15-year sum of the differences between the effects of the best and the worst policy for 1970-1985, that is,

$$\sum_{i=1970}^{1985} \Delta GNP_i$$

where GNP_i stands for the difference between the effect of the best policy and the worst policy in the superior year. However, the wording of the question did not make this explicit. Assuming that most respondents answered

Figure 10
Expected Percentage of Data Banks Containing Personalized or Critical Information Effectively Controlled by or in the United States




Policy D
Policy E
Electronic Components
Manufacturing
50
25
1970
1975
1980
1985
Chemical
20
10
1970
1975
1980
1985

the question in the way we had intended, we interpreted any estimate given as a single value as the 1970-1985 cumulative effect, and we summed year-by-year effects for any estimate given in this form. In all, 15 respondents answered this question, and the results are given in Figure 11.

In dollar terms of the overall 15-year cumulative effect, the respondents rated Policy A as the best, with the median effect on Canada's economy being $170 million with respect to Policy C, which was rated the worst. The cumulative effect of $170 million, of Policy A over Policy C, is surely very small in relation to the size of the Canadian economy — the annual gross national product of Canada would cross the $100 billion mark during that period of time. The clear *preference* of the respondents for Policy A should be compared with the not-nearly-so-clear indication of the *consequences* of Policies A and C on their industries. This discrepancy may be due to the dominance of the intangible effects of Policy C over its measurable effects.

(b) Measurable Effects of the Worst Policy

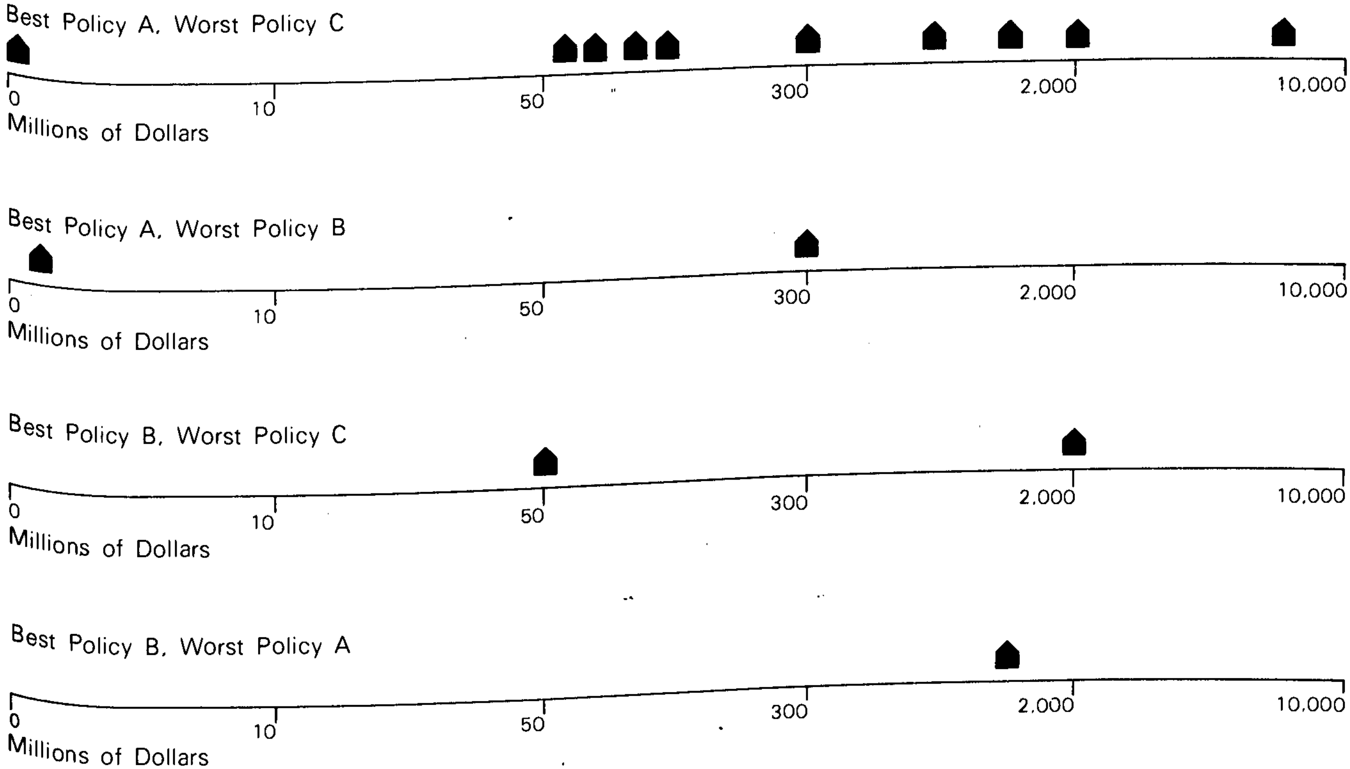
In another question, respondents were asked to identify the policy that, in their opinion, is the worst and to estimate the 1985 measurable effects of this policy. There was a broad consensus that Policy C (*i.e.*, the Crown Corporation) is the worst option. Measurable effects of this policy include high costs, contrasted with those for comparable services in the United States, and a technology lag, which would result in low-quality, inflexible, inefficient service. The effect of these factors would lead to a loss of productivity and a decline in the growth of the GNP. A more detailed analysis of the results of this question is presented in Figure 12.

(c) Intangible Effects of the Worst Policy

Similarly, we asked the respondents to identify the 1985 intangible effects of the worst policy. These effects are summarized in Figure 13.

The principal reasons given to support the view that Policy C was the worst policy were that the Crown Corporation would be insensitive to innovation and that increasing government control would result in the stifling of progress.

Figure 11
Dollar Effect on Canada's Economy of Computer/ Communications Decisions*



* Each arrow represents the opinion of one respondent as to the cumulative 1970-1985 dollar difference to Canada's economy that would result from the adoption of the "best" policy rather than the "worst"

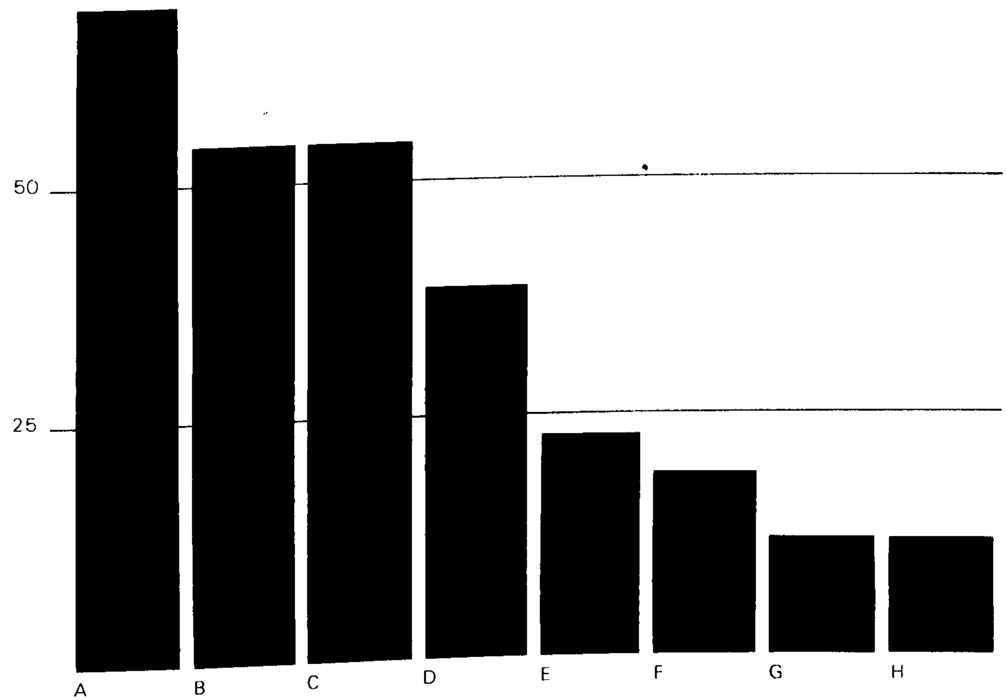
Such a policy would lead to a "civil service" attitude on the part of the Crown Corporation and to a lack of co-operation between the supplier and the user. The lack of competition under this policy would ensure a low-quality, inflexible, bureaucratic system that would lead to internal processing of data by industries.

(d) Summary

As shown in Figure 14, as a panel, the respondents preferred Policy A (*i.e.*, no regulation with respect to computer/communications), by a three-to-one margin. By the same margin, they chose Policy C (*i.e.*, Crown Corporation) as the worst alternative. There was no marked difference between the replies of large businesses, the data processing industry, and academicians.

Figure 12
Measurable Effects of Worst Policy
for Computer/Communications

Percent of Respondents
Citing Each Effect
Total: 19 Respondents



A 68.4%
Higher Costs (Eliminating ability to compete)

B 52.6%
Technology Impeded

C 52.6%
Decline in Productivity Leading to Decline in GNP

D 36.8%
Inefficiency — Low Quality Service

E 21.1%
Inflexibility

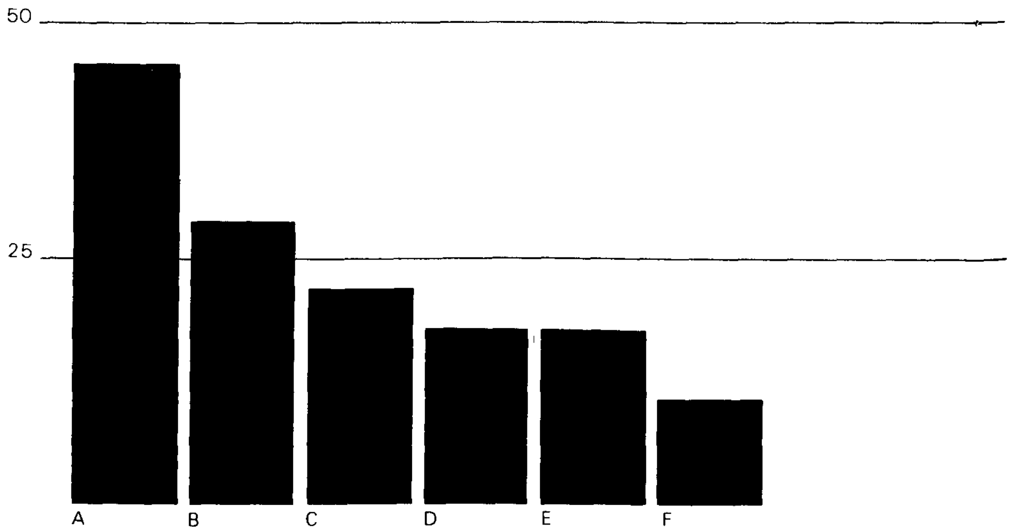
F 15.8%
High Degree of Government Regulation

G 10.5%
Obsolete Equipment

H 10.5%
Excessive Number of Employees

Figure 13
Intangible Effects of Worst Policy
for Computer/Communications

Percent of Respondents
Citing Each Effect
Total: 18 Respondents



A 44.5%
Technological Stagnancy

B 27.7%
Low Industry Morale — Less Attractive Working Environment

C 22.2%
Government Regulation and Restriction

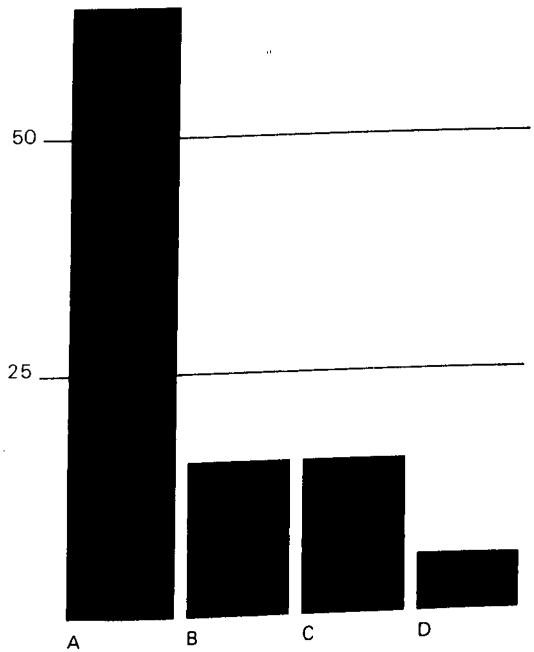
D 16.7%
Less Competition

E 16.7%
Increasing Dependence on and Resentment of U.S. Industry

F 11%
Higher Costs Compared with U.S.

Figure 14
Computer/Communications
Policy Preferences

Percent of Respondents
Total: 19 Respondents



A 63.1%
"A" Best
"C" Worst

B 15.8%
"A" Best
"B" Worst

C 15.8%
"B" Best
"C" Worst

D 5.3%
"B" Best
"A" Worst

5. Respondents' Preferences for Data Bank Policies

(a) Effect on Canada's Economy

Because of the specialized nature of this question, only nine respondents were able to give estimates of the dollar difference between the best and the worst policy for the regulation of data banks. The small panel was split with regard to these estimates, as shown in Figure 15. Five chose Policy D (no licensing) as the best policy, while four chose Policy E (licensing). The median value for the 1970-1985 cumulative dollar effect on Canada's economy was $1 million, favouring Policy D over Policy E. Because of the division in the panel, however, the median may not be the best estimator of the cumulative dollar effect. Therefore, we should consider the average of each group of estimates — $210 million for the effect of Policy D rather than E, and $1,812 million for Policy E rather than D.

(b) Measurable Effects of the Worst Policy

The respondents indicated that the adverse effect of licensing data banks (*i.e.*, Policy E) will be to increase cost of services provided, which in turn will lead to the slower development of information systems and the possibility of less computerization in industry and government. If the present situation with regard to data banks were to continue (*i.e.*, Policy D), the respondents expressed fears of the possible multiplicity of data banks, each storing inadequate information. This possibility would make complete data information difficult to obtain because of the scattered and incomplete nature of the information system. A more complete listing of measurable effects is included in Figure 16.

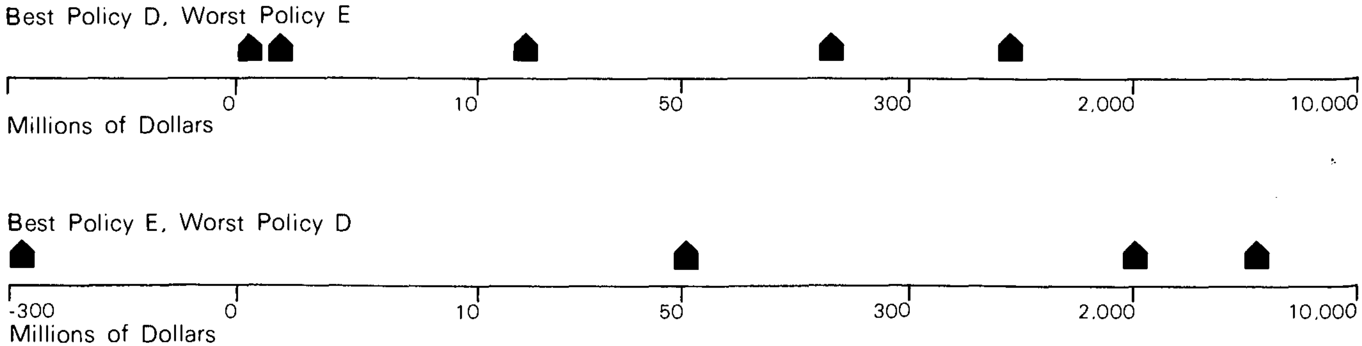
(c) Intangible Effects of the Worst Policy

The intangible effects of the worst policy, which are listed in Figure 17, also reflect the division in the panel regarding the best and the worst policy. The respondents who thought that Policy D was the worst policy argued that this policy would result in the misuse or exploitation of data and in the invasion of privacy. For those respondents who thought Policy E was the worst policy, the adverse effects included the stifling of progress caused by inefficiency and the bureaucratization of the industry.

(d) Summary

There was no clear panel preference with respect to the licensing of data banks, as indicated in Figure 18. The panel was divided between Policies D and E as the best. Of the twenty respondents who answered at least one of the questions relating to data banks, ten preferred Policy D (no licensing) and ten preferred Policy E (licensing). Both large businesses and the data processing industry reflected the division of the panel.

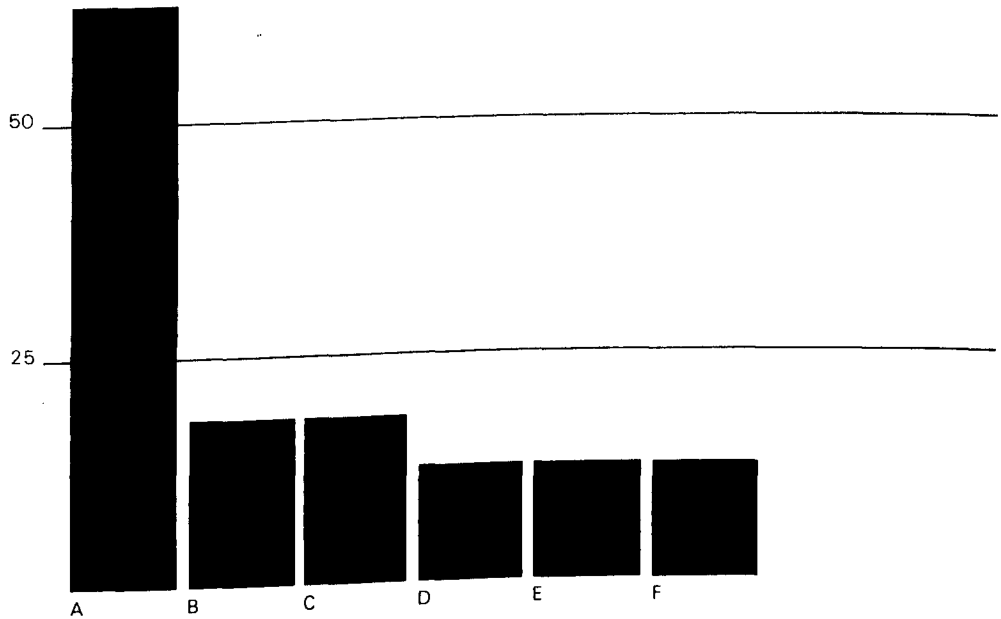
Figure 15
Dollar Effect on Canada's Economy of Data Bank Decision*



* Each arrow represents the opinion of one respondent as to the cumulative 1970-1985 dollar difference to Canada's economy which would result from the adoption of the "best" policy rather than the "worst"

Figure 16
Measurable Effects of Worst
Policy for Data Banks

Percent of Respondents
Citing Each Effect
Total: 17 Respondents



A 58%
More Fragmented and Incomplete or Inefficient Information Systems

B 17.6%
Increased Crime

C 17.6%
Increased Costs of Services

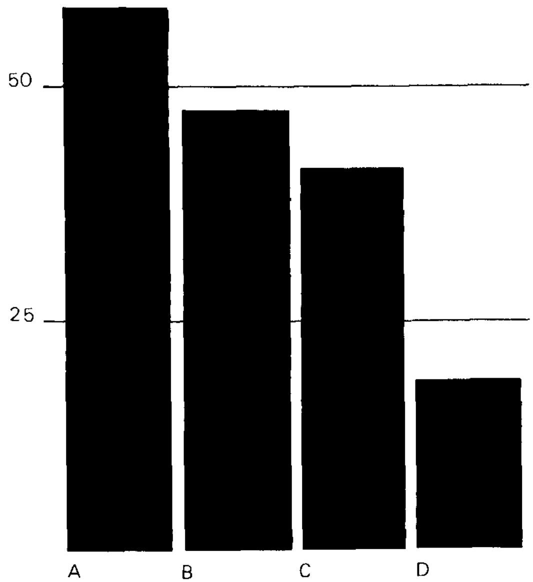
D 11.8%
High Degree of Government Control

E 11.8%
Proliferation of Private Data Banks

F 11.8%
Technological Stagnancy

Figure 17
Intangible Effects of Worst Policy for Data Banks

Percent of Respondents Citing Each Effect
Total: 13 Respondents



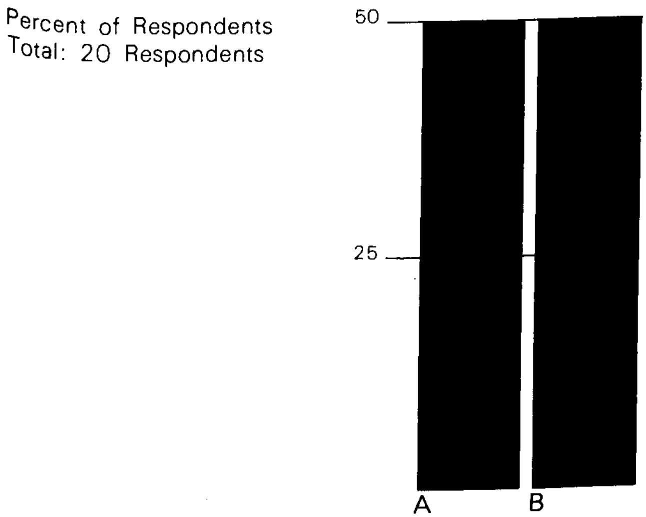
A 54%
Misuse or Exploitation of Data

B 46%
Invasion of Privacy

C 38.4%
Inefficiency — Stifling of Progress

D 15.4%
Bureaucratization of Industry

Figure 18
Data Bank Policy Preferences



A 50%
"D" Best
"E" Worst

B 50%
"E" Best
"D" Worst