PILOT STUDY ON THE ECONOMIC IMPACTS OF INFORMATION TECHNOLOGY

FINAL REPORT

Prepared for:

Department of Communications

Ottawa, Ontario

12 May 1980

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IRSA IRVING R. SILVER ASSOCIATES

TABLE OF CONTENTS

Executive Summary

Introduction: Major questions for a research agenda 1

1. Outline for Analysis 7
   - Introduction 8
   - Patterns of demand 15
   - Technological relationships 16
   - Factors of production 19
   - Organizational structure 21
   - Income and wealth distribution 21
   - International interdependence 22
   - Public policies 24

2. Issues and Hypotheses for Investigation 26

3. Appraisal of Analytic and Forecasting Techniques 102
   - Introduction 103
   - Criteria for Appraisal 103
   - Review of relevant techniques 108
   - Comparison of relevent techniques with appraisal criteria 118

4. Recommended Research Agenda 125
   - Overview 126
   - First phase - framework studies 128
   - Second phase - sectoral studies
   - Third phase - prediction and quantification of aggregate impacts 140
   - Summary and preliminary time and resource estimates 142
   - A core agenda 145

Bibliography 148

Appendix

EXECUTIVE SUMMARY

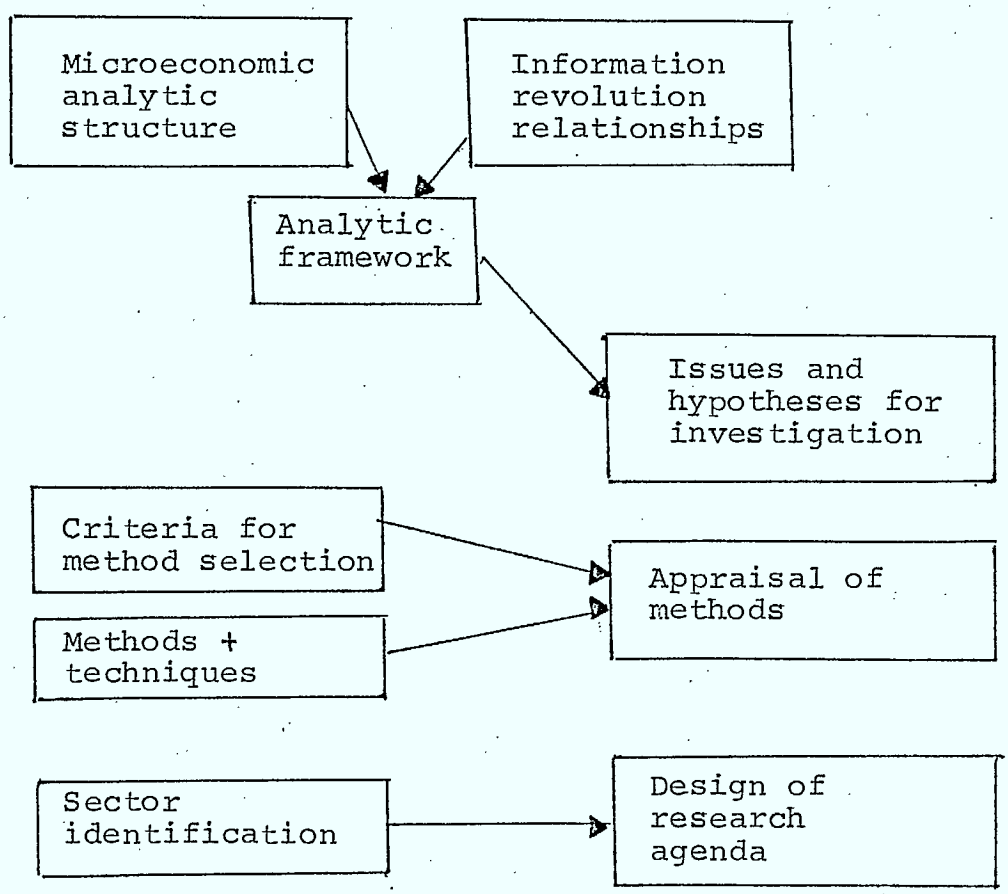
The purpose of this study is to examine the feasibility of an investigation into the economic impacts of the new information technology, or what has come to be called "the information revolution".

A number of questions are identified about which either assumptions must be made or which require specific investigation if a supportable set of conclusions about the overall impacts are to be formulated. These are:

- from a world prespective, which of the planned applications of the new information technology will be realized, to what extent, at what time and in what sector;
- will further information technology developments, now beyond the research stage, but for which applications have not yet been foreseen, lead to an overtaking of these former applications during the 1980's;
- where will production of the new technology occur and will there be significant diffusion of IBHS know-how away from the loci of such production through either vertically-linked or horizontially-linked industries;
- what new types of goods and services will be created as a result of the application of the new information technology and what existing goods and services will become obsolete, facing declining demand and possibly becoming non-existent;
- for Canada, what lines of production will be created of find enlarged markets and what lines will be destroyed or be diminished;
- will Canadian production become more or less integrated into that of multi-national enterprises;
- will the net impact on domestic income-generation be positive or negative;
- for public policy, at what stages and in what forms should infra-structure and other types of stimulus, as well as controls, be provided;

- what will be the impacts of the information revolution on income distribution and what are the appropriate instruments for achieving an equitable distribution.

The structure of the current investigation is shown in the following diagram.



In Chapter 1, a number of dimensions are presented as the main elements of an analytic structure for the appraisal of the impacts of technological change. These elements include:

- demand patterns
- factors production
- technological relationships
- organizational structure
- income and wealth distribution
- international interdependence
- public policy

The major relationships of the information revolution involve the production of basic hardware and software as inputs to downstream electronic production which in turn find application, both internally and in the other productive and the household sectors of the economy. The relationships comprehend both direct and induced effects. Impacts are classified according to displacement of pre-existing technologies for existing functions and the creation of entirely new functions.

An elaborated outline is developed containing the questions to be investigated in a comprehensive analysis, and suggesting types of theoretical models to be employed.

Using the analytical schema of Chapter 1 as an organizing device, a number of considerations pertaining to the information revolution, as derived from the literature, are arrayed in Chapter 2. The objective is to arrive at a number of testable hypotheses.

Four features which are important for considering the feasibility of various approaches can be inferred from the results:

- much of the literature contains speculative statements which are not capable of being tested;
- there is uneven coverage of the dimensions which we have outlined in our analytical schema, considerable information being available on issues such as market penetration, industry concentration, competition in specific markets and labour displacement, while much less has been written on questions related to income and wealth distribution, international interdependence in production and public policy;
- nearly all of the discussion is devoted to the impacts of known technology in producing goods and services currently marketed or in the development stage;
- there is disagreement, among the variety of authors represented, on a number of points such as the speed of adaptation to new technology by households, integration of industrial processes into plant-wide systems and the feasibility of integrated office processing and intercommunication.

In Chapter 3, there are presented briefly the criteria according to which a variety of analytical and forecasting approaches are to be evaluated, with a view to possible implementation in the follow-on study. The criteria include:

- identification of sectors of greatest impact
- identification of critical hypotheses
- evaluation of behavioural parameters
- development of forecasts
- consistency and empirical content
- sensitivity to exogenous assumptions
- identification of transitory versus long-term technologies
- policy effects
- feasibility

A number of approaches and techniques are then summarized, and are appraised on the basis of the criteria. The general conclusion is that some combination of intuitive methods and formal economic analysis should be employed. In particular, the former should be applied to develop a set of working hypotheses and forecasts within a limited set of time and resource constraints, while exploring these hypotheses in the more open-ended context of the latter.

The recommended research agenda, presented in Chapter 4, is divided into three phases. The framework studies constituting the first phase would be designed to present a set of most likely alternative development paths. It is important to articulate a small number of alternatives in order to make the task of discussion and prediction of impacts a manageable one.

This phase would include two main steps. The first would consist of the writing of a set of scenarios pertaining to alternative development paths. These would be concerned with global developments in the information revolution, but with explicit consideration of the implications for the Canadian economy. In the construction of these scenarios, four ancillary techniques will be employed: first, the reasoning to be employed in the scenario construction would be organized according to the analytical framework presented in Chapter 1;

second, in order to clarify the relationships constituting the system, a set of so-called "relevence diagrams" would be constructed to trace the flow of events and interdependencies; third, trend extrapolation would be employed to provide estimates of reasonableness for quantitive projections; and fourth, as an integral part of the scenario-writing exercise, the alternatives would be reviewed with experts, to aid in selecting a most likely scenario. The second step would consist of a structural analysis for the purpose of identifying high-impact sectors - a continuation of work contained in this pilot study. On the basis of this analysis, a knowledge of sectors of particular concern for policy, and the judgemental weighing of the various partial effects, a limited number of sectors would be singled out for further detailed investigation in the second phase. The initial analysis conducted as part of this pilot study indicates the sectors of greatest impact as being: communications; utilities; trade; finance, insurance and real estate business services; business machinery and equipment; public administration; consumer durables; consumer services; and travel and promotion.

Three principal steps would be involved in this second phase. First, an historical background for each sector would be developed concerning its adaptation of technologies preceding, or representing early stages of, the new information technology. For each sector there would be an analytical interpretation of the particular developments using the general framework presented in Chapter 1. The second step consists of econometric studies employing, for each sector or technological configuration, a set of relationships which might include: demand, investment, production, employment, wages and prices. The third step would be more forward-looking. It would consist of the application of the model parameters derived in the preceding analysis for simulating the rate of adaptation and impact on the sectors being studied.

The objective of this third phase would be to estimate the magnitude of aggregate effects of the new technology in specific dimensions, conditional on alternative assumptions and/or parameters derived in the second phase about availability of direct and indirect inputs, learning-curve effects, speed of adjusment, etc. Some of the topics which might be investigated include:

- long-run shifts in labour requirements
- changes in industrial structure (Input-Output configuration);

- the composition of final demand; and
- economy-wide growth in productivity.

Resource requirements for the study vary according to the amount of detail required, the number of sectors to be investigated and consequently, the comprehensiveness of, and confidence to be placed in the ultimate results. A set of core procedures is presented, in addition to the preferred research agenda.

INTRODUCTION: MAJOR QUESTIONS FOR A RESEARCH AGENDA

The purpose of the project, the results of which are reported here, is to examine the feasibility of an investigation into the economic impacts of the new information technology, or what has come to be called " the information revolution".

A great many issues have been raised, or implied, in the general literature, relating to the information revolution. As a background for understanding the specific directions which will be taken in the design of the research program to be presented in this report, the following questions may be considered. The order represents, approximately, a logical sequence for ultimately focusing upon problems of Canadian Public Policy. Each question is related to what appear to be the corresponding main problems of analysis and prediction.

1. From a world perspective, which of the planned applitions of the new information technology will be realized, to what extent, at what time and in what sectors. This question can be viewed as one of the determinants of market penetration for the new technology as well as the timing of application of complementary technology in the form of hardware, software and human skills.

2. Will further IBHS developments, now beyond the research stage, but for which applications have not yet been

foreseen lead to an overtaking of these applications during the 1980's. Here we have little in the way of economic criteria in helping us to formulate a basis for prediction. Recourse would have to be made to expert knowledge of industry plans and to intuitive forecasts by the same experts.

3. Where will IBHS production occur and will there be significant diffusion of IBHS know-how away from the loci of such production through either vertically-linked or horizontially-linked industries. The importance of this question depends upon whether applications have a heavy component of user input or are made primarily with embodied technology - in hardware and software of a general-purpose nature. Addressing this question also requires some judgement as to the rate of sustained innovation of which the IBHS sector is capable, since diffusion or lack of it ceases, at some stage, to become a problem with a static technology. Thirdly, the problem of location is likely to depend importantly upon the influence of the new technology upon efficient scale of production. Finally, the answer to the question depends upon the industrial structure obtaining for IBHS, other electronics production and user-industry production - specifically, whether they will become more integrated or remain as separate industries.

4. What new types of goods and services will be created as a result of the application of the new information technology and what existing goods and services will become obsolete, facing declining demand and possibly becoming non-existent. As with Question 2, we have little or nothing in the way of economic criteria to guide us in making predictions in this area. We can probably only rely upon prognostications made by others of "holes in the market". Unfortunately, past experience with this approach to market research makes its reliability appear very questionable. Forecasts of a general nature, however, might be made on the basis of alternative assumptions about the type of electronic infrastructure which might be available and the types of norms and controls which might be in place over the forecast period. Decisions on these latter may be reasonably anticipated to reside primarily with the public sector.

5. For Canada, what lines of production will be created or find enlarged markets and what lines will be destroyed or be diminished. Related to this question are matters of change in demand characteristics, Canada's elements of comparative advantage and flexibility in converting

to processes and products which can best utilize these elements.

6. Will Canadian production become more or less integrated into that of multi-national enterprises. The information revolution may be expected further to enhance economies of coordination-at-a-distance. In addition, promotion via enhanced communication media may lead to standardization of products and few brands. This trend would be further promoted by scale economics of production. National norms and procurement policies might no longer be effective counter-actions.

7. Will the net impact on domestic income-generation be positive or negative. While an adequate appraisal of the income affect can only be obtained with the aid of a comprehensive accounting of the components of national income, a study of the microeconomic effects of the information revolution can lead to an quantification of growth in productivity versus expanding markets for output constrained by the existing stock of physical and human capital in those sectors which are most significantly affected.

8. For public policy, at what stages and in what forms should infra-structure and other types of stimulus, as well as controls, be provided. This question leads to a consideration of the possible impacts of public sector actions and their stimulative or inhibiting effect on competition and innovation. In a dynamic sense, effective policy depends on an appraisal of the form and timing of phasing-in of appropriate technology and controls, particularily so as to achieve economies from systems intregration. An optimal strategy will depend upon the appraisal of the likelihood of alternative development paths.

9. What will be the impacts of the information revolution on income distribution and what are the appropriate instruments for achieving an equitable distribution. Such an appraisal will depend, on the output side, upon concentration and competition in industry and the influence of the new technology upon centralization of control and production. On the input side, the concern is with labour displacement and unemployment and the roles of wage flexability and occupational and geographic mobility in ameliorating these negative impacts.

1. OUTLINE FOR ANALYSIS

INTRODUCTION

This initial chapter has three purposes. First, it is intended to set out in outline form the major elements of an analytical framework which might be applied to the micro-economic aspects of that set of technological changes which have come to be known as the "information revolution".

Second, a number of issues have been identified or, more often, have been implied, in the literature regarding the course of structural changes in the economy and the policy problems which would ensue from the information revolution. The frame work presented here would serve as the basis for an elaborated discussion to be pursued in the larger study or set of studies of which this pilot study is the forerunner, by which the plausibility of alternative courses of development would be examined. It is intended that the analysis be employed in identifying and evaluating the need for specific types of public policy and the appropriateness of specific policy instruments.

Third, the outline has served as a basis for discussion between DOC and the consultant as to those areas to be emphasized in the ensuing study or studies. While it is recommended that all of the factors included in this outline receive attention in the larger study, some initial

guidance has already been received from the client as to emphasis. It has been established initially that DOC would like to give greater emphasis to an exploration of the impacts of the application and the diffusion of the information revolution technology than to the feasibility of its domestic production. Nevertheless, the outline has been made as comprehensive as possible both in this regard and others. Thus, using the case in point as illustration, assumptions about the feasibility of domestic production of information revolution products would affect the validity of various inferences on the diffusion and application side. The speed of adaptation may be strongly related to whether there are domestic producers of the basic technology who would be able both to promote applications actively and to provide supporting design services etc. Thus, the outline, at the very least, provides a basis for explicit recognition of assumptions about such exogenous factors. The question of the emphasis of the analysis is made more concrete in two further steps which have been performed in the pilot study, and which are reported in subsequent chapters. First, it was felt desirable by DOC to identify, at least tentatively, those sectors to which greatest emphasis is to be paid in the subsequent study or studies. Work was undertaken in the framework of the pilot study to identify those sectors where the direct economic impact is likely to be greatest. This

criterion will be compared with a second one, namely, the priority given to various policy concerns as interpreted by DOC, in the detailed specification for subsequent investigation. The second step leads to a selection of the specific techniques to be used for analyzing and forecasting information revolution impacts. A variety of approaches are to be considered in the light of the information they are likely to yield about the problems implied by the points in this outline relative to the time and resource requirements necessary for implementing them.

The outline is organized methodologically according to a conventional microeconomic schema, and substantively according to the elements of what might be termed the information revolution system.

The main elements of the microeconomic schema and a brief elaboration of each is given as follows:

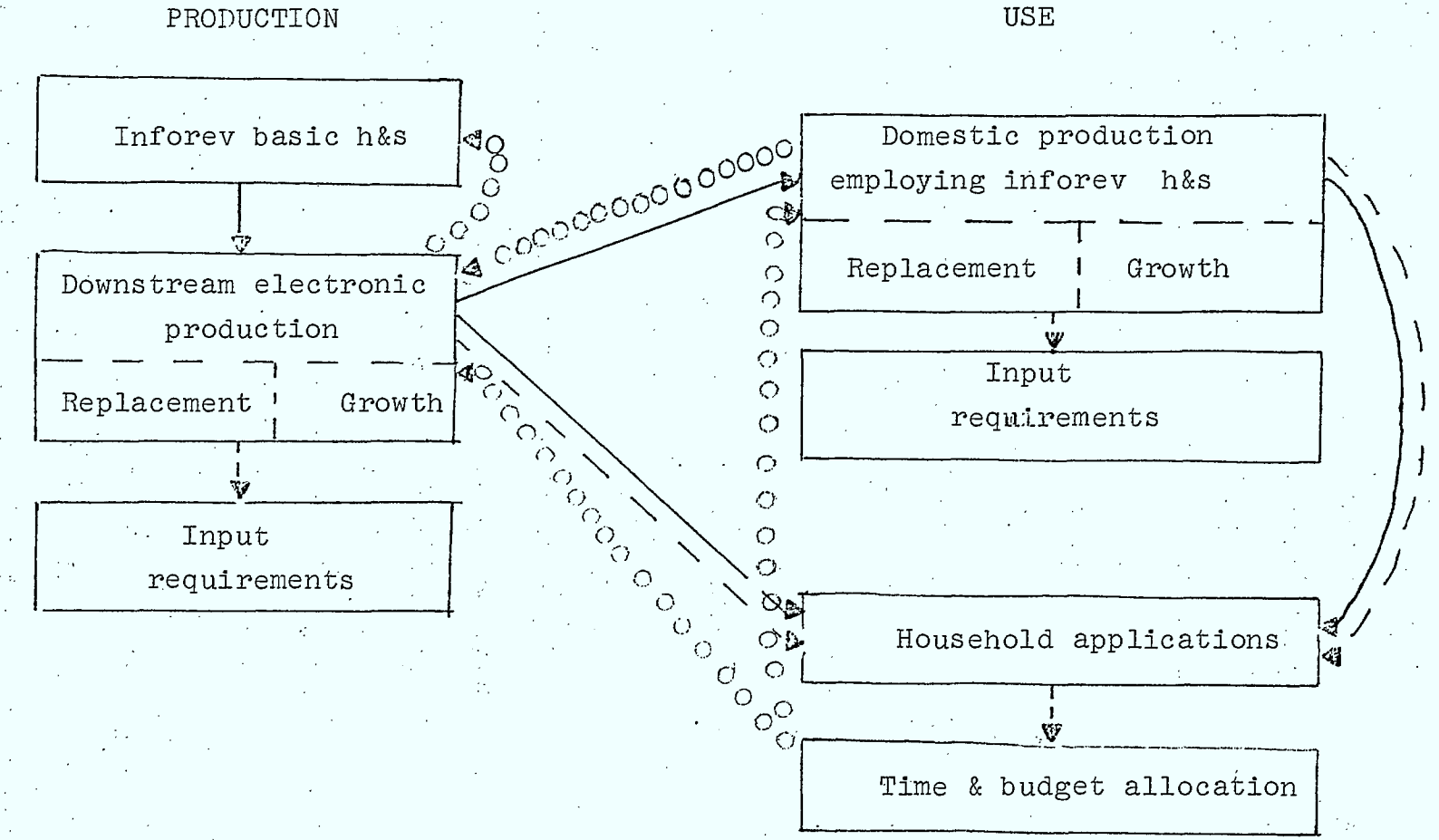
- demand patterns reflect the satisfaction of private and public needs through the allocation of income and wealth;
- factors of production, include land, labour, capital and natural resources;
- technological relationships pertain to the techniques of production, the means by which new techniques are introduced and diffused within industries and the repercussions on the methods of production of both supplying

and consuming industries of altered input requirements, prices and products.

- the organizational structure of production and distribution refers to a host of matters such as degree of integration of production, ownership patterns, degree and form of competition, specialization at plant and national levels, the labour markets, etc.
- income and wealth distribution effects pertain to shifts in resources among individuals, regions and sectors which may stimulate or retard technological innovation and diffusion;
- international interdependence is concerned with market shares of individual nations, production, vertical (stage-of-processing) relationships and the migration of production facilities abroad;
- public policies related to procurement, tariffs, taxes, R&D, etc., influence the viability of production of various types, as well as the speed with which innovation, both domestic and purchased from abroad, may proceed.

The substantive basis for the outline organization, which is shown schematically in the accompanying diagram, derives from a vertically-related set of production and use

INFORMATION REVOLUTION - MAJOR COMPONENTS AND RELATIONSHIPS



activities. A set of products, which we may label "information revolution basic hardware and software" (IBHS in the outline) and consisting of microprocessors, optical fibres, communication satellites, other types of advanced hardware and their associated software are used as inputs to a variety of electronic goods, including telecommunication systems, as well as a variety of components, equipment, and consumer goods. This "downstream electronics" production involves development, fabrication and marketing of goods incorporating IBHS, by means of both conventional methods of electronics production and innovative methods induced by the abailability of the basic hardware and software. These electronic goods are employed in domestic production in all applications in the household sector of both forms as electronic goods employed directly in the home and in the component services distributed to households.

There is a complex of feedback relationships in this system which are indicated as induced effects. These include, for instance, the freeing of household time for application in labour force and other activities which affect the entire supply of labour in force and other activities which affect the entire supply of labour in the productive sector and consequently the configuration of factors of production in the long run and the

adaptation to new methods of production in the short run. The IBHS and downstream electronics sectors appear to be very closely linked in terms of the strength of both direct and indirect effects. As indicated above, the availability of IBHS technology is a force for innovation in downstream electronics. Requirements of electronics production have not been so influential in shaping IBHS developments, but may be expected to be so in future.

Impacts may be further classified as to replacement and growth. The former term refers to the replacement of traditional processes by new ones, the characteristics of the outputs of goods and services other than marginal changes in reliability, durability, etc., remaining fixed. The growth component refers to the creation of totally new goods and services either not previously produced anywhere or not previously produced in the domestic Canadian economy. The growth component may also be negative, i.e., domestic production of goods and services may become insignificant or disappear.

1. PATTERNS OF DEMAND

A. Production processes (intermediate demand plus government expenditure)

1. Replacement of traditional inputs

- potential decrease in average cost
  - -- demand for output and minimum average cost
  - -- market size
  - -- market share
- change in product characteristics
  - -- demand for performance characteristics
  - -- embodiment (make-or-buy decisions)
  - -- produced optimization of durability
  - -- model life

2. Growth in outputs (addition of lines not previously domestically produced, or loss of lines privously produced)

- effect on scale economies
- multiple-output production economies
- custom/standard demand
- product market entry conditions
  - -- industry structure
  - -- brand loyalty
  - -- degree of competition

3. Growth in outputs (novel products and services)

- domestic innovation capability
- expected payback and rate of diffusion

B. End products and services (final demand)

1. Replacement of traditional products and services

- household sector (consumption)
  - -- income, price, and quality elasticities
  - -- time savings and opportunity cost
  - -- induced effect on demand via labour market
- capital goods
  - -- effect on rate of replacement
  - -- effect on "malleability"
    - --- utilization and expansion of capacity
    - --- substitution for labour in production
- trade
  - -- price and quality elasticities of export demand
  - -- import replacement and loss of domestic production.

2. TECHNOLOGICAL RELATIONSHIPS

A. IBHS production

1. Existing products

- nature of products
  - -- description
  - -- standard/ custom
- methods of production
  - -- continuous/ non-continuous
  - -- scale of plants
  - -- specialization by firm and plant

2. New products and processes
   - process changes in production of existing products
   - changes in characteristics of products
   - impacts on production methods
   - impacts on efficient plant/firm scale
   - directions of induced change
3. Domestic production
   - nature of products
   - methods of production
   - possibilities for achieving/maintaining efficient scale

B. Downstream electronics production

1. Existing products
   - nature of products
   - methods of production
   - intermediate inputs
   - possibilities for replacement by IBHS
     -- developments to date
     -- complementarity of IBHS with other inputs
     -- sources of bottlenecks in replacement
     -- costs associated with conversion vs. expected impact on cost of production

2. New products and processes
   - expected dimensions of product change
   - impacts on production methods
   - impacts on efficient plant/firm size
   - relationship to IBHS production
     -- backward integration into IBHS production vs. embodiment of IBHS technology
     -- bottlenecks in adaptation of IBHS technology
   - major system types

3. Domestic electronics production
   - nature of products
   - methods of production
   - intermediate inputs
   - possibilities for replacement by IBHS
   - possibilities for introduction of new product lines

C. Applications: Domestic industry
   1. Existing industry and product configuration
      - suitability of products/processes to adaptation to IBHS technology
        -- minimum scale of production
        -- information content of productive inputs
      - rate of turnover in capital equipment
      - rate of industry innovation

   2. New lines and industries resulting from IBHS technology (lines and industries disappearing from domestic production)
      - anticipated new products and processes, autonomous and induced
      - change in threshold levels of size and cost for production feasibility (emphasis on IBHS marginal effect)
      - inter-industry linkages

D. Applications: Households
   1. Replacement of existing products and systems
      - possibilities for improved performance characteristics vs. costs
      - durability and replacement

2. New products and services
   - economies of centralization versus decentralization
     -- content of information flows
     -- scale and cost
   - requirements for skill inputs by household

3. FACTORS OF PRODUCTION

A. IBHS production
   - skill content of labour force
   - shortages and bias in production
   - implications of developments in technology
   - capital requirements
   - implications of growth

B. Downstream electronics production

1. Replacement of processes in existing industry and product configuration
   - change in skill requirements
   - shortages and influence on direction and rate of technological change
   - supply elasticity of labour in medium term and impact on prices
   - capital requirements

2. New industries and products (displacement of existing industries and products)
   - dimensions of change and new areas of application
   - direct input requirements for production
   - viability of existing lines
   - impacts on labour force
     -- net changes in requirements by skill level
     -- possibilities for training, retraining
   - capital requirements

3. Domestic electronics production
   - factors governing rate of adaptation
   - labour supply characteristics relative to other countries
   - specialized production possibilities

C. Applications: Domestic industry
   1. Replacement of proucesses in existing industry and product configuration
      - change in skill requirements; growth of information occupations
      - shortages of skills and possibilities for IBHS or other capital replacement
      - domestic labour content of capital and intermediate inputs of new vs old processes
   2. New industries and products (displacement of existing industries and products)
      - dimensions of change and new areas of application
      - change in skill requirements
      - shortage of skills and possibilities for IBHS or other capital replacement
      - domestic labour content of capital and intermediate inputs of new products and industries

D. Applications: Households
   - induced change in labour force activity resulting from greater efficiency in production of household services
   - expanded possibilities for supply of labour services from in-home technology

4. ORGANIZATIONAL STRUCTURE

A. IBHS and downstream electronics production

1. individual markets and degree of competition
   - horizontal integration
   - proprietary products and licensing
   - price leadership
   - leadership by product innovation
   - entry barriers
     -- product differentiation
     -- cost advantages of established firms
     -- scale economies

2. direct government involvement
3. level of vertical integration

B. Domestic production

1. level of competition
2. determinants of regional competition and branch plant production
   - efficient size of production runs
   - transportation cost
   - integration of products
   - immobile resources
3. market strategies and incentives to innovation
4. potential market size and minimum efficient plant size

5. INCOME AND WEALTH DISTRIBUTION

A. Functional
   - possibilities for substitution
   - effects on workers' marginal product
   - intersectoral differential growth rates
   - imperfect competition and exploitation
     -- monopsony and wage discrimination
     -- seniority and return to training

-- discrimination in output markets
-- control of international technology transfer, transfer pricing and exclusion of domestic firms from input markets
-- returns to innovation

B. Sectoral
- relative growth rates
- competitive conditions in input markets

C. Regional
- centralization/dispersion of production and consumption (system dependence)
- aggregation economies
- mobility of resources

6. INTERNATIONAL INTERDEPENDENCE

A. IBHS and downstream electronics production
1. Specialization and branch plant economies
- steps in production
- economies of joint production
- critical inputs, agglomeration economies and factor mobility
2. Integration of IBHS and electronics production
- influence of technological characteristics (programmability, etc.)
- relative returns to standardization vs. customization (user orientation)
- firm/industry scale
3. Domestic IBHS and electronics production
- existing systems development
- embodiment
- critical skill requirements
- institutional factors (captive markets, etc.)
- MNE's and plant specialization
- protective measures

B. Applications: domestic production processes

1. Replacement of existing processes in existing product and industry configuration
   - pricing and competitiveness of outputs in international markets
   - viability of custom production
   - protective measures
   - growth of export markets as stimulus to technological change
   - rationalization of production by MNE's
   - competition between domestic and subsidiary enterprises
   - sources of productivity growth relative to other countries
   - network integration (international systems)
     -- scale economies
     -- centralization/decentralization economies
     -- specialization economies
     -- confidentiality
2. New industries and products (displacement of existing industries and products)
   - elements of comparative advantage
     -- applications of domestic systems
     -- innovative capacity
     -- technology transfer
   - protective measures
   - MNE's
   - institutional factors

C. Applications: households
   - cultural identity
   - confidentiality
   - labour mobility

7. PUBLIC POLICIES

A. Relative emphases
- new technology for export
- diffusion in domestic industry
- amelioration of displacement and training

B. Patterns of demand
- reduction of distortions
  -- startup and learning costs and prices
  -- predatory pricing
  -- misleading advertising
- provision of technical and consumer information
- provision of infrastructure and complementary goods

C. Technological relationships
- provision of systems infrastructure
- amelioration of bottlenecks
  -- training
  -- facilitation of investment
  -- tariffs
- standards for quality
- norms

D. Factors of production
- training for changing skill requirements
- income maintenance for employment transition
- short-term subsidies during phase-out of processes and industries
- stimulus to investment
- standards for safety, confidentiality, etc., relating to human intervention and attainable capital/labour ratios

E. Organizational structure
- controls on concentration and non-competitive practices (carriage/content, etc.)
- government procurement
- r&d policy
- patents
- fiscal impacts on firm size
- domestic tariffs

F. Income and wealth distribution
- income stabilization and maintenance
- regional incentives
- sectoral incentives
- treatment of investment and capital gains relative to earned income
- choice of systems favouring centralization/ decentralization, embodiment/specialized software

G. International interdependence
- support for domestic systems infrastructure
- tariffs on imports
- NTB's
  -- favoured domestic sources
  -- subsidies
- promotion of international diffusion
- restraints on foreign investment and control
- international conventions (spectrum, etc.)

2. ISSUES AND HYPOTHESES FOR INVESTIGATION

INTRODUCTION

In this chapter there are arrayed, using the analytical schema of Chapter 1 as an organizing device, a number of considerations pertaining to the information revolution. The objective is to arrive at a number of testable hypotheses. The ability of alternative evaluation methods, to be considered in Chapter 4, to incorporate and to test these hypotheses would be a major criterion in the design of a specific approach to be employed in the subsequent investigation.

The factual statements and hypotheses which form the body of this chapter are drawn from the literature of the information revolution. This literature is extensive and is growing rapidly. Because of the time available for this portion of the study, we have been forced to be selective; but we have attempted to make our choices of literature for review representative. Specifically, we have favoured those writings* which present a comprehensive treatment of the applications of the new technology and insofar as possible, raise issues related to the variety of economic dimensions with which we are concerned. We have also attempted to incorporate ideas from any of

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*Because several of the sources drawn upon for statements in this chapter are proprietary or otherwise indicated as not for attribution we have not identified the sources for individual statements. All sources are listed in the Bibliography, however.

the relevant Canadian writings which were available to us.

Insofar as we have been successful in obtaining a set of considerations and hypotheses which are representative of the literature, four features which are important for considering the feasibility of various approaches can be inferred.

First, much of the literature contains speculative statements which are not capable of being tested. This is perhaps to be expected in a field which is new and evolving rapidly. Much more work needs to be done in re-formulating the hypotheses included in this paper to enable economic reasoning to be applied. This implies, for any subsequent study to be completed in the near future, either great selectivity in the areas covered or the employment of a method less rigorous than would be possible in an established field.

Second, there is uneven coverage of the dimensions which we have outlined in our analytical schema. There is considerabl information available on issues such as market penetration, industry concentration, competition in specific markets and labour displacement. Much less has been written on questions related to income and wealth distribution and upon international interdependence in production. The latter is, of course, a long-standing area of concern for Canada, but is only beginning to be given attention in the broader economic literature in other countries. Surprisingly, although many public policy questions may be inferred, there is

little direct discussion of consequences of, and problems emerging for, the public sector's role.

Third, nearly all of the discussion is devoted to the impacts of known technology in producing goods and services currently marketed or in the development stage. This limitation may not be important for a study limited to the 1980's. In the Canadian situation, however, international migration of the production of traditional goods and services could be significant within that time frame as the result of the application of the new information technology, and much of this production, from the point of view of the recipient country, will be new.

Fourth, there is disagreement among the variety of authors represented on a number of points such as the speed of adaptation to new technology by households, integration of industrial processes into plaul-wide systems and the feasibility of integrated office processing and intercommunication.

Demand Patterns

Application: Production Processes

Issue: Competition

Mode of Application/Production	General Considerations/Timing	Hypotheses for Investigation
General		- productivity and competitiveness of end equipment could be independent of learning in the process of design and manufacture of components.

Demand Patterns

Application: Production Processes

Issue: Market Penetration

Mode of Application/Production	General Considerations/Timing	Hypotheses for Investigation
Data Processing		
- costs of data processing reduced significantly if complementary costs also reduced: software and introduction via standardized products; operation via elimination of specialized personnel.	- short-term	- reduced cost of hardware and reversal of previous influence toward: - concentration - centralization - specialized application by function in firm (high cost per operation) - separation of data processing function within firm.
- move toward product orientating now in intermediate stage associated with falling hardware costs offset by high selling costs and partially customized software.		
- integration of data processing and office automation.	- long-term	- office automation will develop independently of data processing in short, medium-term because of low cost of piecemeal additions.
Process control	- resource industries prime candidates.	- fastest penetration likely in capital-intensive industries with continuous processes.
Microprocessors	- motives for choosing microprocessors include: - cost savings, - accuracy, leading to savings in computation, - safety, - "amenity" (remove engine knocks, etc.), - defensive measures vis-a-vis imports, - convenience.	- success at this point in time attributable to: - application to existing products, - improvement in product with little change in process, - little capital investment, - user team of microelectronic experts including "design integrator" and "creative programmer", - follow "buy-off-the shelf" policy during exploratory stage.
	- increased complexity of microprocessors has led to decrease in expertise necessary to design products based on microprocessors.	

Demand Patterns

Application: Production Processes

Issue: Market Penetration

Mode of Application/Production	General Considerations/Timing	Hypotheses for Investigation
Industrial	- industry is demanding instruments with more automation in operation, on-line reduction capability, greater sensitivity, accuracy, and repeatability.	
Medical/Clinical		- the demand for simple automated instruments will increase, as more and more medical/clinical laboratories and hospitals plan to replace their old instruments. However, medical research laboratories will require more complicated instruments to carry out complex analysis, and research and development investigations. - in Canada, public expenditures in medical research will continue to rise as more and more emphasis is given to programs such as cancer research, heart and circulatory disease research, etc. Because these programs require intensive instrumentation the analytical instruments market will grow correspondingly.
Academic/Non-Profit Organizations		- the future in this market segment depends entirely on the fiscal policies of the government rather than on the objectivity of the scientific community. Although tight budgetary controls may restrict the growth of this market, the expansion of existing institutions for higher education and the establishment of new ones, and modernization of existing laboratories with the latest instrumentation will cause this market sector to grow.

Demand Patterns

Application: Production Processes

Issue: Market Penetration

Mode of Application/Production	General Considerations/Timing	Hypotheses for Investigation
- more powerful computation.	- short-term, continuing	- R&D market declining share of computers. Users may need increasingly used computers designed for other markets leading to need for adaptation of systems and software.
- more rapid dissemination.	- short-term, continuing	- "
- expand range of alternatives identified.	- short-term, continuing	- "
- integration with production, procurement and planning.	- short to medium-term	- depends upon complete electronics representation of design.

Automatic Test Equipment

- three basic trends have combined to increase the rate at which ATE is sold:
  - electronics-based end markets have been growing rapidly. Over the past five years, these markets have been primarily the computer and the telecommunications industries. Currently, consumer and office equipment markets for electronics are beginning to make strong gains. The growth in these end markets and their use of LSI devices are spurring the growth of ATE.
  - throughout industry in general, the use of LSI and intelligent electronics has been on the increase. A good example of this is the process control industry, which is moving toward more intelligent local loop controllers and distributed intelligent control systems.
  - the increased penetration into the in-house built test equipment market has resulted in an increase in the sale of commercial automatic test equipment.

Demand Patterns

Application: Production Processes

Issue: Market Penetration

Mode of Application/Production	General Considerations/Timing	Hypotheses for Investigation
Energy Management Controllers	- the present status of the market can be summed up as follows: - the federal and provincial governments are stymied because the function of energy management in buildings conflicts with the demands of special interest groups; - potential users are confused and have been made suspicious by sellers who who generally lacked credibility; - wholesalers and distributors have expressed trepidation that their traditionally limited role of stocking and selling standard electrical components is being expanded and changed by these relatively complex engineered system products; - contractors have had their concepts of user apathy confirmed by the attitude of potential users and are convinced that "nobody needs energy management"; - manufacturers of energy management controllers have become impatient with the lackluster market.	

Demand Patterns

Application: Production Processes

Issue: Market Penetration

Mode of Application/Production	General Considerations/Timing	Hypotheses for Investigation
Control of Industrial Processes	- use of computers in large-scale continuous plants well-established. - short, medium-term. - applications costs dominated by instrumentation and systems developed.	- microelectronics opens up new approach to industrial automation through preceived improvement of plant leading to broader application.

- development of integrated systems at plant level.	- long-term.	- need for standards for communication.
		- need for complementary pricing policies by utilities for more efficient utilization of plant.
		- development of effective robotics and/or radical product re-design slow because of technical and assimilation problems, respectively.
		- adaptive operation of robotic devices only following long period of use of repetitive devices.
		- problems of introducing automation
		  - theoretical difficulties with developing total control systems and robotics;
		  - disparity between applications;
		  - costs have made computer control applicable to large systems only;
		  - feared consequences and labour resistance.
		- microelectronics helps to overcome these barriers, but progress likely to be slow, uneven.

Demand Patterns

Application: Production Processes

Issue: Market Penetration

Mode of Application/Production	General Considerations/Timing	Hypotheses for Investigation
Office Automation - text processing terminals		- the text processing terminals will eventually dominate the market in larger offices, because their communications orientation will allow multiple media to be handled, which the preceding classes of devices cannot. - total shipments of both typewriters and word processors will slowly be eroded by shipments of text processing terminals. Their dominance will develop slowly, however, because of the following constraints: - the rate at which offices install advanced communications systems, - problems of compatibility among the many devices and systems that must be interfaced. Intelligent electronics can help reduce compatibility problems via microprocessors performing protocol conversions, etc., but the problems will never never be eliminated, - the need to depreciate existing products that lack communications capability (particularly the coming wave of electronic typewriters). (11-K-86)
- smart copiers		- the smart copier will perturb the market for conventional products such as convenience copiers. - national policies will strongly affect the markets for facsimile machines. - facsimile devices are expected to show relatively rapid early growth based on the availability of a public packet switching network, with growth in the later part of the period at a rate proportional to the size of the economy.

Demand Patterns

Application: Production Processes

Issue: Market Penetration

Mode of Application	General Considerations	Hypotheses for Investigation
- Office Information - text processing		
- word processing		- market sufficient for significant price decreases
- electronic typewriter		- advantages sufficient so that it will initially be purchased as stand-alone device, with inter-firm communication following
- electronic mail	- advantages: - current competitiveness with foot mail; advantage will increase - capable of transmitting urgent messages - better integration with internal information-handling machinery - eliminate unnecessary data-prep to recapture information (orders, etc.) from computers in other firms	
- electronic mail	- forms of communication now served by facsimile transmission	- intimate communication: question of premium willing to pay for manuscript transmission; - signatures and authentification; electronic alternatives are possible; - graphical and picture information; much of the requirement may be satisfied by electronic graphical systems and electronic cameras;
	- aspects of mail system not reproducible by EM	- confidentiality of envelope; implies confidence in integrity of postal system

Demand Patterns

Application: Production Processes

Issue: Market Penetration

Mode of Application/Production	General Considerations/Timing	Hypotheses for Investigation
Electronic Funds Transfer		- banks might invest in EFT in medium-term for following reasons - present cheque system nearing capacity and costs high - credit-card system unsuccessful; most holders use as money card - EFT system would attract new customers to banks - banks could offer new services including personal accounting

Demand Patterns

Application: Production Processes

Issue: Market Replacement

Mode of Application/Production	General Considerations/Timing	Hypotheses for Investigation
Micrographics		- microfilming of transactions will be somewhat reduced by electronic funds transfer systems.

Demand Patterns

Application: Production Processes

Issue: Cost and Performance Characteristics

Mode of Application/Production	General Considerations/Timing	Hypotheses for Investigation
Intelligent Electronics	- Intelligent electronics will find widespread use within the process control industry. The continuing reduction in size and cost of the electronics, coupled with increased capacity and ability to operate within the environment found in process plants, will dictate application in: - Transmitters - Controllers - Actuators - Operator interface - Communications, and - Unit controllers	
	- Intelligent electronics will find application in transmitters as a cost reducing means as well as a means of instrument enhancement.	- such devices require: - a highly competent engineering sales and service organization, - a complete product line suitable for the process industry sectors served (process control valves optional), and - a reputation for manufacturing reliable equipment and providing good technical support ranging from initial applications engineering to maintenance assistance. - these requirements imply market dominance by multi-nationals

Demand Patterns

Application: Households

Issue: Market penetration

Mode of Application/Production	General Considerations/Timing	Hypotheses for Investigation
General		- household applications will follow business applications. - applications most rapid in areas of enhanced performance and lower prices of existing products rather than new products which reduce own input of time. - competition by competing brands and technologies will inhibit early introduction of integrated services. - digital circuitry will increasingly take over from analog. This could lead to more efficient sharing of circuits by multifunction devices such as AM/FM/TV/CB/Tape. - sensors and actuators will not follow the same cost curve as microprocessors. The cost of sensors and actuators will continue to provide limits on what can economically be accomplished in many systems. - by 1987, a large proportion of all homes will have a terminal and various means of interacting with it. - lack of applications for home computers/home terminals will not be a serious limitation to market growth. - hobbyist market, via the programmable game convertible to a computer, - viewdata or Qube-type systems, - health monitoring systems, - phone answering/message/dial/display systems, - burglar and fire alarm systems, - environmental control systems, - education/training systems, - business and quasi-business applications, - information storage, - various control and monitoring systems for water, electricity, fuel oil, gas, etc., - communications and facsimile systems, - financial management and control, - diagnostic functions for other systems, - customs and special interest applications.

Demand Patterns

Application: Households

Issue: Market Penetration

Mode of Application/Production	General Consideration/Timing	Hypotheses for Investigation
		- companies with limited technical resources, but strong marketing and distribution skills, can buy their inventions from outsiders (like the toy and game companies).
General	- five problems in implementing the use of microprocessors in these products: - lack of familiarity and experience with microprocessors, - lack of, or shortage of, in-house qualified technical manpower resources, - lack of learning curve experience with the technology, - lack of test equipment and software development systems, and - inadequate software support and training programs from manufacturers of micro-processors.	- new inventions (home computer) may, in turn, create new outlets (computer stores), new services (computer magazines), and new supporting products and services (peripherals and software). - microprocessors will be distributed liberally throughout the home, with many microprocessors in many different products and systems. The continuing decline in logic cost will favor microprocessors in many devices rather than central wired systems.
		- once home terminals become widespread, then the infrastructure to support and enhance their application becomes more powerful. There may be many different forms and applications for what we call "home terminals."
		- more general application in very long term as personal computers "understand" (human languages).
	- market for microelectronics to replace control systems in current consumer products only about 3 billion units per annum for all industrialized countries.	- existing control applications place little demand on microcomputers; large increase in market size would result only with truly innovative applications.
digital T.V.	- feasible in mid-1980's	
silicon digital cassettes	- competitive with records in late 1980's	
electronic books	- competitive with printed books in late 1980's	- depends upon low-cost reader. Electronic typewriter could provide such a device. - alternative: centralized information plus telecommunications unlikely to precede electronic books and records.
Field Service		- signature analysis, along with self-diagnostic programs, will dominate field services in the future.

Demand Patterns

Application: Households

Issue: Market Penetration

Mode of Application/Production	General Considerations/Timing	Hypotheses for Investigation
Multifunctional communicating home terminals (home subsystem)		- because of the interrelationship of infrastructural conditions and various applications which need to come together to make the whole proposition sufficiently attractive, it is expected that it will take some time before multi-functional communication home terminals become a significant market.
Intelligent electronics		- this is an application area which demonstrates micro-electronics technology's ability to open new product and application opportunities which lead to potentially substantial growth of markets and industries.
General		- impact of microprocessor will vary depending upon nature of the product application - greater accuracy; - the part of the total cost represented by the remaining mechanical component; - possibilities for reduction of the cost of the mechanical components through enhanced monitoring and control systems (universal motors with variable speed controllers) by means of controls; - orientation toward audio-visual communication and less inclination to written communication; - familiarity with calculators and computers. - long exposure to electronic displays; - videotape records, microwave ovens are current applications; - this process is frequently accompanied by: - improved performance, - lower price, - expanded infrastructure; - it is hypothesized that the home terminal is beginning its journey across this spectrum and may move significantly toward the necessity category by 1987; - the corporate R&D lab will not be the only place (nor necessarily the most important center) of new product invention and innovation.

Demand Patterns

Application: Households

Issue: Market Penetration

Mode of Application/Production	General Considerations/Timing	Hypotheses for Investigation
General	- microelectronics-based products, because they will penetrate other spheres of peoples lives, will increasingly be considered a natural answer to problems in the home.	- growing pressure on households to reduce the time required for holsehold managerial tasks. - decreasing importance of family life, decreasing number of children per households, increasing leisure time and availability, resulting in greater need for entertainment and communications. - growing need for security and safety in the home because of frequent periods of absence will promote the accumulation of valuable equipment in the home. - growing importance of economic energy consumption for heating and household management purposes. - growing importance of continued education, professional updating, and access to information. - the incorporation of electronics into home products will lead to a wave of product innovation and to intensified competition, with a clear competitive advantage to those firms that manage to exploit electronic technology optionally in response to perceived or real needs and wants of the consumer. - in the long run, consumer expectations, service requirements, and compatibility considerations will reinforce the trend toward electronically equipped products and toward increasing availability of new or improved product features and functions, even those of marginal importance
Home sub-system		- the availability of new and improved home subsystem products with capabilities based on microelectronics will have to be paralleled by changes in consumer habits in order to lead to significant market impact. - the consumer is less open to changes in household management than in area of entertainment co[redacted]ica[redacted].

Demand Patterns

Application: Households

Issue: Market Penetration

Mode of Application/Production	General Considerations/Timing	Hypotheses for Investigation
Audio and Visual Home Entertainment	- passiveness and absence of two-way communications are typical for the currently dominant forms of entertainment.	- deliberate efforts to augment choice lead to proliferation of entertainment products (at a high cost, hence limited to higher income classes), to increasing skill requirements, or to time conflicts.
Energy/Environment		- energy saving measures and exploitation of new sources of energy will increasingly call for investment in: - heating control systems, - energy storage/conservation systems, - solar energy collection systems.
Market Integration (Home electronics)		- forces for integration - economics of basic components - advertising persuasion - financial incentives at the time houses are constructed - attractiveness of multifunctional or multi-purpose equipment. - forces against integration - lack of standards, - difficulty of linking different media, - limitations of transducer technology, - market penetration of stand-alone products with more direct need/want satisfaction effect, - consumer lack of "systems" approach. - far more likely is the development of modular multi-purpose systems. - strong driving force toward integration does not seem apparent.

Demand Patterns

Application: Households

Issue: Market Penetration

Mode of Application/Production	General Considerations/Timing	Hypotheses for Investigation
Small appliances		- microprocessors initially destined for the more expensive small appliances. - there will be no substantial increases in primary demand or significant reduction in replacement cycle. - do not expect major shifts in market share and industry structure. - expect a continued demand to bring out new products to satisfy the gift-giving segment of this market.
Major Appliances (especially microwave oven)		- will not materially increase primary demand, significantly alter replacement cycle or change industry, structure at manufacturer's level.

Demand Patterns

Application: Households

Issue: Market Penetration

Mode of Application/Production	General Considerations/Timing	Hypotheses for Investigation
Microprocessor controls in hand tools (maintenance equipment)		- major candidates are electric lawn mowers. - as volume increases and costs are decreased, we expect more penetration into the middle-line products. - could penetrate the bottom-line products (50% prob.). - the relatively modest improvements in the perceived cost/performance function can hardly be expected to have any significant effect on primary demand; particularly where simple products are in high saturation stages.
Electronic toys and games	- further penetration	- future market is further enhanced by higher per capita income and lower birth rates. - new products substantially reduces the replacement cycle. - short entertainment life of same electronic products may dampe demand for new products. - new technology used as a wedge to enter market of other proprietary products.
Home computer		- appeal limited to hobbyists, technically oriented individuals and a small and narrow segment of consumers.

Demand Patterns

Application: Households

Issue: Market Penetration

Mode of Application/Production	General Considerations/Timing	Hypotheses for Investigation
General		- young people tend to have a greater willingness to accept new gadget type products, and have more money to spend on them. This market segment is considered to be larger than that of the hobbyists, but is generally not stable. - wealthy households are not very sensitive to price. They often acquire products at an early stage of market introduction. This segment gives products an increasing level of acceptance by lower income segments, price being the only limiting factor.

Audio and Visual Home Entertainment	- inroads for extended television applications:
	  - decreasing size of family units,
	  - decreasing time availability for entertainment.
	- search for entertainment need/want satisfaction:
	  - greater choice of preprogrammed entertainment
	  - more access to commercially available entertainment
	  - increasing possibilities of active and creative entertainment.
		- expect that the added capability of digital recorder/player has considerable strategic impact at the retail level.
		- primary demand should be stimulated, which will create demand for recordings.

Health and Hygiene		- it is an area where there is probably considerable potential, but inventions and new products are required to develop that potential.
Miscellaneous (Photography and sewing machines)		- it is expected that new features will be added first at the top of the line and gradually work their way down to some of the less expensive cameras.

Demand Patterns

Application: End Products and Services

Issue: Market Penetration

Mode of Application/Production	General Considerations/Timing	Hypotheses for Investigation
General		- more general application in very long term as personal computers "understand" human languages
	- market for microelectronics to replace control systems in current consumer products; only about 3 million units per annum for all industrialized countries;	- existing control applications place little demand on micro-computers; large increase in market size would result only with truly innovative applic-ations
	- about size of current total semiconductor market.	
Digital TV	- feasible in mid 1980's.	
Silicon digital cassettes	- competitive with records in late 1980's.	
Electronic books	- competitive with printed books in late 1980's.	- depends upon low-cost reader; electronic typewriter could provide such a device
		- alternative: centralized inform-ation plus telecommunications unlikely to precede electronic books and records
Military		
- defense against attack and ground conquest.	- short-term	- development of surveillance, data-collection and data-correlation systems.
- proliferation of sophisticated weaponry.		- high priority, special purpose applications of military may divert resources so as to slow civilian applications.
- reduced vulnerability of geographically distributed forces.		- Canada as supplier to U.S.: competitive position.
		- microelectronics enhances copying, makes erection of barriers to diffusion more difficult.
		- danger of misuse: "police state".

Technological Relationships

Application: Downstream Electronics Production

Issue: Market Penetration

Mode of Application/Production	General Considerations/Timing	Hypotheses for Investigation
LSI (Large Scale Integration)		- LSI devices will continue to increase in complexity and speed and will begin to evidence built-in-test features. - printed circuit subsystems will tend to increase in complexity so that testability must be considered during design. - LSI device testers will cope with the increasing complexity of LSI devices at a falling price per function ratio (except for the leading edge of technology products). - in-circuit subsystem testers will erode the sales of functional testers. - the character of both subsystem tester types will alter dramatically over the 10-year period, much more so than LSI device testers, which will evolve more slowly. It is likely that integrated data bases will be utilized that serve computer-aided circuit design, board design, automated manufacturing, and subsystem testing.

Technological Relationships

Application: Downstream Electronics Production

Issue: Development Problems

Mode of Application/Production	General Considerations/Timing	Hypotheses for Investigation
Information Services		
- services providing rapidly changing information of great value to the businessman	short-term	
- transient information with few barriers - encyclopedias, shopping service, etc.	medium-term	
- information physically expensive to access and transport by alternative methods - books, library services, etc.	medium-term	

	Current prototype systems:
	- computer-based systems for reservations, etc.
	- database access - teleglobe, etc.
	- videotex - Telidon
		Problems in development and application
		- competition between computer-based services and videotex
		- videotex constrained by
		  - use of TV display
		  - not convenient to telephones
		  - TV utilized for other purposes
		  - TV in recreation environment

Technological Relationships

Application: Production processes

Issue: Scale economies

Mode of Application/Production	General Considerations/Timing	Hypotheses for Investigation
General	- cross-over point for custom LSI now estimated at 30-40K units, but declining costs will lead to greater user-orientation.	- mass production can allow realization of efficiency-in-use from customized production and scale economies from mass production of such chips. - there is expected to be an increasing divergence between complex circuits for high performance at high cost and circuits produced at high volumes and low costs.
Computation	- rapid advances in memories are leading to the demise of time-sharing.	

Technological Relationships

Application: Production processes

Issue: Intermediate input substitution

Mode of Application/Production	General Considerations/Timing	Hypotheses for Investigation
Office automation		- in long-run, paperwork will be eliminated; but the demand for printed output will rise in the short-run.

Technological Relationships

Application: Production Processes

Issue: Integration of Systems

Mode of Application/Production	General Considerations/Timing	Hypotheses for Investigation
Data Communications - Telephone and data networks	- arguments for a single network are compelling	- can be implemented by same technology - use of common network will make PSDN more acceptable during its early growth - difficult to forecast relative growth; single network allows flexibility - in long-term, most users will require access to both services - complementarity of loading over the day

Technological Relationships

Application: Production Processes

Issue: Alternative Development Possibilities

Mode of Application/Production	General Considerations/Timing	Hypotheses for Investigation
Office Automation		- storage capability will be improved by availability of semiconductor storage cassettes - shared printers will greatly reduce cost - alternatively, direct photocopying from electronic media; hard-copy requirements will eventually recede (long-term) with general use of electronic typewriters to read information - price competitive with current typewriters in short-term - will become completely semiconductor product in medium to long-term - price in long-term might be comparable to pocket calculator
Automated office		- alternative modes of development - central processing - distributed processing - extensions of PABX systems - terminals plus functionally-differentiated central products, e.g. message-switching systems
Office Automation - Electronic Mail	- informal use of EM in medium-term - formal systems perhaps by 1990	- widespread use would depend on general presence of electronic typewriters in offices; start-up costs of EM large enough that independent development unlikely

Technological Relationships

Application: Production Processes

Issue: Alternative Development Modes

Mode of Application/Production	General Considerations/Timing	Hypotheses for Investigation
Office Automation - Text processing	- computer can store, transmit retrieve and transform text	
	- in long-term, computer can be programmed to have some understanding of texts; need for development and integration of formal language systems and programming languages	- conventions needed about form and significance of various parts of the text, because of complexities of language and lack of understanding of linguistics
Word processing	- current systems: - automatic letter writer - computer-program editor	
	- recent developments: intermediate systems - editing typewriters with enhanced abilities - visual terminal systems - centralized storage and printing	- such systems expensive, but sufficient market for significant price decreases
Electronic Funds Transfer	- three types of system, all currently feasible technologically	- off line systems most plausible initially because: - "no direct financial incentives" for products of decentralized system - direct on-line system would place great burden on telecommunications system
	security problems	- use of credit cards could be made secure by their containing microcomputers and by cryptographic techniques
		- initial level of investment could be constrained if terminal costs borne by vendor, bank system based on local computers, high minimum on size of transaction.

Technological Relationships

Application: Downstream Electronics Production

Issue: Integration of Systems

Mode of Application/Production	General Considerations/Timing	Hypotheses for Investigation
Data Communications	- service bureau industry has concentrated on packet-switching for DC	- effective consideration of alternatives for specific purposes has been hindered
	- early requirement for DC dominated by need for centralized processing; phase-out in medium-term	- changing relative cost of processing and telecommunications will make this mode increasingly unattractive
	- another major demand for computer-to-computer connections for private networks; phase-out in medium-term	- public switch data controls will make this disappear
	- future pattern of data communication mainly: - electronic mail - electronic funds transfer - remote telemetry	
Public Switch Data Network	- DC characteristics: - no characteristic bandwidth - can transmit information at greater effective rate than voice - instantaneous transmission not required for many uses	- key to provision of an adequate PSDN: - local communication distribution capability
		- most appropriate form: high-speed multiplexed communication line from which local stations could tap bandwidth as desired
		- data relative to voice volume (in bits) small; may be 10-30% in long-term, 80-90% in very long-term; however picture transmission could increase share
Artifical Intelligence	- development of artificial intelligence will be slow	- lack of computer-based semantic models
	- medium to long-term	- concentration on specific subjects may make possible limited progress
		- speech recognition the most tractable and important problem
		- prospects for robotics appear to be poor, but microcomputers could provide limited degree of intelligence to various forms of production equipment
	- general learning and inductive capability very long-term	- technology to support such systems likely to be available long before there is adequate understanding of their design
		- breakthrough, when it comes, likely to be rapid

Technological Relationships

Application: Domestic Industry

Issue: Market Penetration

Existing industry & product configuration

Mode of Application	General Considerations	Hypotheses for Investigation
Industrial process control - individual in-plant processes	- use of computers in large-scale continuous plants well-established	- applications costs dominated by instrumentation and systems development; microelectronics opens up new approach to industrial automation through piecemeal improvement of plant leading to broader application

- development of integrated systems at plant level	- need for standards for communication
	- need for complementary pricing policies by utilities for more efficient utilization of plant
		- development of effective robotics /or radical product re-design slow because of technical and assimilation problems, respectively
		- adaptive operation of robotic devices only following long period of use of repetitive devices
		- problems of introducing automation
		  - theoretical difficulties with developing total control systems & robotics
		  - disparity between applications
		  - costs have made computer control applicable to large systems only
		  - feared consequences and labour resistance
		- microelectronics helps to overcome these barriers, but progress likely to be slow, uneven

Technological Relationships

Application: Domestic Industry

Issue: Suitability of Products/Processes to Adaptation

Mode of Application/Production	General Considerations/Timing	Hypotheses for Investigation
Field Service		- major modifications, whether required because of a positive decision by marketing or because of extensive field failures, will be a substantial problem unless the product is carefully planned. In many circumstances, it may be cheaper to redesign it, than attempt to expand the applications program within the constraints of the hardware implementation.
Micro processors	- the following technology-related developments are anticipated by 1982. - Instruction sets capable of handling analog signals directly. - Mask-selectable instruction sets equivalent to the programmable logic array or the ROM. - Field-programmable instruction sets equivalent to the field-programmable logic array or PROM. - Associative processors and content addressable memories. - An integrated crosspoint switch capable of handling bus structures and linking many microprocessors into a matrix or mesh array. - Input/output extenders, so that many more devices can be attached to one microprocessor.	

Technological Relationships

Application: Domestic Industry

Issue: Price/Performance

Mode of Application/Production	General Considerations/Timing	Hypotheses for Investigation
Computing Capability (Industrial Process Control)	- reduction of costs - enhancement of information processing	- government regulation regarding pollution and energy conservation will justify increase in computing capability
Automotive Industry		- regulation of emission control and fuel consumption could have major impact as to introduction of - drivetrain control - dashboard display system
Plant Automation	over next decade, scattered and randomly distributed introduction	- automatic material handling can be justified by itself as a separate application - robots can be economically installed to increase utilization of production equipment - new numerically controlled machines installed to upgrade a limited number of operations

Technological Relationships

Application: Households

Issue: Diffusion of production

Mode of Application/Production	General Considerations/Timing	Hypotheses for Investigation
Production: electronic products	- expect major impact	- greater expertise to exploit electronics
	- large markets in short to medium term	- microprocessor more applicable to these products - processing rather than control.
	- large changes in product design	
Information products (products dominated by semiconductor content)	- major market only in long-term	- personal-computer market will develop based on pre-programmed packages executed on an extended version of the electronic typewriter.
- computer		
Production by		
- electronics-oriented	- short-term	- diffusion of microelectronics hindered by its difficulty and lack of technical expertise and awareness by management
- electromechanical	- medium-term	
- mechanics-based	- long-term	- high initial costs of micro-electronic systems imply applications in areas where short-term returns high and/or production is large-scale and continuous
Replacement of electromechanical or mechanical sub-systems	- this will represent early application	- skill changes required in manufacturing process and in servicing activity; these, especially the latter, represent barriers
Production: mechanical products	- expected to be slow	
- automobiles	- largest short-to medium-term user of microcomputers	- planning and development cycle of the auto is long; major sub-assemblies must have long production life to cover fixed investment. Major changes e.g., microcomputer-controlled automatic transmissions will be introduced slowly
Production: electromechanical products	- direct replacement or extension of present electromechanical control systems	- shorter product life and greater electronic expertise of electro-mechanical firms compared with those in the mechanical field
	- should become widespread in medium-term	
	- unlikely to extend significantly capability of user	

Factors of Production

Application: Domestic Industry

Issue: Make-or-Buy

Mode of Application/Production	General Considerations/Timing	Hypotheses for Investigation
Office Automation - Electronic typewriter		Increase in productivity may not lead to proportionate decline in level of staffing because of: - secretary as status symbol; - secretaries distributed throughout organization - under-utilization; - major changes only if ET becomes effective as a working tool for management; - may provide other facilities to manager e.g. data processing capability - direct speech input makes secretary as intermediary unnecessary; however not expec expected to be available in short or medium-term; - increased management efficiency may lead to reduction of managers for firm of a given size.
- General		- important source of efficiency improvement for management in ability to internalize critical examination of procedures; creates opportunity for management counselling.

Factors of Production

Application: IBHS Production

Issue: Labour Displacement

Mode of Application/Production	General Considerations /Timing	Hypotheses for Investigation
Computer related technology		- has led to shortage of information workers in some categories and might cause total reduction in employment in the sector
General	speeds up shifts of labour among occupations or professions, enterprises, industries and sectors	- especially in office automation and telecom. - role of middle managers reduced

Factors of Production

Application: Downstream Electronics Production

Issue: Labour displacement

Mode of Application/Production	General Considerations/Timing	Hypotheses for Investigation
Telecommunications - Pulse-coded modulation	short-term	- PCM and electronic digital exchanges should enhance reliability of telephone system and reduce need for large maintenance force

Factors of Production

Application: Production Processes

Issue: Labour Displacement

Mode of Application/Production	General Considerations/Timing	Hypotheses for Investigation
Office Automation		- relatively larger productivity gains for office workers could be associated with decline in administrative/ production worker ratios.
Electronic mail	- existence of network of electronic typewriters in both offices and houses could lead to rapid elimination of postal workers	- price of ET's relative to performance as stand-alone devices would have to be sufficient to realize large market.
Programming		- elimination of mechanical aspects of programming will make it more difficult leading to its being performed by creative individuals without specific computing experience who would be able to solve their own problems.
General		- information revolution appears to substitute for blue-collar workers, but creates demand for white-collar workers.
	- positive net employment effects may be expected from microelectronics in the medium and long-term.	- high technology industries create more employment than new technology industries.
	- in short-term effects mainly on information occupations.	- effects on employment in direct manufacturing relatively small.

Factors of Production

Application: Domestic Industry

Issue: Labour displacement

Mode of Application/Production	General Considerations/Timing	Hypotheses for Investigation
Computer/Communications	- at risk, because of labour displacement are proof-readers, library assistants, mail carriers, telegraph operators, draughtsmen, programmers, accountants, financial administrators, secretaries, billing clerks, key punchers, cash filing clerks, meter readers, shipping clerks, TV repairmen, plateprinters, telephone repairmen, light electricians, machinists, mechanics. - there will be a need to consider, at every stage, the opportunities for linking technological change with a reduction in the working week, working year and working life-time.	- if some jobs are not sacrificed to automation, the whole sector risks becoming internationally uncompetitive, with resulting job loss to a much larger number of people. - jobs destroyed in agriculture and manufacturing will be soaked up in services. - the absorptive capacity of the tertiary sector is reaching its upper limits. The braking of growth of the public sector and the decline of employment opportunities in the education sector, point in this direction. - middle managers are expected to be the hardest hit. - overall, it is the women, who form the bulk of information manipulators in the service sector, who are expected to bear the brunt of the impact.
Computer/Communications	- microelectronics-based automation in services has generated jobs	- unemployment rates ascribed to a large part to technological unemployment. - rate of growth of unemployment attributable large international transfers of technology. - jobs destroyed in one sector or area would be compensated in the other. - the labour force which remains requires extensive re-training.

Factors of Production

Application: Domestic Industry

Issue: Employment Patterns

Mode of Application/Production	General Considerations/Timing	Hypotheses for Investigation
General		- public service employees will generally fare better than their opposite numbers in the private sector for at least two reasons: - high level of unionization, - and a habit of measurement of managers by the number of subordinates - no direct market test of output - the impact of new technology on employment levels will depend crucially on the future relationship between productivity growth and output growth, the latter depending upon demand elasticities. - the extent of job displacement will depend largely on the rate at which new processes are adopted and the structure of the industry.
Education		- by massive expansion of education system; there could be accelerated a shift-away from manufacturing into the information sector of the economy. - the quality of the available jobs may not be compatible with the rising educational levels of the work force. - most of the work force will require a continual updating of skills. This will likely render millions superfluous. - universities will offer less specific knowledge to students to counter for changing technological world.
General		- technological advance obstructed by shortening the work week. - increased investment can no longer maintain full employment through economic growth. - technological change may lower the level of skill required of complementary labour or leave it relatively unchanged. - the most important employment effects will probably involve competitors that shift with conventional technology.

Factors of Production

Application: Domestic industry

Issue: Labour Displacement

Mode of Application/Production	General Considerations/Timing	Hypotheses for Investigation
General		- higher labour force participation (of women, young and older workers) is likely. - over the long haul technological change will reduce per capita requirements for direct labor.
Government operations		- the automation resulting from its use has led to the non-creation or actual disappearance of an even larger number of jobs in other activities. In the short run this will contribute to the level of unemployment in Canada and other automating countries.
Office Automation		- predominance of impact on females, with consequences for family income; - this sector mobile and predominantly non-unionized, hence little resistance to change; - both secretarial and management groups could become more militant leading to strife among main sectors of the community.

Organizational Structure

Application: IBIIS production

Issue: Vertical integration

Mode of Application/Production	General Considerations/Timing	Hypotheses for Investigation
	- growing competition for IC manufacturers from computer manufacturing industry.	- semiconductor firms do not understand needs of systems developers as well as do the computer firms. - thrust toward vertical integration may stem from desire to cushion cyclical fluctuations in demand.
Information Processing	- increased number of systems sold as compared to rented - increased number of compatible peripherals and central units by independent manufacturers (greater recourse to external suppliers) - sector's supply structure oligopolistic, particularly at international level	- strong rate of innovation increases obsolescence and does not allow time for sufficient amortization of equipment available for rental - encourages buying rather than making components
Data communications	- U.S. anti-trust legislation has prevented Bell from developing computers and IBM from participating in communications.	- this artifical barrier has hindered the development of effective networks at continental or world scale.

Organizational Structures

Application: IBHS and Downstream Electronics Production

Issue: Market Replacement

Mode of Application/Production	General Considerations/Timing	Hypotheses for Investigation
Information Processing		- if mini computers are favored technology, it would lessen the need for service bureaux as the source of computer power and slow their rate of growth. - will be the medium through which new applications will be made available to the public.

Organizational Structure

Application: IBIIS and Downstream Electronics Production Issue: Market Penetration

Mode of Application/Production	General Considerations/Timing	Hypotheses for Investigation
Mainframes	- tendency to make investments in component firms in order to keep control of component suppliers	
	- enlargement of market area from medium/large computers to small business systems, office automation and telecom systems	- maintain control of shares in the large user-market, acquire medium and small user market and new applications markets
	- by incorporating firms in the new product areas - by obtaining cross-licensing between firms	- leads to concentration of markets with dynamic modified entry of commercial and application types
Minicomputers	- development phase characterized by: - high level of specialization - reduced level of production activities - reduced direct commercial presence	- product areas are formed and dissolved preventing companies from consolidating their positions in any particular area
		- newcomers into the market will increase competition
Office Automation and Distributed Processing	- hardware technology weakening oligopolistic tendencies while software marketing persists and technical assistance enhance them.	- technological transformations are enabling medium-size firms to enlarge the "interstitial space"
General	- trend in production processes and sales away from strong vertical integration towards a distribution of the various phases of production of a system/service among different operators	- greater number of alternatives offered as solutions to application requirements
	- average product life becoming very short (2-4 years)	

Organizational Structure

Application: IBHS and Downstream Electronics Production

Issue: Entry Barriers

Mode of Application/Production	General Considerations/Timing	Hypotheses for Investigation
Computers		- no important industrial benefits for Canada in designing and manufacturing computers. - new applications will be lost to Canada because investors cannot invest here.

Organizational Structure

Application: IBIS and Downstream Electronics Production

Issue: Market and Competition

Mode of Application/Production	General Considerations/Timing	Hypotheses for Investigation
Electronic technologies		- new technologies have brought about; - increase in technical economies of scale; - strengthening monopsony power - shifts to commercial and innovatory functions - breakdown of vertical integration; - concentration around new productive processes
Office Automation - central services	- pattern of competition unclear	- likely that a communications system would develop to which plug - compatible services could be added by individual suppliers. - need for creation of a common set of intercommunication standards
- electronic mail		- widespread use by business would have radical effect on postal service because concentrated delivery to business means its contributions to revenues disproportionately high
- general		- radical effect on information flow within firm leading to greater efficiency in resource allocation and greater competitiveness - this may make greater diversity of operations feasible leading in some cases to greater product differentiation in others to more firms competing in a given market

Organizational Structure

Application: IBIS Downstream Electronics Production

Issue: Markets and Competition

Mode of Application/Production	General Considerations/Timing	Hypotheses for Investigation
Office Automation		
- Electronic typewriter		- evolution into a completely semi-conductor product would open up large markets which might be expected to be dominated by semi-conductor firms (parallel with watches and calculators).
- Automated office	- integration of e.t.'s with filing, cataloguing, dissemination.	
	- market competitors - mainframe manufacturers - minicomputer manufacturers - copier manufacturers - PABX manufacturers - existing office product manufacturers - new entrants	- must overcome barriers of scale and technology
- Terminal market	- large firms like IBM and Xerox will capture market for total system among large multinationals in short-term - total systems will yield to individual low cost terminals in medium-term - patterns of competition for central processing unclear	- semi-conductor manufacturers will benefit because of competitive advantage

Organizational Structure

Application: Domestic production

Issue: Concentration and market power

Mode of Application/Production	General Considerations/Timing	Hypotheses for Investigation
Data processing	- high cost of computing has had four effects: - competitive advantage to larger firms, - promotion of centralization, - restricted to certain high cost functions within firms, - Data processing as a separate profession with power within firms.	- reduced costs of computing could reverse the effects if: - cost of software is reduced, - cost of introduction is reduced by use of standard products and products more closely related to current business practice, - cost of operating Data processing system reduced by eliminating specialist personnel.

Organizational Structure

Application: Domestic production

Issue: Mode competition

Mode of Application/Production	General Considerations/Timing	Hypotheses for Investigation
Telecommunications	- technological development, e.g., fibre optics would allow cable systems to compete with broadcasters and telephone companies, leading to alternative configurations, e.g., cable companies barred from distribution, but might compete with broadcasters to provide programming content.	
	- interconnection may weaken traditional monopolies.	- possibilities for creating private markets for distribution of public good aspects of information.
		- lack of co-operation among semiconductor, computer and telecommunications industries results from regulation.

Organizational Structure

Application: Domestic Industry

Issue: Market penetration

Mode of Application/Production	General Considerations/Timing	Hypotheses for Investigation
Micro computers		- the effect of the microcomputer will be to "flatten" the growth of conventional computers (including minicomputers) somewhat earlier than might otherwise have been the case. They will provide an alternative to computing for some office, analytical and scientific tasks where conventional computers have not really been cost effective. - as the number of smaller users increases, the share of the market of both small computers and service bureau operations should increase, that of middle-sized in-house computers would decrease. A continued growth in absolute numbers seems likely; the decline will be only as a share of a rapidly growing total.
Computer/Communications		- equipment supplier revenues will exceed total depreciation allowances.

Organizational Structure

Application: Domestic production

Issue: Regional Competition and Branch Plant Production

Mode of Application/Production	General Considerations/Timing	Hypotheses for Investigation
Telecommunications	- increased capacity for telecommunication facilitates control at a distance.	- result may be greater decentralization of production with greater centralization of control.

Organizational Structure

Application: Domestic Production

Issue: Concentration

Mode of Application/Production	General Considerations/Timing	Hypotheses for Investigation
Office Automation		- increased efficiency in internal communications will favor large over small firms.

Organizational Structure

Application: Domestic Production

Issue: Market entry

Mode of Application/Production	General Considerations/Timing	Hypotheses for Investigation
End Products - Information products (products dominated by semiconductor content) - typewriters - computers - television - hi-fi - books	- short and medium-term	- entry of semiconductor products manufactured by new firms leads to eventual dominance by semiconductor firms and low prices (electronic watch precedent); complete replacement of current techniques

Organizational Structure

Application: Domestic Production

Issue: Market Strategies

Mode of Application/Production	General Considerations/Timing	Hypotheses for Investigation
End Products		- standardization and compatibility will continue to be a problem. Standardization will be slow and may only emerge after one or two companies have dominated a market and forced their systems on it.

Organizational Structure

Application: Domestic Production

Issue: Competition

Mode of Application/Production	General Considerations/Timing	Hypotheses for Investigation
Consumer Products		- revolutionary change is more likely when new industries are originated or when outsiders enter an existing mature industry. Frequently with new approaches (Technology, Marketing, or Services). - emerging industries are usually accompanied by unstable market positions of the participants; the home computer/home terminal industry will go through a great deal of turmoil as market positions change during the industry's formative years.

Income and Wealth Distribution

Application: Functional

Issue: Labour Displacement

Mode of Application	General Considerations	Hypotheses for Investigation
Automated Office	- long term	- migration of labour from goods producing sector to the service sector - trade unions welcome technological change for it opens a better quality of work and life - joint control of trade unions with management over introduction of advanced office equipment - trade unions are supported for reduced working time - attention given to vulnerable labour groups - concentration of women in occupations in risk of labour displacement

Income and Wealth Distribution

Application: Sectoral and Regional

Issue: Labour displacement

Mode of Application	General Considerations	Hypotheses for Investigation
Office Automation	- office workers concentrated in civil services, local government and major towns	- labour displacement will be distributed unevenly geographically and between public and private sectors

Income and Wealth Distribution

Application: Regional Effects

Issue: Centralization/Dispersion and Mobility

Mode of Application/Production	General Considerations/Timing	Hypotheses for Investigation
		- information revolution could lead to decentralization of production with centralization of control exacerbating regional disparities. - reduced need for labour mobility could ameliorate this effect.

International Interdependence

Application: IBMS and Downstream Electronics Production

Issue: Natural monopoly

Mode of Application	General Considerations	Hypotheses for Investigation
Telecommunications - Satellite communications	Possibility of IBM creating a world-wide communications system	- individual nations'state systems could attempt to block such development, but would face strong commercial pressure

International Interdependence

Application: Domestic Electronics Production

Issue: Integration with User Industries

Mode of Application	General Considerations	Hypotheses for Investigation
General		- foreign competition likely to worsen by technical change - competitive disadvantage stems from the loss of opportunities to design end equipment in parallel with component developments; and in turn to influence component development in the light of end equipment market needs - Canada needs to bear this in mind in light of US competitors

International Interdependence

Application: Domestic production processes

Issue: Technological capability and domestic control

Mode of Application/Production	General Considerations/Timing	Hypotheses for Investigation
Multinational enterprise	- the new technology reduces the costs of managing large, complex organizations.	- leads to: - further growth of MNE's, - increased specialization of branch plants, - undermining of purely national enterprises, - centralization of computing resources at headquarters.
	- the international division of tasks leads to problems of: - achieving the right balance of imported information and domestic production, - overcoming domestic protection by trading partners, - achieving the right balance of use versus manufacture of new technology to maintain competitiveness, - mitigating out-flow of human capital associated with trans-border data flows.	

International Interdependence

Application: Domestic Production Processes

Issue: International Competitiveness

Mode of Application/Production	General Considerations/Timing	Hypotheses for Investigation
General		- the maintenance of international competitiveness is seen as essential in curbing the labour displacement effects of the technology. - maintaining competitiveness will reduce rather than neutralize labour displacement. - improved international competitiveness will not guarantee full employment. In order to compensate for the displacement effects of increased productivity, it would be necessary to increase external outlets to an extent that would seem implausible. - to the extent that these jobs are created abroad because of the centralization of activities by multinationals, they will be accompanied by the migration of other jobs as well. It is not uncommon for many users of computer/communications - especially managers, planners and management support workers - to be consolidated at head offices along with most computer/communications staff. The outflow of employment associated with the import of computer/communications services (especially subsidiary-parent imports) is much greater than the number of computer/communications workers involved.

International Interdependence

Application: Domestic production processes

Issue: Comparative advantage

Mode of Application/Production	General Considerations/Timing	Hypotheses for Investigation
General	- Canada's sources of comparative advantage appear to be: - its natural resources, - potential achievement of threshold levels for production, as the new technology reduces scale economics, - strength in space, telecommunications, electronic switching and fibre optics, - a nationwide banking system, - provincially-owned utilities and transportation systems, - the recent integration of computation and communication services, - competitiveness of its service bureaux.	

International Interdependence

Application: Domestic IBHS and electronics production

Issue: Competitiveness

Mode of Application/Production	General Considerations/Timing	Hypotheses for Investigation
Electronics	- trade balance in electronics has deteriorated in the face of an increasing volume of international trade.	
High performance products	- Canada may have advantages in producing for U.S. military.	- U.S. might restrict high-technology exports for military strategic reasons, lowering rate of diffusion.
High volume, low-cost products	- Canada's domestic market is small.	- domestic firms may be unable without assistance, to penetrate international markets; limited to role of supplying components to U.S. manufacturers.

International Interdependence

Application: Domestic Production

Issue: Competitiveness in International Markets

Mode of Application/Production	General Considerations/Timing	Hypotheses for Investigation
General		- one of the most important and essential competitive factors confronting Canadian suppliers and other foreign companies abroad is the traditional policy of "buy national".

International Interdependence

Application: Households

Issue: Competitiveness

Mode of Application/Production	General Considerations/Timing	Hypotheses for Investigation
		- foreign manufacturers will continue to dominate many segments of the home electronics business. The microprocessor will not change the dominance of Far Eastern manufacturers of household electronics products in the near term. Over the longer term, with a significant change from analog content to digital content, there could be a shift back to the United States as the source for more of these products.

Public Policy

Application: Technological relationships

Issue: Labour displacement

Mode of Application	General Considerations	Hypotheses for Investigation
Education		- added pressure on governments to substitute human teachers for advanced education technology - major technological changes in organizations facing rapidly increasing demand for their goods and services will have an upward effect on educational and skill requirement - the higher the levels of education relative to the requirements of work-processes, and the greater the flexibility in transference of work-functions among related occupations, the lesser would be the dislocative effect of technological change - technological change as subsitute or complement for education and skills

Public Policy

Application: Demand Patterns

Issue: Regulation and Procurement

Mode of Application/Production	General Considerations/Timing	Hypotheses for Investigation
Analytic instruments		- increasing regulatory pressure, energy management in plant operation, investment for existing plant expansion, and modernization of worn-out inefficient plants plus spending for pollution control and employees' safety and health, etc., will have a positive impact on the demand for analytical instruments. - these positive factors will be helpful in counteracting a slowing rate of growth of industrial capital investment that will persist until 1983, when historic rates of growth are forecast to resume. - the demand for analytical instruments will increase as more stringent standards are put into effect. The regulatory enforcement, in effect, increases the instrumentation requirements in the performance of programs such as the following: - identification and characterization of potential pollutants - measurement of known pollutants - impact of toxic chemicals on the environment - product development/improvement - process development/improvement - quality control - government purchases are expected to continue to grow with the average growth rate of the analytical instrument market in Canada.

Public Policy

Application: Technological Relationships

Issue: Provision of Systems Infrastructure

Mode of Application	General Considerations	Hypotheses for Investigation
Communications - satellite communications		- satellite systems may develop as an alternative to ground-based systems, or - may be seen as an extension of ground-based systems e.g., serving sparsely-populated areas
Communications - data communications	- lack of generally-available data communications network has forced large organizations to develop their own, using leased lines	- future of private networks uncertain; if telco's introduce general network they will have incentive, to stimulate phasing-out of private networks via higher rates

Public Policy

Application: Organizational Structure

Issue: Controls on Concentration and Non-Competitive Practices

Mode of Application	General Considerations	Hypotheses for Investigation
Information Services - Videotex	- problems of - whether Post Office or telco's should have monopoly, versus carriage and/or intercommunication with private sources - public versus private supply of new terminals which will be required - rate of return on carriage - control of content - pricing of service - availability of local-distribution network - potential for private-public sector conflict - regulatory constraints needed	- semiconductor firms may pursue non-competitive practices associated with vertical integration
Automated office - central services		- need for creation of a common set of intercommunication standards.
- electronic mail		- impact on postal services: alternatives -intermediate stage: electronic transmission to local post office for foot delivery or customer collection, -low cost of electronic typewriter will make direct electronic transmission to the home feasible in time frame which would make this stage unneccessary. - impact on facsimile transmission: freeing-up of spectrum.

Public Policy

Application: Organizational structure

Issue: Procurement

Mode of Application/Production	General Considerations/Timing	Hypotheses for Investigation
Local governments		- local governments' future procurement policy for business communications products conformity to national and international standards.

Public Policy

Application: Income and Wealth Distribution

Issue: Regional Incentives

Mode of Application/Production	General Considerations/Timing	Hypotheses for Investigation
Regional computer centers	- level of service available in the Atlantic provinces and Quebec is increasing. - the size of selected service bureaux in Western Canada is increasing.	- greater emphasis will be given to a more even distribution of purchases throughout the country in order to develop regional computer centers.

Public Policy

Application: International Interdependence

Issue: Foreign Investment and Control

Mode of Application/Production	General Considerations/Timing	Hypotheses for Investigation
IBM - Major supplier of computer services in Canada		- IBM's actions are compatible with Canadian interests. - A "special industrial sector" will be created to govern foreign participation. - Suasion will be effective in dealing with IBM, particularly in R&D. - Government grants will favor competitors.

Public Policy

Application: International Interdependence

Issue: Barriers to Acceptance

Mode of Application/Production	General Considerations/Timing	Hypotheses for Investigation
Computer/Communications		- the large multinational firms responsible for most imports of computing equipment would produce in Canada for export sufficient of their products to roughly balance their imports.

3. APPRAISAL OF ANALYTIC AND FORECASTING TECHNIQUES

INTRODUCTION

This chapter is intended, first, to present briefly the criteria according to which a variety of analytical and forecasting approaches are to be evaluated, with a view to possible implementation in the follow-on study. The criteria imply that particular outputs will evolve from that study, both in terms of predictions and of reasoning, backed by empirical evidence where available, to justify the predictions.

Second, a number of approaches and specific techniques will be examined for their conformance with the stated criteria. Subsequently, in Chapter 4, recommendations will be made as to a preferred approach, reflecting the results of this analysis.

1. CRITERIA FOR APPRAISAL

A. Identification of sectors

Because of the plethora of possible applications and of impacts of such applications which have been claimed for the products of the information revolution, it is felt necessary to make some initial identification of those sectors where the impact is likely to be most significant within the time frame of interest - approximately the period of the 1980's. The term "sector" pertains to a relatively homogeneous grouping, in this instance either

in the dimension of functional areas - process control, consumer products, etc. - or of industries, in the SIC sense, but including "household production" as an additional category.

Several constraints appear to govern the choice of methods:

- The heterogeneity of functional areas (applications), and of industries with respect to their amenibility to various types of application argues for the construction initially of a relatively simple set of indexes by which an initial screening may be performed.

- A sub-set of application-industry pairs, once identified may then be subjected to more detailed investigation, for which see the following headings in this outline.

- Such an initial screening, and to a considerable extent, the more detailed analysis, is likely to have to rely in part upon expert opinion. The state of understanding of the process of technological change, combined with the recency and rapid changes in developments in production and dissemination of information technology does not allow for the establishment of well-tested hypotheses in a timely enough fashion to be of use in guiding policy. Therefore also, informal methods are likely to be chosen as part of the approach.

B. Identification of critical hypotheses

While formal hypothesis testing may be beyond the scope of the study, assumptions about behaviour in the system

should be identified which, if incorrect, could lead to significant errors in forecasts, in terms of size, distribution and timing of impacts. A desirable property for the approach to be chosen, therefore, is that it generate explicit conditional predictions. It should be possible, in concept if not in practice within the scope of the study, to examine the sensitivity of forecasts to changes in the critical assumptions.

C. Evaluation of behavioural parameters

Explicit models of behaviour in the system would allow the evaluation and interpretation of parameters with respect to a variety of adjustments in the system including ease of substitution, rate of adaptation, etc. Evaluation of parameters may be performed by reference to expert opinion, analogy with similar processes or other means. There is likely to be a trade-off between the identification of explicitly behaviour-linked parameters in a highly structured model of the system, and the ease with which forecasts can be produced.

D. Development of forecasts

It will be necessary to produce forecasts of the timing and magnitude of impacts. Methods should:

- be appropriate to the 10-year forecasting period which is desired;

- be specific to Canada, either by means of "ground up" analysis or by modifications, based upon explicit assumptions of available forecasts of more global scope or pertaining to another country;

- take cognizance of the possibility of, and allow evaluation of the effects of critical bottlenecks in development and diffusion;

- include not only the "replacement" component of technology impact but also, where significant within the time frame indicated, the "growth" component; this capability implies the identification of potential economies of joint production and scale, conversion from batch to continuous production, threshold levels for domestic production, etc.;

- deal with indirect as well as direct effects of applications; the latter pertain to qualitative changes and income generation effects in the processes under study while the former pertain in general to input markets, especially for labour and to induced structural changes such as industry concentration, international specialization of production, etc.;

- include estimates as to the interpenetration of markets by competing products and services in terms of degree and timing, e.g., for remote access versus individual processing, based upon relative prices, long-run equilibrium points and rate of dynamic adjustment to equilibrium;

- incorporate estimates of significant cross-sectoral impacts associated with both pecuniary and technological externalities resulting from market aggregation and competition for scarce resources.

E. Consistency and empirical content

The criteria under D, above, imply a range of possible analyses in terms of their power to explain the underlying phenomena of the system. This characteristic can be evaluated in terms of two criteria:

- the application of a consistent model of economic behaviour for predicting decisions;
- the ability to incorporate real-world observations in the evaluation of behavioural responses.

F. Sensitivity to exogenous assumptions

The method employed should be sensitive to variations in assumptions about exogenous growth, e.g., the rate at which other countries, industries will apply process control technology and its influence, via reduction in export prices or otherwise upon investment in Canadian industries.

G. Identification of transitory versus long-term technologies

The method should be capable of identifying transitory versus long-term technologies, e.g., the use of office copiers to handle both paper and transmission pending completely integrated electronic systems.

H. Policy effects

The method should show the relation between future deve-

lopment and major policy problems and decisions, e.g., it has been asserted that future flexibility may be sacrificed by current developments in packet-switching networks.

I. Feasibility

All of the above criteria must be balanced against measures of feasibility including:

- the availability of data (qualitative and quantative) for calculating the magnitudes of parameters and variables over time; this includes the time and resources necessary for capturing and processing such data, as well as its quality;
- other resources requirements for detailed design, computer programming, calculation, etc.

2. REVIEW OF RELEVANT TECHNIQUES

In this section we shall review a number of approaches and specific techniques which have been employed in the assessment and forecasting of technological change. As these techniques have been described in detail in a number of publications*, we shall present only the briefest possible exposition.

A. Extrapolation of Trends

A curve is fitted to a historic time series of the variable under investigation and is extrapolated,

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* See, e.g., the works cited in Ayres, Hetman or Jantsch.

possibly in the form of an envelope intended to represent the level of confidence of the forecast and reflecting conditional expectations of deviations from the past trend due to novel developments. This approach might be employed to project the various properties of the new information technology, e.g., bits per semi-conductor device. It might also be used to forecast a variety of "environmental" variables, e.g. demand for information-processing capacity. Particularily in an area such as the one under investigation, where changes are very rapid in many dimensions, judgemental constraints will likely need to be introduced to preserve realism.

B. Heuristic Forecasts

This set of techniques relies upon empirical observation of correlations between particular variables. The variable which is desired to be forecast is treated as the dependent variable. A variety of indicators, the growth of which is anticipated to be stable or capable of being forecast with a high level of confidence, are treated as independent. The former can then be forecast using the quantified historical relationship with the latter. A second type of technique under this general approach is the

use of analogies and metaphors. As an illustration of this technique, the growth of human populations in a limited environment has been described by a curve which has been sucessfully employed in the biological sciences to predict the growth of organisms in a laboratory. Somewhat further from the original application, such curves have been suggested for describing the growth in level or complexity of technological activity. The third technique involves the use of phenomenological models. These are more formal than the growth curve approach but are also atheoretical. For instance, scientific progress has been viewed in terms of information gain. It has been proposed that "the rate of increase of information is proportional to the amount of information which already exists, to a probability... that a scientist encountering a "bit" (or unit) of information will "react" and create a new unit of information, and to the number of scientists...in the field". (Ayers, pp. 129-130.)

C. Operational Models and Simulation

This approach involves the use of operations-research methods, (including linear programming and large-scale

models) designed to simulate the behaviour of a very complex system. To quote Ayers again, the attractive feature of this approach "is that irregularities in the trend curves show up explicity, often in terms of readily identifiable causes such as "bottlenecks"... the unattractive feature is simply that in many cases the amount of quantitative apparatus required is too great in relation to the reliability of any conclusions one can reasonably expect to arrive at...the net result (is) little better than a guess...except for short-term forecasts... (Ibid), pp. 140-141).

D. Intuitive Methods of Forecasting

Three general approaches may be identified under this heading. The first is expert opinion. In practice, particularily in the field of market forecasting, where it is most frequently applied, the experts are suppliers of the product in question. Their forecasts generally rely on some knowledge of the total market size, including the stimulus to demand which their new product is expected to create, as well as some reliance on the penetration previously of products in their own or analogous markets. Because of the self-interest of such experts, forecasts are likely to be biased towards the optimistic.

A second intuitive approach is the writing of scenarios. "A scenario is a logical and plausible (but not necessarily probable) set of events, both serial and simultaneous with careful attention to timing and correlations wherever the latter are salient. In scenario writing one major emphasis is usually on the critical branch points...where small influences may have great affects on the outcome...it is sometimes illuminating to show explicity how a single arch-type scenario can generate families of variants as elements are changed. (Ibid, p.146) The advantages claimed for scenarios are that they" counteract 'carry-over' thinking and force the analyst to look at cases other than 'surprise-free projections' and that they are an antidote for concentrating exclusivly on the forest and ignoring the trees. By limiting themselves to abstract generalization analysts may easily overlook crucial details and dynamics." (Ibid, pp. 8-11).

A technique which may be applied usefully in conjunction with the construction of scenarios and which has also been applied as part of the Delphi approach is the so-called "relevance tree" or "relevance matrix". This technique is a combination of network theory and morphological analysis (see Section E). The relevance

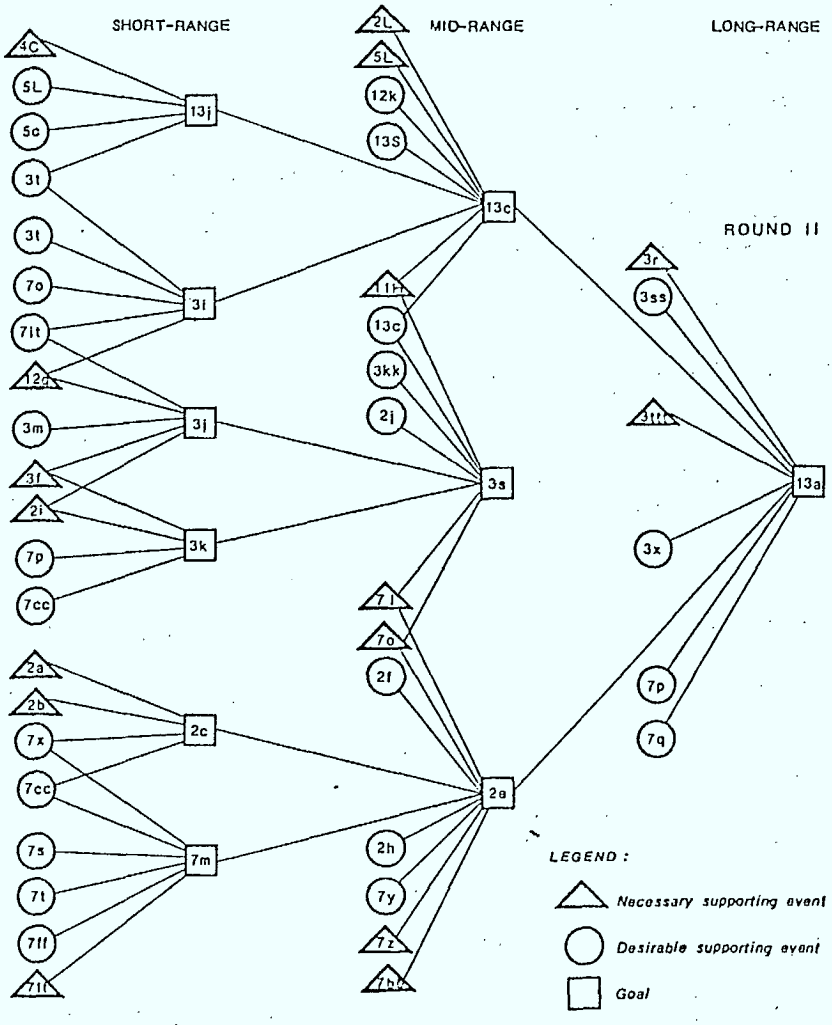
tree or matrix involves a representation, in an orderly fashion, of the interdependence of events and activities constituting the field of investigation. An illustration of the application of this technique in the field of data processing is shown in the accompanying diagram. Problems with this approach are the delineation of the intensity of the various effects and relating the important branches and nodes in a way which reflects simultaneity and feedback effects.

A third set of techniques under the heading of intuitive methods are "Structured Man-Man Interactions." One of these is "brainstorming", the format of which is the group meeting or meetings in a setting conducive to free speculation. The ground rules generally include focus on a single well-defined problem, but the admission of any idea without criticism or exploration of its implications.

A well-known technique is the Delphi Method. The method employs panels of experts to derive a picture of future events and the timing of those events. It is based

Chart 27

THE SEER - TECHNIQUE APPLIED TO INFORMATION PROCESSING



BLOCK IDENTIFIER	EVENT
13 a	An international technical data system will be in operation with access by individual scientist through desk top devices.
13 c	Development of machine-processable languages capable of representing and simulating the combined action of hardware and software systems at whatever level is desired, from logic elements through modules and more complex units.
21	The 100-fold increase in the use of large scale integrated circuit technology on a truly integrated basis.
11 h	Research identifying technical and cultural linguistic communities within a natural language, with a view to simplifying man-machine intercommunication by specifying the linguistic environment.
5 l	An inexpensive alphanumeric terminal (with limited graphic capability) will revolutionize this field at about $ 1 K per terminal.
12 k	User will have his choice of performing many functions either in the hardware or as programmed in the software.
13 s	Hardware and software purchases will be divorced.
13 c	With the advent of time-sharing, interpreters will assume greater importance in systems and provide simpler processing of variability.
13 j	A major increase in the use of computers for simulation is predicted, facilitated by major change in the use of peripheral equipment.
4 c	Input/output data communication terminals will become more versatile at higher speeds and lower costs by sharing common control electronics within geographical clusters.
3 t	Very cheap special purpose computers to solve specific data processing problems in standardized ways will be available.
5 c	A flat TV tube providing reduced glare, will be available on the market at reduced cost.

Reproduced from Hetman, Society and the assessment of technology, Paris: OECD, p.237

on informal techniques of surveying and reconciling the judgements and forecasts of the participants. The participants do not meet as a group, thus reducing serious psychological factors such as inhibition or bandwagon effects.

Gaming, on the other hand, involves the participants in some hypothetical, including future, situation in which they are asked to play a specific role. An initial set of conditions and rules is specified, but within these the individual participants are allowed to play their roles according to what they feel to be appropriate behaviour for the actors whom they represent.

E. Morphological Analysis

This technique involves the identification of a number of dimensions in which some specific technology may develop, e.g., speed, performance at high or low temperatures, which may or may not conform to specific known configurations or models. The probability of development from one configuration to another is made

a function of the number of dimensions of change and the probability attached to joint changes. The original application of this technique to specific technologies has been broadened by some investigators for the generation of scenarios of future world situations, corresponding with a variety of social, economic and military developments.

F. Economic Analysis

Economic analysis is too broad a field, even in relation to technological change to be summarized easily. Hetman has pointed out that technological change has for long been treated as a residual factor in economics. Major problems involved in internalizing such change in economic models include first, the input of intangible capital in the generation of progress and the creation of such capital as itself being a source of direct satisfaction. Secondly, technological change is associated with external affects. These have led to a search for corrective actions whereby the negative impacts of economic growth and technological development could be mitigated. For present purposes the characteristics of economic analysis of

most relevance are, first, the availability of well-developed models of firm and household behaviour. The aspects of household behaviour of most relevance are demand for goods and services and supply of labour. There has been some attempt at extension of the classical demand model to take account of trade-offs between timing-saving and quality characteristics of products as well as response to the introduction of new goods and services according to their attributes. For the firm, the most relevent models are that of production and choice of techniques and of investment. The question of diffusion, which is anticipated to be of great relevance in the study of Information Revolution impacts has thus far had only rudimentary development in economics.

The second methodogical aspect of economic analysis of importance for our purposes is that quantification relies upon historical evidence. Inferences are drawn on the basis of models, the relationships of which are assumed to be stable. This represents, of course, a restriction upon the specificity and precision of the

predictions which can be made from economic analysis.

3. COMPARISON OF RELEVENT TECHNIQUES WITH APPRAISAL CRITERIA

The techniques reviewed in Section 2 may be compared with the set of appraisal criteria presented in Section 1. The statements made in this comparison reflect a judgement, developed in the course of the present study, as to what is known about the economic determinants of changes associated with the information revolution. In Chapter 4, we shall proceed to outline a research agenda which represents a blending of relevant techniques into a (hopefully) coherent analysis.

A. Identification of Sectors

Initially the identification of sectors of greatest impact should rely upon the existing pattern of information production and consumption. As an initial or "base case" this pattern might be extrapolated with the aid of some available macroeconomic scenario. This "base case" scenario may be viewed as the least arbitrary projection, and would have the advantage of relying.

upon detailed data. In addition, it might be argued that, if the economic system has a great deal of inertia, such a projection might be very realistic. A more adequate analysis would rely upon reasoning about impacts of the information revolution and other sources of technological change in altering the existing structure. Such reasoning may include formal theoretical models; however, the qualitative nature of much of the technological change would almost certainly require the application of intuitive methods.

B. Identification of Critical Hypotheses

This criterion implies methods which are oriented to conditional prediction rather than to extrapolative forecasting. For the formulation of such hypotheses there is no alternative to rigorous reasoning supplemented, for technological relationships, by well-elaborated structures such as that of morphological analysis. How useful and generalizable such hypotheses will be depends upon the time available to construct and elaborate the relevent models. In the literature pertaining to the information revolution such of it as is not technically-oriented is primarily descriptive and contains little information which, by itself, could form the basis for a researchable question.

C. Evaluation of Paramaters

This step would follow from the activities implied under Criterion 2,above. Again, the satisfactorinous of the results will depend on the amount of time available for applying specific techniques. Preferably, there would be rigorous testing using historical data. As a second-best approach in some areas, judgemental values would be assigned, relying upon expert knowledge obtained via Delphi and other techniques.

D. Development of Forecasts

Some forecasts will have to be derivative if the research is to be kept within reasonable resource bounds. In particular, published studies of global technological developments could be reviewed and synthesized. For Canada, there would then be a need to develop hypotheses for intervening variables with respect to share of world production, etc. There would also be required a set of "home-grown" forecasts. These could be a combination of extrapolative and conditional forecasts based upon an assessment of Canada's particular economic features.

E. Consistency and Empirical Content

The comments under Criterion 3, above, are applicable here also. Techniques involving simple trend extrapolation, intuitive methods, and morphological analysis tend to be ruled out; however it should be stressed that this criterion will only be partially met under the best of circumstances; hence, as a practical matter, such techniques will have a role.

F. Sensitivity to Exogenous Assumptions

This criterion implies a well-elaborated structure, either in the form of scenarios or models or a combination of the two.

G. Identification of Transitory versus Long Term Technologies

The former of these is very difficult to achieve because of the wealth of variables affecting timing and of achievement of threshold levels. Any attempt at formalizing defensible statements about such transatory effects needs to be done in the context of a narrowing-down to a limited number of development paths which, by consensus, are taken to be feasible and likely on the basis of explicitly stated preconditions.

H. Policy Effects

Whether policy effects can be meaningfully incorporated in the analysis depends upon how well it is possible to formulate policy instruments and the channels of their impacts in scenarios and models. Again, this depends upon the amount of time available for elaborating the scenarios and models for testing the relevent assumptions.

I. Feasibility

Here there is a trade-off. Rigorous methods, such as econometric models, potentially allow for very detailed investigation. In such an underdeveloped (from a theoetrical point of view) area, however, much of the investigation will be unsatisfactory in the sense that application of historical relationships to future events cannot be performed with great confidence. An approach which relies more heavily on intuitive methods applied at very aggregate levels is much more feasible within prespecified constraints of time and other resources. There has been much speculation, however, on the

impacts of the information revolution; but the arguments are frequently not very defensible and the conclusions are in conflict. A reasonable strategy, under the circumstances, would appear to be to employ intuitive methods to develop a set of working hypotheses and forecasts within a limited set of time and resource constraints, while exploring these hypotheses in the more open-ended context of formal economic analysis.

This comparison of techniques with criteria is summarized in the accompanying chart. The codes used in the table are as follows:

A - suitable as a primary approach

B - possibly suitable as a "second best approach, i.e., to be employed if the preferred approach proves to be infeasible due to data, resource or time constraints.

C - suitable as an auxillary technique for implementing either of the above.

We have given emphasis to scenarios and economic analysis as the principal methods of investigation. Their roles, and the relationships to them of auxillary techniques in the overall research agenda are discussed in the following chapter.

	Sector identification	Critical hypotheses	Parameter estimation	Forecasts	Consistency; empirical content	Sensitivity	Transitory vs long-run effects	Policy Effects	Feasibility
Trend extrapolation	C			C	C				C
Heuristic forecasts									
- correlation				C	C				
- analogy + metaphor				C	C				
Operational models + simulation				C		C	C		
Intuitive forecasting					B				
- expert opinion	C	C	B	B	B				C
- scenarios	A			A	B	A	A	B	A
- relevance trees	C	C		C	B		C		C
- structured man-man interaction (brainstorming, Delphi)	C	C	B	B	B				
Morphological analysis		C		C	C				
Economic analysis	A	A	A	C	A	A	B	A	C

4. RECOMMENDED RESEARCH AGENDA

1. OVERVIEW

In this section we shall present in some detail our recommendations for a research agenda aimed at addressing the questions presented at the beginning of this paper. The program which we recommend is organized in three phases. In general, it is proposed to proceed first by establishing a general framework in which major developments associated with the Information revolution both globally and specifically in the Canadian Economy will be traced. From this phase there would follow a set of studies which would examine in detail a number of sectors in which the direct impacts are likely to be greatest. This latter phase would be a means of testing the possibility of the relationships developed in the framework studies. In a third phase the previous work would be consolidated so as to yield predictions of impacts in particular dimensions for the Canadian Economy as a whole. The reasoning and forecasts developed in the framework studies would be "fleshed out" and given greater precision. Inferences about policy which might be drawn from either more superficial or more partial analyses could be critically examined as the result of conclusions drawn from this final phase.

The framework studies constituting the first phase would be designed to present a set of most likely alternative development paths. It is important to articulate a small number of alternatives in order to make the task of discussion and prediction of impacts a managable one. Since the shape of the information revolution as it evolves will be determined mainly outside Canada, much of the discussion will be in terms of global developments; but implications for Canada as the result of technological diffusion, multinational enterprise, etc. will be included. Primary concentration on developments on the Canadian scene will characterize the studies of the subsequent phases, however. The emphasis of this initial phase will be on synthesis of information and speculation derived both from the literature and from experts on matters primarily pertaining to technological interdependencies, on the one hand, and reasoning about economic behaviour on the other.

In the sectoral studies, detailed information on applications in individual industries and the household sector, both of the new information technology to date and analogous development in the past would be employed to trace through impacts in and via these

sectors. In addition, studies of particular technological sequences or configurations would be made. The emphasis in this phase would be on rigorous examination of historical behaviour patterns and structure as well as likely developments in order to test the reasoning employed in the first phase.

2. FIRST PHASE - FRAMEWORK STUDIES

A. Objectives

The objectives of this phase would be, first to present the major alternative development paths, in terms of modes and areas of application, associated with the information revolution. The emphasis would be on relating economic reasoning about questions such as the behaviour of demand and the location of production to major areas of application of the new technology. The analysis would serve both to reduce to a manageable set the numver of alternative possibilities - stemming from different assumptions - to ve included in the subsequent investigation and to form an articulated and reviewable basis for further work. It must be stressed that, in spite of the existence of a large literature pertaining to one or another aspect of the information revolution, no such systematic discussion exists, either for Canada or, as far as we have been able to ascertain, for any other country.

The second major objective of this phase would be to identify both the sectors and technological configurations of greatest impact. This analysis would lead to the definition of the areas to be examined in the second phase.

B. Steps and Methods

The first step would consist of the writing of a set of scenarios pertaining to alternative development paths. These would be concerned with global developments in the information revolution, but with explicit consideration of the implications for the Canadian economy. The alternatives would be generated by the identification of critical assumptions (branch points) on matters such as:

Behavioural

- Income growth
- Dynamic response of demand to quality and price changes of specific types of technology
- Scale economies and learning curve effects on supply prices
- Timing of the introduction of electronic infrastructure
- Regulatory decisions
- Locational determinants of production

Technological

- Embodiement of new technology in general-purpose devices versus internalization of methods by user firms
- Proliferation of free-standing devices with subsequent integration versus de novo systems development
- Rates of diffusion of technologies
- The replacement of mechanical and human functions by electronic and of electronic-analogue by digital technologies, respectively

In the construction of these scenarios, four ancillary techniques will be employed. First, the reasoning to be employed in the scenario construction would be organized according to the analytical framework presented in Chapter 1. The analyses indicated by that framework would be developed primarily by an examination of the literature both on the information revolution per se and more general studies related to technological change. These analyses would be quantified where possible by means of data to be found in these studies or from primary sources, particularily Statistics Canada and OECD and other international sources.

Second, in order to clarify the relationships constituting the system, a set of relevence diagrams will be constructed to trace the flow of events and interdependencies. These diagrams would be useful particularly in clarifying the prerequisites for implementation of some particular technological change. In the area, e.g., of plant automation it has been argued that pre-requisites include: adequate standards for communication; complementary pricing policies by utilities for more efficient plant utilization; a long period of use of simpler devices for repetitive operations; etc.

Third, trend extrapolation will be employed to provide estimates of reasonableness for quantitative projections. Such projection might include, e.g., determinants of demand for information services, rates of investment, capital-labour ratios, shares of domestic and international markets, etc.

Fourth, as an integral part of the scenario-writing exercice, the alternatives would be reviewed with experts, both in the fields of information technology and of economic growth and technological change generally to aid in selecting a most likely scenario. While alternative scenarios would continue to be considered during the course of the research program, the implications of the preferred scenario would be dealt with most intensively.

The second major component of the first phase would consist of a structural analysis for the purpose of identifying high-impact sectors. This work consists of a series of partial but sector-exhaustive studies. This analysis would include the following elements:

- the impact of process change within individual industries;
- interindustry impacts via forward and backward linkages;
- shifts in labour and capital requirements; and
- substitution effects in output markets.

On the basis of these analyses, a knowledge of sectors of particular concern for policy, and the judgemental weighing of the various partial effects, a limited number of sectors will be singled out for further detailed investigation in the second phase.

To illustrate the nature of the analyses and to provide, at this point, an indication of the specific sectors to be dealt with in the second phase studies, as well as to provide some guidance for areas of particular emphasis in the scenario-writing of the first phase, a set of analyses has been performed. These are presented in the Appendix. They correspond to the first two types of studies listed above, ie., impacts via process change and via vertical linkages. These initial analyses are based upon the existing structure of information production and consumption in the economy. With the aid of information developed in the scenarios, the analysis could be extended to reflect substitution and shifts in these patterns.

The results of the initial analysis, in terms of the sectors which appear to display the greatest impact are: communications; utilities; trade; finance, in-

surance and real estate; business services; business machinery and equipment; public administration; consumer durables; and consumer services; and travel and promotion. These findings correspond well with qualitative statements in the literature. Some or all of these sectors, or major components within them might be the subjects of individual investigations. It is noteworthy that, while several individual large manufacturing industries will be the loci of significant impacts, the manufacturing sector as a whole is not as sensitive, relative to its share of economic activity, as are the service and public sector industries.

3. SECOND PHASE - SECTORAL STUDIES

A. Objectives

The first objective of this phase of the research program is to examine in detail, for those sectors anticipated to display the greatest impacts, their capacities and speeds of adaptation to the new information technology. Second, for each of the sectors, this phase would aim at estimating the impacts on their own production characteristics, on the quantity and nature of their outputs (e.g., product specialization) the location of production and on direct inputs in vertically-linked industries. For house-

holds, equivalently, the analysis would be concerned with the impacts upon the distribution of consumer demand, labour force participation and income growth and distribution.

For one or more specific technological sequences or configurations, multi-sectoral impacts would be traced. Such a study or studies would complement those which focus on an individual sector. For instance, the evolving technology associated with "office automation" affects all productive sectors and will ultimately also affect the production of services within the household. In practice, each study will probably tend to focus upon a specific application-industry pair.

Three principal steps would be involved in this second phase. First, an historical background for each sector would be developed concerning its adaptation of technologies preceding or representing early stages of, the new information technology. The dimensions of these background studies would include:

- investment;
- indirect inputs, effects or supplying industries and domestic versus import shares;

- contribution to the creation of new industry;
- productivity change;
- employment affects, including both total workers and occupational mix;
- prices;
- profits;
- wages;
- taxes paid;
- induced investment;
- first-round effects on consuming and industries; and
- shares of production to domestic versus export markets.

For the household sector, similarily, historical patterns and response to specific technological improvements such as time-saving household equipment, etc., with respect to consumption of market goods, use of leisure time, labour force participation, savings behaviour, etc., would be developed.

For each sector there would be an analytical interpretation of the particular developments using the general framework presented in Chapter 1. To support this analysis an appropriate data base would be constructed for each sector and would be employed to create

cross tabulations, trend series, etc. This somewhat informal approach would allow a selection of the most important hypotheses and a sharpening of these hypotheses for more rigorous statistical treatment in the second component of this phase.

The second step consists of econometric studies employing, for each sector or technological configuration, a set of relationships which might include some or all of the following:

- demand
- investment
- production
- employment
- wages
- prices.

From the list of functional relationships indicated above, two deserve further comment at this point. In the area of demand, a particular problem with the information revolution, though not unique to it, is deciding under what conditions a user industry employing a variety of special-purpose devices is likely to replace them by technology in which the various functions are performed by integrated systems. No adequate model appears to have been developed to

deal with this problem. The second problem is in the area of production. The models to be developed would need to be structured so as to reflect the influence of the relevent technological changes and the competition between new and old technologies.

If possible, the response to technological change in a variety of dimensions should be parameterized so as to allow simulation of the pending information revolution technologies, e.g., penetration rates as a function of productivity-weighted relative prices.

For the service sector, it may be assumed that the analysis will be generally more simplified than for goods-processing. There is a problem of devising a suitable metric for real output in this sector. It will be possible, however, to rely on some work already performed and reported in the literature e.g., in banking and insurance (see Geehan). It would also be very desirable to be able to account for factors such as the "supply-push" situation which prevailed in the labour market for much of

the 1970's and which led to qualitative change in services reflecting new want-creation and satisfaction. It is of considerable importance to be able to judge whether this kind of situation would be enhanced by the Information Revolution. This consideration would also be important in the econometric studies of the household sector to be undertaken in this component of the second phase.

All of the individual studies which might be undertaken in this phase would benefit by review with experts in the individual sectors who would be in a position to give their own interpretation of historical developments.

Having developed formal models for explaining the behaviour of individual sectors in adapting to technological developments analagous to the information revolution, the third major step of this phase would be more forward-looking. It would consist of the application of the model parameters derived in the preceding analysis for simulating the rate of adaptation and impact on the sectors

being studied. To pursue the previous example, a model explaining penetration rate as a function of productivity-weighted relative prices for some past technological innovation with specified attributes which are also included in the model could be applied to elements of the information revolution on the basis of judgemental (or more desirably endogenously-derived) values of their own characteristics.

4. THIRD PHASE - PREDICTION AND QUANTIFICATION OF AGGREGATE IMPACTS

The objective of this phase would be to estimate the magnitude of aggregate effects of the new technology in specific dimensions, conditional on alternative assumptions and/or parameters derived in the second phase about availability of direct and indirect inputs, learning-curve effects, speed of adjustment, etc. We shall leave the design of specific steps and methods in this phase to development during the course of the research program. A few observations may be made, however, about the types of questions which should be addressed. In general, predictions of short-run effects such as labour displacement and mobility are very hazardous. Furthermore, any approach which

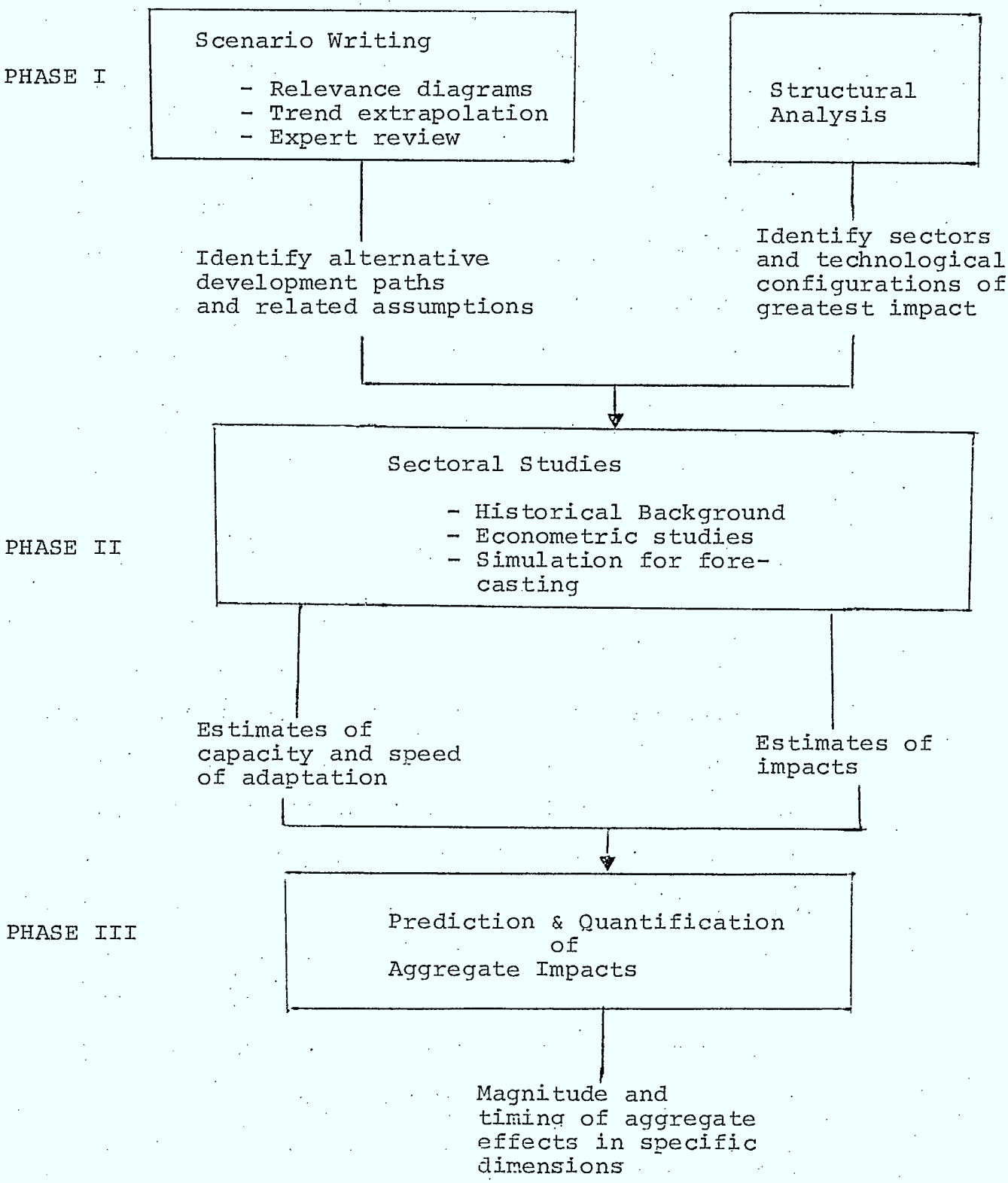
relies, for an evaluation of net impacts, upon an enumeration of impacts and reactive behaviour is bound to produce results which are incomplete and which are liable to be biased. The potential to displace existing technologies is usually well recognized but the extent of such displacement and the possibilities for countermeasures to sustain the older technologies are usually not so well foreseen. In general, the stimulus of any wave of technological change such as the one known as the "information revolution" to the creation of new products and processes is likely to be underestimated because so many directions of innovation are unforeseeable. Some of the topics which might be investigated in this third phase include:

- long-run shifts in labour requirements;
- changes in industrial structure (Input-Output configuration);
- the composition of final demand; and
- economy-wide growth in productivity.

While implementation of this phase would likely require the design and specification of original models, consideration should be given to the replication of existing models and methods for the Canadian economy. Examples of such studies are the works of Stoneman for labour requirement effects of computers in the U.K. and of Wolff on the productivity impacts of changing technology in the U.S. In either case, it should be possible to employ parametric values derived in the second phase in implementing these models for forecasting. Therefore, an initial design, at least, for the third phase studies should be available by the time those of the second phase are undertaken.

5. SUMMARY AND PRELIMINARY TIME AND RESOURCE ESTIMATES

The recommended research agenda is summarized in the accompanying diagram. As indicated, the conduct of Phases II and III depends on the completion of the respective preceding phases. Phase II studies would rely upon the identification of testable hypotheses and of sectors in Phase I. Phase III studies would utilize predicted values and estimated parameters from Phase II. Some overlap may be desirable however. The scenarios, and even the structural analysis of Phase I might be revised following the more detailed investigation of individual sectors in Phase II.


PHASE I
Scenario Writing
- Relevance diagrams
- Trend extrapolation
- Expert review
Structural Analysis
Identify alternative development paths and related assumptions
Identify sectors and technological configurations of greatest impact
PHASE II
Sectoral Studies
- Historical Background
- Econometric studies
- Simulation for forecasting
Estimates of capacity and speed of adaptation
Estimates of impacts
PHASE III
Prediction & Quantification of Aggregate Impacts
Magnitude and timing of aggregate effects in specific dimensions

Some design, at least, of Phase III studies should be performed before launching the studies of Phase II, in order to define needed inputs. Only rough estimates of time and resource estimates can be made in the absence of more detailed specifications. In particular, the number of sectors to be investigated, attention to be devoted to the existing leterature, degree of formalization of models, types of procedures to be used in investigating hypotheses and corresponding information requirements will govern the size of the overall research effort.

With this caveat in mind, we estimate the cost and duration of the first phase framework study as being, respectively, in the order of $20,000 - $50,000 and 4-12 calendar months. The bulk of these resources would be devoted to the scenario writing, with the structural analysis requiring a much smaller share. The individual sectoral/industry/technological configuration studies of the second phase would each appear to require $25,000-$45,000, including computer costs of model estimation and simulation. A calendar time of 4-9 months is estimated depending upon the number of studies to be undertaken and the extent of overlap in calendar time. For the third phase, each study would be of a magnitude comparable to those in the second phase, i.e., costing

$25,000 - $45,000 and lasting 4-9 months.

6. A CORE AGENDA

The research agenda presented in the previous sections represents, both in scope and in content, our assessment of what is required to yield conclusion about information revolution impacts sufficiently defensible to provide a basis for policy formulation. Should time and resource constraints, however, be such that a commitment cannot be made initially to the program which has been outlined, there are a number of studies which could be undertaken for providing interim results. It must be stressed that the approach of this alternative program differs from the one recommended only in terms of scope. The tasks to be outlined represent a sub-set of those which would be included in the more comprehensive program. Resource requirements and timing for each of the three tasks (where each case study is viewed as a separate task) would be close to the lower bounds indicated for the corresponding components of the preferred approach. There would be three principal elements.

A. A framework for the estimation of impacts in the dimensions of employment and income generation of impacts in the dimensions of employment and income generation at the microeconomic level would be developed. This frame-

work would have three major elements:

- a scenario which might be based on macroeconomic forecasts provided by one of the standard Canadian sources and which would be elaborated in the dimensions required for further discussion of the information revolution - in particular, to include assumptions as to the elements of the new information technology which, at a global scale, would find application, or, more broadly, as to the nature of supply conditions in markets for indirect inputs.
- development of methods for estimating both income and price elasticities and the sensitivity of demand to breakthroughs in particular areas of technology corresponding with "growth" areas where entirely new applications are developed.
- The assessment of factors which may intervene between potential or latent demand on the one hand and effective demand on the other, including learning curve effects mis-match between labour requirements and labour skills, frictions in labour and capital mobility, habit formation with respect to traditional lines, etc.

B. The above framework would be applied in appraising evidence from a series of sectoral, industry and indivi-

dual application case studies obtained by a combination of literature search and original field work. These case studies would in terms of resources, represent the bulk of the research agenda. Sectors or industries to be examined would be selected on the basis of the analysis contained in the Appendix of this study, with some modest extensions.

C. On the basis of the above, a set of judgemental estimates would be made, conditional upon alternative sets of assumptions, of the direct impact on the sectors included in the study, as well as prominent indirect impacts via related markets.

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A P P E N D I X

1. IMPACT OF THE INFORMATION TECHNOLOGY ON PRODUCTION PROCESSES

In Table A-1 we present a listing of the most prominent industries associated with use of the new information technology in their production. The basis for selecting these industries is a set of points assigned by J. Scrimgeour and his collegues.* Details may be found in the unpublished paper by Scrimgeour et.al., "A matrix approach to the identification of sectors of the Canadian economy most affected by CAD/CAM technology". Their weightings or "technology change factors" were assigned for three components of the information revolution:

- The Electronics Revolution;
- The Computer Revolution; and
- CAD/CAM.

These weightings were multiplied against the corresponding 1971 share for each industry in Real Domestic Product, as published by Statistics Canada. We have normalized these figures to obtain the percentage impact of the components of the information revolution attributable to each industry. We have also combined the scores, using equal weights for each component. In addition, we have updated the analysis employing the original technology change factors and the 1979 weights for the individual industries in RDP.

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* "The approach taken...has been to assign a factor for the rate and impact of technological change...ranging from a maximum of 10 which is very strong, to zero for those sectors and activities for which there is negligible foreseeable impact within the next five to ten years."

To summarize the results, we list below those major industries (including important sub-industries in manufacturing and services) each representing 2% or more of the combined impact. Industries having scores greater than their respective RDP weights are shown with an asterisk. Those industries which displayed a growth between 1971 and 1979 in their share of impact (as a result of growth in share of RDP) are underlined.

Agriculture

Mining (especially crude petroleum & natural gas)

Manufacturing

- food and beverage
- paper and allied
- transportation equipment
- * primary metals
- metal fabricating
- electrical products

Construction

Transportation

* Communication
* Utilities
* Wholesale
* Retail
* Finance, Insurance & Real Estate

Services [x]

- * education
- health & welfare
- * business

* Public administration

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[x] percentages for components of Services sector sum to more than sector total in Table A-1 because of inconsistency in source weightings

A-1: IMPACT OF INFORMATION TECHNOLOGY ON PRODUCTION PROCESSES

Industry	RDP 1971 Weight	Share of Technology Impact (%)				RDP 1979 Weight	S.T.I (%)	Difference
		Electronic Revolution	Computer Revolution	CAD/CAM	Combination		Combination	
REAL DOMESTIC PRODUCT.....	100.00	100.0	100.0	100.0	100.0	100.0	100.0	0.0
AGRICULTURE.....	3.371	0.7	1.0	1.3	1.0	2.842	0.8	-0.2
MINES (including milling). QUARRIES & OIL WELLS	3.819	4.5	2.4	3.0	3.3	3.051	2.6	-0.7
Metal mines (except gold & iron).....	1.223	1.2	0.9	0	0.7	0.683	0.5	-0.2
Mineral fuels.....	1.492	1.8	2.3	1.2	1.8	1.329	1.7	-0.1
Crude petroleum & natural gas industry.....	1.379	1.6	2.1	1.1	1.6	1.112	1.4	-0.2
MANUFACTURING INDUSTRIES..	22.862	13.4	21.1	36.1	21.0	22.532	20.4	-0.6
Food & beverage industries.....	3.254	1.3	2.0	5.1	2.3	2.814	2.0	-0.3
Rubber & plastics products industries.....	.650	0.5	0.6	1.0	0.6	1.026	1.0	+0.4
Paper & allied industries.....	1.878	2.2	2.3	3.0	2.4	1.720	2.2	-0.2
Pulp & paper mills.....	1.361	1.6	1.7	2.2	1.7	1.227	1.5	-0.2
Printing, publishing & allied industries.....	1.123	1.8	1.7	2.7	1.9	1.128	1.9	0
Primary metal industries.....	1.976	2.3	2.4	4.7	2.8	1.586	2.2	-0.6
Iron & steel mills....	.940	1.5	1.4	2.2	1.6	0.905	1.5	-0.1

A-1: IMPACT OF INFORMATION TECHNOLOGY ON PRODUCTION PROCESSES

Industry	RDP 1971 Weight	Share of Technology Impact (%)				RDP 1979 Weight	S.T.I Combination(%)	Difference
		Electronic Revolution	Computer Revolution	CAD/CAM	Combination			
Metal fabricating industries (except machinery & transportation equip. industries).....	1.887	0.7	1.7	7.5	2.4	1.808	2.3	-0.1
Transportation equipment industries.....	2.571	4.0	3.2	8.1	4.4	2.525	4.2	-0.2
Aircraft & aircraft parts manufacturers...	.292	0.6	0.4	0.7	0.5	0.322	0.6	+0.1
Motor vehicle & truck body & trailer manufacturers.....	1.035	2.0	1.6	4.1	2.2	1.111	2.3	+0.1
Motor vehicle parts & accessories manufacturers.....	.836	0.7	0.5	1.3	0.7	0.779	0.7	0
Electrical products industries.....	1.631	2.6	1.5	4.5	2.4	1.546	2.3	-0.1
Communications equipment manufacturers....	.515	1.0	0.5	1.6	0.9	0.497	0.8	-0.1
Chemical & chemical products industries.....	1.363	1.1	1.3	1.0	1.2	1.561	1.3	+0.1
Miscellaneous manufacturing industries.....	.713	1.4	1.1	1.7	1.3	0.777	1.4	+0.1
CONSTRUCTION INDUSTRY.....	6.990	2.7	5.4	8.3	4.9	5.812	4.0	-0.9
TRANSPORTATION, STORAGE & COMMUNICATION	9.096	16.0	12.6	10.8	13.5	10.161	14.9	+1.4

A-1: IMPACT OF INFORMATION TECHNOLOGY ON PRODUCTION PROCESSES

Industry	RDP 1971 Weight	Share of Technology Impact (%)				RDP 1979 Weight	S.T.I Combination%	Difference
		Electronic Revolution	Computer Revolution	CAD/CAM	Combination			
Transportation.....	5.874	8.0	6.3	7.0	7.1	5.802	6.9	-0.2
Air transport & services incidental to air transport.....	.679	1.1	0.8	0.8	0.9	1.138	1.5	+0.6
Railway transport.....	1.700	2.3	1.8	2.0	2.0	1.576	1.9	-0.1
Communication.....	2.964	5.8	4.6	2.3	4.6	4.218	6.5	+1.9
ELECTRIC POWER GAS & WATER UTILITIES.....	2.816	4.4	3.5	2.2	3.6	3.461	4.3	+0.7
Electric power.....	2.270	3.6	2.8	1.8	2.9	2.889	3.6	+0.7
TRADE.....	11.367	13.4	14.0	9.0	12.9	11.860	13.2	+0.3
WHOLESALE TRADE.....	4.509	5.3	4.2	10.7	5.7	4.421	5.6	-0.1
RETAIL TRADE.....	6.858	5.4	5.3	5.4	5.3	7.453	5.7	+0.4
Food stores.....	1.368	1.6	1.3	1.1	1.4	1.141	1.1	-0.3
General merchandise stores.....	1.562	1.2	1.0	1.2	1.1	1.604	1.1	0
Department Stores.....	.927	1.1	0.9	1.5	1.0	1.062	1.2	+0.2
FINANCE INSURANCE & REAL ESTATE.....	12.036	18.9	18.5	0	15.3	13.532	17.0	+1.7
COMMUNITY BUSINESS & PERSONAL SERVICE INDUSTRIES..	19.359	11.4	8.9	23.0	12.3	19.191	12.0	-0.3
Education & related services.....	6.509	10.2	8.0	0	7.4	4.904	5.5	-1.9
Health & welfare services	5.272	6.2	6.5	0	5.2	4.948	4.8	-0.4

A-1: IMPACT OF INFORMATION TECHNOLOGY ON PRODUCTION PROCESSES

Industry	RDP 1971 Weight	Share of Technology Impact (%)				RDP 1979 Weight	S.T.I Combination (%)	Difference
		Electronic Revolution	Computer Revolution	CAD/CAM	Combination			
Services to business management.....	2.311	3.6	3.6	1.8	3.4	3.885	5.4	+2.0
Accommodation & food services.....	2.799	4.4	3.4	2.2	3.6	2.834	3.6	0
PUBLIC ADMINISTRATION AND DEFENCE	7.388	14.5	11.4	5.8	11.5	6.795	10.4	-1.1

It can be seen that, while the information revolution impact is well distributed over the industrial spectrum, its relative growth over the past decade is concentrated in the tertiary sector, particularly in communication, utilities, retail trade, finance, insurance and real estate and in business services. Of these, growth in business services, communication and finance, insurance and real estate are most prominent.

2. IMPACT VIA INPUT MARKETS

In Table A-2 we present information obtained from the 1974 Input-Output Tables - specifically the Input and Final Demand Matrices. The analysis is intended to identify those industries and final demand sectors where impacts of changes in the nature of information goods and services will initially occur. For this purpose we have identified a number of services and commodities as constituting the "Information Sector". These include:

- Printing & Publishing
- Advertising, Print Media
- Appliances & Receivers, Household
- Other Electrical Products
- Scientific Equipment
- Radio & Television Broadcasting
- Telephone & Telegraph
- Postal Services
- Business Services
- Education Services
- Amusement & Recreation Services
- Travel, Advertising & Promotion

We have also included Transportation and Storage on account of the potential substitutability between some of these inputs and the services and products of the Information Revolution. In the analysis, results are shown, however, both with and without the inclusion of this last set of services.

Under either definition of the information sector seventeen industries or final demand sectors show significant shares of total demand (at least 2%); however the configuration changes slightly as between the two. If we leave out transportation and storage these are, together with their shares of total demand:

Intermediate-Demand		Final Demand	
Transportation Equipment	3.7	Consumer Expenditures on Durables	8.5
Electrical Products	3.5	Consumer Expenditures on Semidurables	4.1
Food and Beverage	2.7	Consumer Expenditures on Services	14.9
Construction Industry	9.1	Business Machinery & Equipment	8.6
Wholesale Trade	3.9	Exports	5.3
Retail Trade	3.7	Imports	-20.0
Finance Insurance & Real Estate	5.7	Gov't net current expenditures	7.5
Services to Business	2.3		
Operating Offices, Laboratories & Food	5.1		
Travel & Promotion	8.8		

A-2: INPUTS OF INFORMATION GOODS AND SERVICES BY SECTOR

Industry or Final Demand Sector	Information Inputs, 1974					
	Including Transportation & Storage			Excluding Transportation & Storage		
	$ million	% of intermediate or final demand	% of total demand	$ million	% of intermediate or final demand	% of total demand
Industry						
Agriculture	50.1	0.2	0.14	29.4	0.19	0.13
Forestry	235.4	1.0	0.7	14.6	0.09	0.06
Fishing, Hunting & Trapping	12.4	.05	0.04	10.6	0.07	0.05
Metal Mines	114.9	0.5	0.4	80.2	0.52	0.36
Mineral Fuels	197.2	0.8	0.6	186.2	1.21	0.83
Non-Metal Mines & Quarries	28.8	0.1	0.07	19.4	0.13	0.09
Services Incidental to Mining	49.5	0.2	0.14	30.5	0.20	0.14
Food & Beverage Industry	429.5	2.8	2.0	595.2	3.9	2.7
Tobacco Products Industries	52.4	0.2	0.14	51.6	0.34	0.23
Rubber & Plastic Prod.Ind.	88.8	0.4	0.3	87.7	0.58	0.04
Leather Industry	24.3	0.1	0.07	23.8	0.16	0.11
Textile Industry	79.1	0.3	0.2	77.1	0.51	0.35
Knitting Mills	16.9	0.07	0.05	16.5	0.10	0.07
Clothing Industry	66.3	0.3	0.2	64.1	0.42	0.29
Wood	60.2	0.3	0.2	56.5	0.36	0.25
Furniture & Fixture Ind.	54.3	0.2	0.14	53.3	0.35	0.24
Paper & Allied Ind.	131.0	0.6	0.4	117.6	0.77	0.53
Printing & Publishing	382.2	1.6	1.1	379.7	2.5	1.7
Primary Metal Ind.	112.1	0.5	0.4	98.8	0.64	0.44
Metal Fabricating Ind.	186.0	0.8	0.6	177.7	1.2	0.8
Machinery Industry	283.5	1.2	0.9	280.7	1.9	1.3
Transportation Equip.Ind.	856.6	3.7	2.6	818.7	5.4	3.7
Electrical Product Ind.	1016.9	4.4	3.1	1005.1	6.6	4.5
Non-metal Mineral Prod. Ind.	67.9	0.3	0.2	65.5	0.42	0.29
Petroleum & Coal Prod.Ind.	90.5	0.4	0.3	85.8	0.55	0.38

A-2: INPUTS OF INFORMATION GOODS AND SERVICES BY SECTOR

Industry or Final Demand Sector	Information Inputs, 1974					
	Including Transportation & Storage			Excluding Transportation & Storage		
	$ million	% of intermediate or final demand	% of total demand	$ million	% of intermediate or final demand	% of total demand
Chemical & Chemical Prod. Industry	365.7	1.6	1.1	357.3	2.3	1.6
Misc.Manufacturing	258.7	1.1	0.8	256.9	1.7	1.2
Construction Industry	2218.3	9.5	6.8	2024.4	13.2	9.1
Transportation & Storage	1568.1	6.7	4.7	414.5	2.8	1.9
Communication	554.9	2.4	1.7	447.2	2.9	2.0
Electric Power, Gas, Util.	59.0	0.28	0.2	55.1	0.36	0.25
Wholesale Trade	1083.5	4.7	3.3	869.2	5.7	3.9
Retail Trade	945.2	4.1	2.9	827.5	5.4	3.7
Finance Ins.& Real Estate	1281.1	5.5	3.9	1276.2	8.3	5.7
Education & Health	204.0	0.8	0.6	198.2	1.3	0.9
Amusement Recreation Serv.	207.1	0.9	0.65	201.5	1.3	0.9
Service to Business Mgt.	527.8	2.3	1.6	515.9	3.4	2.3
Accomodation Services	261.7	1.1	0.8	245.8	1.6	1.1
Personal & Misc.Services	84.8	0.4	0.3	78.	0.51	0.35
Transportation Margin	4843.4	20.8	14.7	-	-	-
Operating Office Lab. & Food	1139.0	4.9	3.5	1139.0	7.4	5.1
Travel Promotion Advtg.	2764.9	11.9	8.4	1974.5	12.8	8.8
Total	23281.8	100.0	70.94	7003.8	100.0	68.6
Final Demand Sector						
Consumer Expenditures						
Durables	1899.5	19.9	5.8	1899.5	27.1	8.5
Semi-Durables	921.5	9.7	2.8	921.5	13.1	4.1
Non-Durables	94.5	1.0	0.3	94.5	1.4	0.43
Services	5106.3	53.5	15.5	3331.7	47.5	14.9
Machinery Equipment						
Business	1923.5	20.2	5.9	1923.5	27.4	8.6
Government	150.4	1.6	0.46	150.4	2.1	0.67

A-2: INPUTS OF INFORMATION GOODS AND SERVICES BY SECTOR

Industry or Final Demand Sector	Information Inputs, 1974					
	Including Transportation & Storage			Excluding Transportation & Storage		
	$ million	% of intermediate or final demand	% of total demand	$ million	% of intermediate or final demand	% of total demand
Inventories	289.1	3.0	0.9	289.1	4.1	1.3
Domestic Exports	1847.8	19.4	5.6	1178.5	16.9	5.3
Re-export & Import	4650.2	-48.8	-14.2	-4464.5	-63.7	-20.0
Net government purch. of goods & services	1952.3	20.5	6.0	1679.2	23.0	7.5
Total	9535.1	100.0	29.06	7003.8	100.0	31.4
Grand Total	32816.9		100.0	22311.3		

If transportation is included the two items transportation and storage and transportation margins are added, while food and beverage and services to business fall below the criterion of 2%.

Intermediate demand accounts for just over two-thirds of information inputs. Consumer expenditures of all kinds amount to about 27%. The trade balance on information goods and services is negative - about 2.3 billion dollars in 1974, or about 15% of total demand.

3. IMPACT VIA OUTPUT MARKETS

In Table A-3 we present an analysis similar to the one shown in Table A-2, displaying information sector output according to the domestic industries in which it originates. The point of this analysis is to identify the industries of greatest direct impact resulting from changes in the level of demand for traditional information goods and services. Total output of information goods and services in 1974, excluding transportation and storage, was over 22 million current dollars. With the inclusion of the latter that amount increases to over 32 million dollars. The most prominent industries

of the information sector include, each with a share of about 19 to 20% of total information output: electrical products manufacturing (various types of transmitting, receiving and processing equipment): communication (largely telephone and telegraph services); services to business; and travel, promotion and advertising. Most other industries, with the exception of printing and publishing (11.2%) have almost insignificant shares.

If the transportation and storage industry is included, it overwhelms the other individual industries. Nearly all of its output is classified, in the commodity and services classification, also under transportation and storage. What share of this output is amenable to substitution by communication of information electronically is a subject for further investigation.

A-3: INFORMATION OUTPUTS BY INDUSTRY

Industry	Information Outputs, 1974			
	Including Transportation & Storage		Excluding Transportation & Storage	
	$ million	% of info. output	$ million	% of info. output
Forestry	4.0	0.01		
Food & Beverage Ind.	0.5	0.002	25.6	0.1
Rubber & Plastic Prod.Ind.	25.6	0.08		
Textile Industry	5.8	0.01	5.8	0.03
Wood	6.7	0.02		
Furniture & Fixtures Industry	50.8	0.02	50.8	0.2
Paper & Allied Ind.	33.4	0.1	33.4	0.15
Printing & Publishing	2497.8	7.5	2497.8	11.2
Primary Metal Ind.	18.9	0.06	15.2	0.07
Metal Fabricating Ind	77.1	0.2	77.1	0.4
Machinery Industry	296.8	0.9	296.8	1.3
Trans.Equipment Ind.	61.9	0.2	61.9	0.3
Electrical Product Industry	4255.8	13.0	4255.8	19.1
Petroleum & Coal Prod. Industry	1.0	0.003	1.0	0.004
Chemical & Chemical Prod. Industry	5.1	0.02	5.1	0.002
Miscellaneous Mfg.	548.1	1.7	548.1	2.5
Trans. & Storage	10494.6	32.0	13.2	0.06
Communication	4057.2	12.4	4057.2	18.2
Elect.Power,Gas,Util.	1.2	0.003	1.2	0.005
Wholesale Trade	33.2	0.2	33.2	0.15
Retail Trade	11.0	0.03	2.0	0.009
Finance Ins.&Real Est	16.9	0.05	16.6	0.07
Education & Health Service	387.1	1.2	387.1	1.7
Amusement Recreation Services	1102.3	3.4	1102.3	5.0
Service to Bus.Mgt.	4199.0	12.8	4199.0	18.9
Accomodation Services	0.6	0.002	0.6	0.003
Travel Promotion Advertising	4572.6	14.0	4572.6	20.5

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