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PROPOSAL TO ASSESS THE MACROECONOMIC IMPACT OF NEW INFORMATION TECHNOLOGIES

Prepared for
Department of Communications

March 2, 1981

Informetrica LIMITED • Ottawa, Canada • Effective Economic Research

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A Proposal to Assess the Macroeconomic Impact of New Information Technologies

Introduction

There is currently widespread concern among government departments, industry and labour about the future impact of new information technologies on the structure of the Canadian economy. These concerns range from fears of massive unemployment -- particularly of female workers -- to uncertainties of Canada's competitive position, or the ability to promote domestic sources of supply of these technologies. While many of the fears may be valid from a policy perspective, there is little doubt that the partial scenarios on which these concerns are based, are open to question. The debate in this area, to date, has been partial in the sense that both very limited information is available on the technologies and the analysis itself has traced through first round impacts of the technologies only.

The volume of work existing on the impact of new technologies makes it impossible to even attempt to find a representative sample of approaches. The most comprehensive survey study "The Impacts of Computer/Communications on Employment in Canada: An Overview of Current OECD Debates" says of the works surveyed, that:

> To sum up, the attempts to analyse the issue quantitatively have so far been less than satisfactory. No account is taken, for instance of the development of entirely new industries. This significant omission contributes to the leaning towards more pessimistic scenarios. ... More seriously, in all three quantitative attempts which we have reviewed, the authors

> analysed sectors or occupational groups in isolation. The intersectoral linkages were completely ignored.[1]

Other studies rely on individual case histories as the basis for analysis, but simply extrapolate experience of a single industry in isolation.[2] Many of the Canadian studies have been cited and discussed in "A Feasibility Study for Assessing the Macroeconomic Impact of New Information Technologies" (prepared by Informetrica Limited for the Department of Communications, March 1980).

The diagram on the following page illustrates the impact of new technologies on the economy. Any technology can be defined to fit into this framework. Note that, to date, most analysis has been restricted to what is described as "Phase One" -- a partial equilibrium analysis of the impacts. The diagram also highlights potential policy "hooks", or areas of concern to policy makers. An incomplete list of the better-known policy concerns is:

(1) Timing of implementation of new technology;

(2) Imports of new technology or creation of a new supply industry;

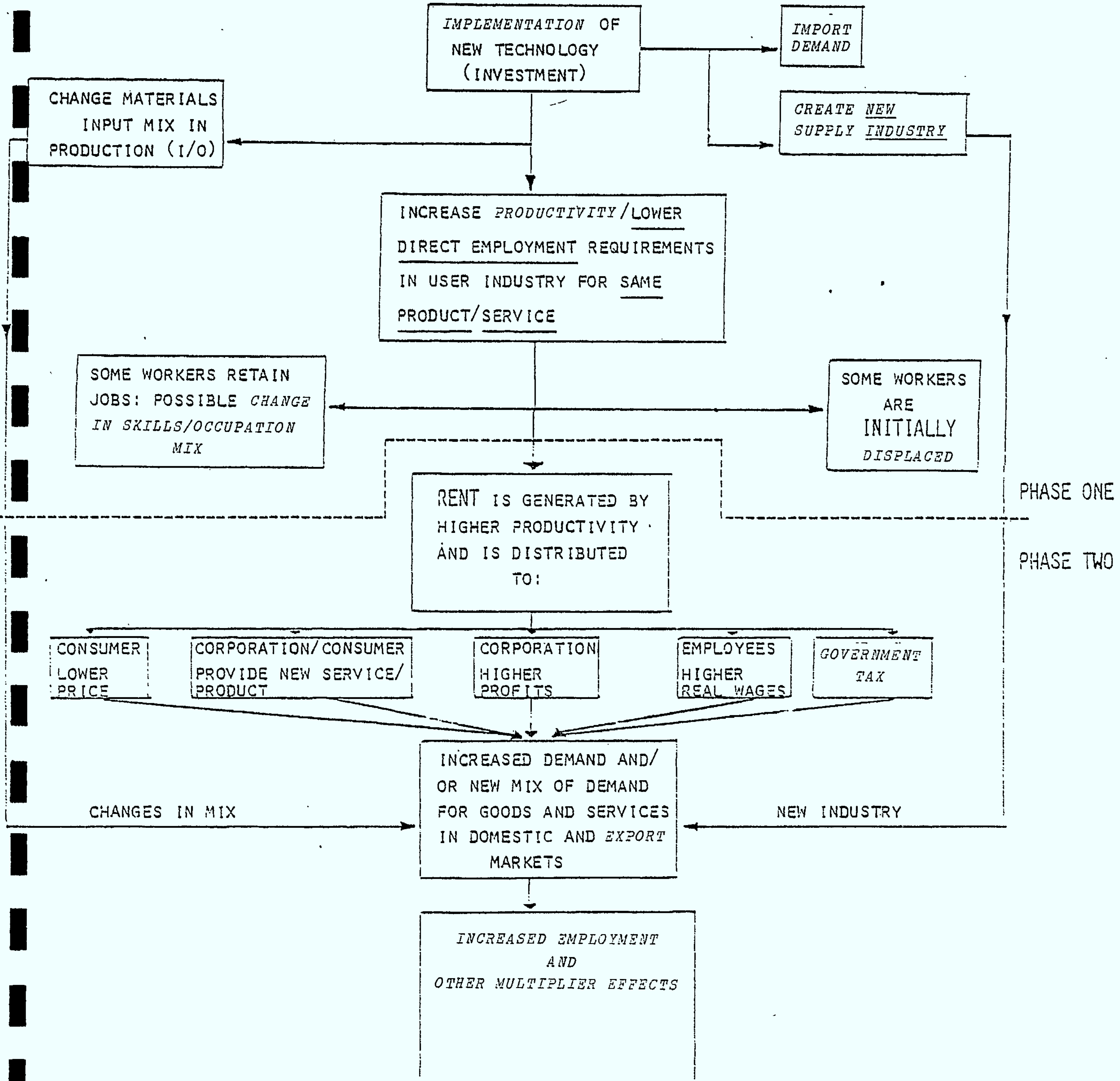
(3) Impact of the technology on productivity and direct employment in the user industry;

(4) Displacement of workers;

(5) Future occupation/skill requirements;

(6) Impact on government revenues;

THE IMPACT OF 'NEW TECHNOLOGIES'



NOTE: Policy hooks are shown in italics.

(7) Potential growth of export markets for new and existing products;

(8) Indirect (multiplier) impacts, particularly on overall employment and unemployment.

That there is concern about the issues is not at question, but the current understanding of new technologies and of their impacts does leave open to question the ability of the many 'actors' to react to, or influence, the impacts. How does the current wave of technological advances differ from others in this century? And has the economy's ability to adapt to, and absorb such changes altered over the past eighty years?

Much of the gloom expressed on the potential employment impacts of new technologies is derived from faulty partial analysis. In particular, such studies often ignore the rationale of the firm in deciding to adopt a new technology. As the diagram illustrates, the new technology provides benefits to the firm, through increased profits or a higher rate of return than its other options. This "rent", as it is labelled in the diagram is ultimately distributed through the economy.

In the report, "A Feasibility Study for Assessing the Macroeconomic Impact of New Information Technologies", the role of macroeconomic analysis and the requirements for a macroeconomic impact study were assessed. One of the objectives of the report was to determine whether sufficient information was in fact available to undertake a macro analysis. A prerequisite to a good macro analysis is a solid micro base. As one task of the feasibility study, experts in several technologies were asked to respond to a series of questions. It was hoped that the responses would provide a basis for the input to the macro study. The list of questions is shown on the following page, and the answers should fill in at least the boxes in Phase One of the diagram. This was regarded as the minimum set of information required by the firm (industry) to reach the capital budgeting decision.

The results of these interviews, in short, were that no one could shed light on the answers to the questions, and although several experts "sensed" that the information " should be" available, none was found. Perhaps, as was suggested by one or two experts, the private decision to invest in or to adopt a new technology is not based on a formal analysis, but rather on an intuition that the technology will succeed and will improve profits. But we feel that even if no formal analysis is undertaken, "intuition" in this case is the result of a combination of "pieces" of information similar to the Phase One boxes, and a sense of the minimum impact required for the technology to succeed in the industry.

Given these results of the feasibility study, a large effort of the macroeconomic impact assessment must necessarily be devoted to front-end micro analysis. The Phase One boxes, and some in Phase Two, must be full before a macroeconomic impact study is possible.

There is a continual discussion preceding studies of new technologies as to whether the focus of the study should be

QUESTIONS FOR THE TECHNOLOGY EXPERTS

1. MATCH (YOUR) TECHNOLOGY WITH RELEVANT USER/SUPPLIER INDUSTRIES.

2. WHEN (IN HOW MANY YEARS) WILL IMPLEMENTATION OF TECHNOLOGY OCCUR?
   -- INTRODUCTION?
   -- DIFFUSION?

3. WHAT WILL BE THE MAGNITUDE OF INVESTMENT REQUIRED BY AN INDUSTRY TO ACQUIRE THE TECHNOLOGY?

4. WHAT MAJOR CHANGES WILL OCCUR IN THE MATERIALS INPUT MIX?

5. WHAT WILL BE THE IMPACT ON EMPLOYMENT?

6. WHAT ARE THE <u>INCENTIVES</u> TO INDUSTRY TO ADOPT THE NEW TECHNOLOGY?
   WHAT COULD CAUSE THEM TO POSTPONE INVESTING?

7. WHAT ARE THE SUPPLYING INDUSTRIES?
   WHERE ARE THEY LOCATED?

8. WHAT INCENTIVES/DISINCENTIVES WOULD CAUSE SUPPLY INDUSTRIES TO LOCATE IN CANADA/ABROAD?

9. WHERE ARE OTHER COUNTRIES IN TERMS OF ADOPTING NEW TECHNOLOGIES IN INDUSTRIES WHICH ARE IMPORTANT IN CANADA?

10. WHERE WOULD CANADA HAVE A COMPARATIVE ADVANTAGE/ DISADVANTAGE IN ESTABLISHING A <u>DOMESTIC</u> SUPPLYING INDUSTRY?

on a particular technology or on user industries. To date, studies which have taken the former approach[3] -- focussing on a technology such as "the chip" -- have not led to any conclusions which are useful to a policy-maker, or which could be substantiated through time. The major difficulty with this approach is that efforts are diffused across a wide range of issues and applications of the technology, and no rigorous analysis is possible. This does not negate the importance of the supplying industry, or its size or location, but means that for purposes of a macroeconomic impact study the focus at the micro level will be on the user industries.

The focus on user industries will make the <u>selection</u> of industries for individual case studies a critical part of the project. It will be important that the choice of industries include a wide range of technologies, so that the focus is not restricted -- for example -- to the use of robotics or CAD-CAM applications, but also include technologies adopted by service industries. Technological change is a continuous process and any attempt to identify the impact of a technology at a discrete point in time will necessarily be incorrect. However, by focussing on the <u>user</u> industry as opposed to individual technologies, it is possible to trace the joint impacts of several technologies through time, and thereby get around some of the difficulties of a "technology" focus.

A major concern of the macroeconomic impact study will be the role of alternative government policies in influencing the impact of new technologies. Within the context of each industry study (see the "Task" outline below), the major relevant policy issues will be identified and the appropriate government policy instruments will be altered, to determine government's ability to direct certain impacts of the technologies. Referring back to the diagram on Page 3, the policy "hooks" are identified and can be easily translated into variables or assumptions in TIM (The Informetrica Model), the macroeconomic model to be used for the impact studies. Not all policy hooks will be relevant in all cases, and the study will be concerned with identifying relevant government policy measures, and examining the effect of changes in these particular policies on the industry, and on the macro-environment.

Statement of the Problem

The Department of Communications (and other Federal government departments) have expressed concern over the potential and suggested impacts of new information technologies. For government to be effective in implementing policy, it should ideally be well aware of its policy options and their potential impacts. Rigorous economic analysis of policy alternatives at both micro and macro levels is a recognized and widely accepted method of assessing policy options. However, in the area of new information technologies, or "computer/communications", such analysis has not been possible, to date. The current inability of government to carry out a rigorous review (and development) of policies in this area, is due to a lack of structure in the information available and the absence of a clear definition of both the "sector" under consideration, and the issues of concern.

The general issues were set out in the Introduction above, and it is clear that the policy question is interdepartmental in nature -- the range of issues is such to include most departments to a greater or lesser extent.

The feasibility study prepared by Informetrica Limited in March 1980 was the first stage in an effort to integrate information from many sources into a rigorous framework for analysis -- namely a macroeconomic model that includes a detailed description of industrial structure. However, the absence of any microeconomic work on new information technologies made detailed macro analysis impossible, and the major recommendation of the feasibility study was for extensive micro research to provide the basis for macro analysis.

The government's major concern for the medium term at least, would appear to be directed more towards the impact of information technologies on Canadian industry than on the consumer directly. In terms of the specific research strategy adopted to address this question, and with the requirements of the macroeconomic impact in mind, it is recognized that there is no single correct approach to the structure of the micro level analysis. Several options are open to the researcher in meeting the micro or industry level requirements of the macroeconomic analysis.

This proposal puts forward one approach to the micro analysis, which is considered most appropriate to this particular study. Briefly, the analysis is based on extensive interviews with industry officials, to develop case studies of industry experience with new technologies. The case study information would be used as an input to the macroeconomic impact. The details to this proposed approach are set out in the subsequent sections. Two alternatives to the industry case study are (a) the development of "chain" models, and (b) the development of a product/service oriented description of the computer/communications sector, identifying key economic linkages between products/services within the sector. Either of these alternatives would provide useful inputs to the macroeconomic impact study, and each is described briefly here.

The "chain" model (a formal econometric model) is similar to an industry model in that it links demand, supply and price aspects of an industry. But it is broader than an industry model to the extent that it includes models of supplying and user industries, in addition to the central industry in question. This model is not restricted to SIC lines, as supplying and user industries (of a technology or product embodying the new technology) are typically not part of the same SIC as the central industry. The model would also directly address the issue of foreign and domestic supply and sales, as trade flows and trade considerations are explicitly included in the model. This, however, is an extensive formal modelling exercise which would include a comprehensive framework for data collection and analysis, prior to the model estimation. It represents a more major micro level effort than allowed for by this proposal, but one which would also be more comprehensive in nature.

Development of a product/service oriented description of the computer/communications or new information technology sector would again provide an extensive framework against which micro issues could be analysed. The sector would be identified in terms of marketable products/services and in terms of the key characteristics affecting the demand and supply of each. This would include a detailed tableau of the sector's products/services at end use and the interrelationships of these and intermediate requirements. To identify the number of uses of the products, the key factors influencing their mutual substitutability or substitutability with other factors would be identified. At this point traditional economics would be used as the analytical point of departure to organize questons related to product pricing and demand, and to identify key policy areas.

These two approaches would both provide the information for the "boxes" in the diagram on page 3, but are of themselves extensive research projects, beyond the scope of this project. It is important to note that other research techniques, used to analyse this sector and its impacts, can provide inputs to the macroeconomic impact.

For this particular project a more direct approach will be adopted, with a particular focus on industry "case studies", or where possible, gleaning information from existing micro-industry models. The "case studies" would be a less formal approach to industry modelling, to the extent that interviews would provide the information base, as opposed to rigorous econometric estimation techniques. The approach would be well documented, so that subsequent studies could be based on the same methodology. It is important to recognize that the information obtained would be input to a dynamic model, and therefore there would be no danger of extrapolation of information in isolation -- the major criticism of most analyses based on case studies.

But because case studies are used (in a holistic framework of analysis), a sufficient analytical basis for policy review and recommendations will follow at the conclusion of each such study. Accordingly, inputs to policy would not have to be delayed until some generalized review was completed. We would, for example, expect that the first policy implications would be forthcoming six to seven months after the start-up of our project.

Tasks

This project may be viewed as a series of tasks, with benchmarks and meetings with the officials or Scientific Authority for the project at the appropriate stages. Each task is described in detail below, including an explanation of any timing considerations in terms of its sequence in the project. In particular the selection and sequence of industry case studies is one aspect of the project which is not likely to be finalized until the work has been underway for approximately two months.

1. Modification of the Input/Output Submodel in TIM (The Informetrica Model);

2. Selection of Candidate Industries for Case Studies;
Development of Case Study Methodology;
Benchmark Meeting with Scientific Authority to Review Progress to Date and Select Industries;

3. Industry Case Study I;

4. Industry Case Study II, ...;

5. Final Report and Presentation.

1. <u>Modification of the Input/Output Submodel in TIM</u>

The Input/Output submodel is at the "centre" of TIM, the macroeconomic model to be used for this project. It currently reflects 1971 technology and industries. In order to take account of new industries, and of very marked changes in material and labour input requirements of industries adopting new technologies, the Input/Output submodel must be modified. The proposed implementation would allow exogenous changes in the Input/Output portion of TIM, such as shifts over time in either the technology associated with the output of one or more industries or the output requirements associated with all or a portion of specific final demand commodities. The proposed implementation would permit:

(i) the modification of row coefficients (in either I/O matrix) subject to column or sub-column constraints;

(ii) allocation of a portion of an existing final demand category to an alternate specific recipe (e.g. shift of a portion of an industry to a new production technology);

(iii) definition of a new industry within the I/O system.

A technical appendix in "A Feasibility Study for Assessing the Macroeconomic Impact of New Information

Technologies" outlined many of the considerations in making such adjustments to the Input/Output model. This is included as Appendix C of this proposal.

2. <u>Selection of Candidate Industries for Case Studies; Development of Case Study Methodology; Benchmark Meeting with Scientific Authority to Review Progress to Date and Select Industries.</u>

As it is clearly not possible or feasible to attempt to cover all new information technologies and their impacts in one pass, a case study approach has been proposed. The case studies could include a "consumer" component as well as industry, but since the government's current concern for the short to medium term is with impacts in industry, the consumer aspects are not dealt with specifically in this proposal. The selection of candidate industries for case studies is a crucial part of this project. Applications of new technologies may be categorized as (i) product innovation; (ii) process innovation; and (iii) new business services. Since an industry approach is recommended over a technology approach, the selection of industries must be done so as to include major aspects of those three applications. It is proposed that consultation with government and industry officials be an integral part of this task, so that the selection reflects existing government and industry concerns. The initial list of candidate industries would include those where the <u>initial</u> impact is likely to be significant in terms of employment, or change in production process or material inputs. It would also be necessary to identify for each industry the nature of the technology(ies) involved along with the rationale for its selection.

A second phase of this task would be the development of a general methodology for the case studies. This would include detailing the specific information requirements; the method used to sample -- for interviewing -- from firms within the industry; the time frame for the focus of the study (e.g. within the past five years, and the next five/ten years).

The third phase would be a presentation of work to date to the Scientific Authority, and subsequent discussion with the Department of the industries selected for the initial list. At this stage it is anticipated that selection of industries would be made, for subsequent case studies. This procedure would allow the sequencing of case studies to reflect government concerns at the time, as there will be no required ordering of industries for the macroeconomic impact assessments.

With no diminution in the concern and work by governments of other major industrialized countries in this area, the discussion and report of the first two phases of this task would reflect any significant industry studies which could provide direction or input to the subsequent case studies. This may be particularly relevant for those industries which in Canada demonstrate a lag in the adoption of new technologies relative to her trading partners.

3. Industry Case Study I

This would be the initial industry case study carried out for this project, regardless of the particular industry selected. The case study and the macroeconomic assessment of the impact of new technologies would be presented in a self-contained report. However, as this would be the first such study, substantial documentation of the procedure is required, to allow for economy in subsequent studies.

The individual tasks may be described as:

(i) interviews to collect required information;

(ii) document methodology;

(iii) macroeconomic simulation;

(iv) review simulation and assess results from a policy perspective;

(v) second macroeconomic simulation to test sensitivity to alternative policy stances;

(vi) prepare report of industry study.

The procedure used to collect information would not be bound to a formal survey of the industry, particularly given the financial and time constraints. The specific approach would be presented in task 2 (above) and agreed on, or altered to meet criticisms, after the meeting with the Scientific Authority, at the end of task 2. It is anticipated that the actual techniques and approaches to the questions will vary somewhat from the specific procedure agreed to. For this reason, and in order to facilitate subsequent case studies, the specific "methodology" for this initial study will be documented in detail. In particular significant involvement of senior professionals in the first study may be reduced to a supervisory role, with a significant reduction in cost for subsequent studies (see below).

The first macroeconomic simulation will incorporate information on the industry, in terms of experience with new technologies, in an impact simulation. The reference view of the economy would be the most recent National Forecast Service reference view, and the impact would assume adoption of new technologies by the industry as indicated from the interviews.

Policy options and impacts are a critical focus of this study, and as shown in the Introduction, the model allows for specific "policy hooks". The results of the first simulation will be assessed with a view to policy reaction to the resulting configuration of the economy. A second simulation will incorporate some relevant changes in policy, and again the results will be assessed in detail.

The final product of this task would be a detailed report of the industry case study. The contents of the report would likely closely resemble the following:

Industry Case Study: Macroeconomic Impact
of New Information Technologies in the XXX Industry

I. Introduction

II. Rationale for Selection of the Industry

III. Results of Interviews

IV. Configuration of the Industry in the Impact Simulation (modifications in the Input/Output system)

V. Simulation Results and Assessment of Policy Implications

a. Reference View
b. Impact: Neutral Policy
c. Policy Options
d. Impact: Policy Reaction

VI. Conclusions

Appendix: Documentation of Methodology

4. Industry Case Study II, ...

Subsequent studies would follow the same format as the first, but benefiting from existing methodology, as documented in the first study.

5. Final Report

As each industry case study would be a self-contained document, this report would pull together the results of the individual case studies, to derive any general conclusions from the work to date. This would be a summary document, and would include the report of task 2.

Costs and Timing

Task 1, the modification of the Input/Output Submodel, must be completed prior to any industry case studies, but may be undertaken simultaneously with Task 2.

Task 1 could be completed in two months from the start-up date for the project, for a fixed price of $20,000 including computer expenses. The senior professionals for this task would be Mr. Paul Jacobson and Mr. Keith May (see Project Team).

Task 2, including the discussion with the Scientific Authority, would require two months from the beginning of work on this task, and would be completed for a firm price of $18,000. Ms. Elizabeth Ruddick, project leader, would be the principal professional for this task.

Task 3 would require five months calendar time to complete. Including computer and travel expenses this initial industry case study would be undertaken for a fixed price of $60,000. Ms. Elizabeth Ruddick, project leader, would be the senior professional resource and would receive support of other professionals on staff.

Task 4, subsequent industry case studies would also require five months calendar time, but at a firm price of $40,000 each. Ms. Elizabeth Ruddick would be the senior professional, but an increased share of the tasks would be carried out by economists on staff, relative to Task 3.

Task 5, the final report, would be completed over a period of one month, at a firm price of $5,000.

To provide an estimate of costs including several case studies, as an example, four industry case studies including a final report, and the initial preparatory tasks (1 and 2), would total $223,000. Once Tasks 1 and 2 were completed, however, the selection, timing and number of individual case studies would be the Department's decision.

Project Team

The nature of the tasks set out above is such that several may be carried out independently of the others -- for example, the Input/Output modifications (Task 1) at the beginning or industry case studies following Task 3. However, since all the tasks are required for a successful project, Ms. Elizabeth Ruddick will act as project leader for the entire project as well as heading up the research teams for specific tasks. Ms. Ruddick's experience, as the author and principal researcher of "A Feasibility Study for Assessing the Macroeconomic Impact of New Information Technologies", places her in a unique position to lead this project. She is familiar both with the technique of macroeconomic impact statements and with the current state of information on new technologies. Her previous experience with macroeconomic impact statements, and earlier work for the Department of Communications provide a strong base for this project. Ms. Ruddick will also be the project leader for the individual Tasks 2, 3, 4 and 5.

Mr. Paul Jacobson (Chief, Quantitative Applications) will be the project leader for Task 1. Mr. Jacobson has been extensively involved in the estimation and construction of TIM, including applications of and revisions to the Input/Output sub-model. His experience in the communications/information technology area extends to estimating a simulation model of a cable TV firm and the CATV industry, providing him with an awareness of the data difficulties in that sector.

Mr. Jacobson will be assisted in this task by other members of his staff, and by Mr. Keith May (Chief, Software and Computer Systems). Mr. May will assist in making modifications to SIMSYS, Informetrica Limited's proprietarial software, in which TIM is implemented, in order to allow for the proposed changes to the Input/Ouput system.

To carry out the impact simulations (with and without compensatory policy responses), we are likely to draw on the services of staff who maintain our National Forecast Service model. This group maintains (on a current basis) a fully-updated set of forecasts that can be used either as the Base Case (for an impact study) or as a starting point for the development of such a Case. Projections to the year 2000 are available. Further, this group is principally responsible for using the model to undertake impact studies and has undertaken as many as twenty-five in the last year through both National Forecast Service and Contract Service venues. Several staff are available and capable of providing such simulations; their work will be reviewed for quality by the Chief of Macroeconomic Services, Mr. William Jarvis (vitae attached).

The project will receive the critical review of Mr. M.C. McCracken (President) and Mr. Carl Sonnen (Vice President) at key points within each of the tasks (1-5). Both Mr. McCracken and Mr. Sonnen are familiar with all aspects of this project. Vitae of the senior members of the project team are attached in Appendix A.

In summary then, the team will be composed of several specialist groups: experts in the software that implements the national model and in the input-output framework that is contained in the model (Mr. Jacobson); experts in the use of the national model to simulate production and demand impacts on the economy (Mr. Jarvis); and experts in high-technology impact issues and analytical approaches (Ms. Ruddick). Since all of these team members are drawn from within the firm and are experienced, full-time employees, we do not anticipate any of the control or communications difficulties that frequently beset inter-disciplinary teams who are drawn from several firms.

Footnotes

[1]"The Impacts of Computer/Communications on Employment in Canada" by Zavis Zeman (project leader), Institute for Research on Public Policy, Montreal 1979, p. 38.

[2]Barron, Iann and Roy Curnow. "The Future with Microelectronics", Nichols Publishing Company, New York 1979.

[3]e.g. "Chips in the 1980s", The Economist Intelligence Unit Ltd., 1979.

CURRICULUM VITAE

M. Elizabeth Ruddick

Education: B. Comm. (Economics Major) McGill University (1971)

M.A. Economics, University of British Columbia (1972)

Post Graduate Study, London School of Economics, 1975-76. Research Area: Industrial Pricing in International Trade Under Fixed and Flexible Exchange Regimes.

Experience:

Informetrica Limited (1976-) - Advisor

- Assessment of the impact of new "information technologies on the economy: feasibility of a macroeconomic impact study of new information technologies
- Consumer demand for entertainment services
- Impact studies of energy policy, energy investments, transfer programs
- Macroeconomic dimensions of energy investment
- Use of leading indicators and Bayesian analysis to forecast major turning points in international and domestic industry shipments
- Evaluability assessment of federal government immigration programs
- Use of relative prices and inflation in capital budgeting
- Price escalation methodology
- Energy demand modelling
- Long-term forecasts with the CANDIDE model
- Spatial cost of living indexes

Department of Regional Economic Expansion - Economist - Responsible for complete documentation of CANDIDE-R econometric model, and analysis of its use in simulating regional and national impact of large scale autonomous investments (1975).

Economic Council of Canada - Economist - Primary responsibility for Chapter 5 "Energy Developments in the 1970s and Early 1980s" in Eleventh Annual Review. Economic Targets and Social Indicators (Information Canada: Ottawa 1974). Responsible for research on foreign impacts on Canadian prices under fixed and flexible exchange rates (1973-1975).

Languages:

English and French - fluent.

Paul M. Jacobson

Education: M.A. Economics, Queen's University (1973)

B.A. Economics, McMaster University (1971)

Experience:

Informetrica Limited (1973 -) - Chief, Infrastructure Group, National Forecast Service

- Responsible for model and database development as well as other aspects of the research capital of the firm. Requires detailed knowledge of following branches of economics: consumption, investment, foreign trade, labour supply and demand, fiscal and monetary theory.
- Responsible for product development and management of Evergreen Data Services.
- Teaching at Professional Development Seminar level: Introduction to MASSAGER/DATABANK, Introduction to Quantitative Methods.

Consulting Projects:

A simulation model of a cable TV firm and the CATV industry utilizing cross-sectional and time-series data

Development of a technique for sub-provincial forecasts consistent with CANDIDE forecasts to provide inputs to pollution control requirements in Southern Ontario.

Management of a project to classify, load and retrieve CANSIM data for a wide variety of user-specific research queries

Development of software to provide company and industry financial reports for a government agency

Preparation of operational plans and budgets for a large-scale, energy-related government survey

Development of major extensions to Informetrica Limited proprietary software products such as Mosaic, Databank and Massager

Keith May

Education: M.Math, University of Waterloo (1973)

B.Sc (Honour) University of Ottawa (1971)

Experience:

Informetrica Limited (1973-) - Chief, Software Services; Advisor

- Responsibility for software R&D, maintenance of and administration for proprietary software, client support
- Software development: econometric model simulation systems (batch and interactive); statistical applications software; large scale system for aggregation and database maintenance of Industrial Selling Prices; interactive leading indicator forecasting and graphics system
- Development of econometric models for cable television systems, electrical energy demand, and emigration
- Application of Input/Output matrix techniques in economic modelling, energy models and immigration flows.
- Technical advisor and database manager for large scale econometric model development project
- Conducts training seminars in quantitative forecasting techniques, seasonal adjustment and firm's proprietary software systems

University of Waterloo (1972-1973) - Teaching Assistant

Economic Council of Canada (1971-1972) - Economist

- Development of computer software for CANDIDE model 1.0 input/output system
- Research in determination of recursiveness of systems of equations
- Program development for SIMSYS simulation system

National Energy Board, Operations Research Branch (Summers 1969 and 1970) Programmer/Analyst

- Program development for short term economic forecasting
- Institution of NEB program library

- Implementation of packages for statistical analysis and mixed integer applications programming

Consulting Activities (1970-72)

- Federation of Mayors and Municipalities - Computer implementation of a sewage costing model

- Carleton University - programming for Monte Carlo simulation package

- National Energy Board - design and implementation of simulation program for small energy demand model

Computer Languages/Systems

- FORTRAN,APL on IBM and UNIVAC hardware

Selected Publications:

- Course Material - Introduction to Seasonal Adjustment,
  Introduction to Econometric Techniques

- Simulation System for Econometric models (User's Manual) 1973 (with M.C. McCracken, C.A. Sonnen, R.J. Dawson)

William D. Jarvis

Education: B.A. (Honours) Economics, Queens University (1970)

M.A. Economics, University of Western Ontario (1976)

Experience:

Informetrica Limited (1972-) - Chief, National Forecast Service

- Development and analysis of medium term economic forecasts using The Informetrica Model (TIM)
- Analysis of short run trends in financial market and monetary policy
- Macroeconomic impact studies on the effects of higher oil prices, wage and price controls, and higher immigration levels
- Production and analysis of various simulations with TIM

Bureau of Census and Statistics
Government of Australia (1971-1972)

- Development of a new methodology to compute depreciation for national income and expenditure accounts

Selected Publications

- (With M.C. McCracken) The Effects of an Additional Increase of 10% in the World Price of Oil, Informetrica Limited, 1976
- (With M.C. McCracken and C.A. Samur) Analysis of the Recent Behavior of the Personal Savings Rate, Informetrica Limited, 1979
- (With M.C. McCracken) Oil Self-sufficiency for Canada: The Easy Way, Gordon Securities, 1979
- (With Paul Malles) Composition of Labour Compensation in Canada and Other Countries, Informetria Limited, 1979

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Michael C. McCracken

Education: B.A. Economics, Rice University (1961)

M.A. Economics, Southern Methodist University (1964)

All requirements except dissertation for Ph.D., Southern Methodist University (1965)

Experience:

Informetrica Limited (1972-) - President, Senior Advisor

- Development of a large econometric model of Canada and its application to forecasting and policy simulation
- Application of quantitative techniques for corporate planning
- Examination of policy options for federal and provincial governments in fields of macroeconomics and energy
- Consulting studies for governments and businesses

Economic Council of Canada (1970-72) - CANDIDE Project Manager; (1965-67) - Econometrician

Office of Economic Research, United States Government (1969-70) - Development of quantitative techniques for economic research - Model-building for various countries

U.S. Army, Captain, Military Intelligence (1967-69) Research on U.S.S.R. and other economies

Teaching - Principles of Economics, International Trade, Mathematics for Economists, Quantitative Methods for Economic Research

Selected Publications

- "A Computer System for Econometric Research", Social Science Information, Vol. VI, No.5, October, 1967, pp. 151-158
- "Data Administration in an Information System" Conference on Government Information Systems (Economic Council of Canada, Ottawa, 1968)
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Selected Publications

- (With M.C. McCracken) "A System for Large Econometric Models: Management, Estimation and Simulation", Proceedings of the ACM Annual Conference, August 1972, Boston (New York: Association for Computing Machinery, 1972), pp. 964-73)
- "Canadian Unity and Some Elements of Long-Term Economic Prospects",

FEE SCHEDULE

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An Implementation of Exogenous Changes in an Input/Output Submodel

An Implementation of Exogenous Changes in an Input/Output Submodel

Within the structure of most large disaggregated macroeconomic models (such as TIM, CANDIDE), a major component is a set of structural equations developed from the input/output model of transactions in the economy. Typically, this input/output submodel serves two key functions. First, it converts real expenditure (i.e. denominated in constant dollars) of final goods and services (i.e. C+I+G+X-M) into requirements for real output (also constant dollars). Secondly, estimates of final demand prices, consistent with the value of that real output, are derived.

Generally, because of lack of detailed, continuous time series information, the structure of input/output relationships is assumed to be constant over time. However, it is possible to define a set of feasible changes to those relationships (i.e. postulate a change in the input/output structure) and using the power of a large model, analyze the resulting macroeconomic and sectoral impacts. The purpose of this Appendix is to outline a method for such analysis. Section A provides an outline of the implementation of the input/output system in TIM. Section B looks at the types of changes in the input/output relationships that might be considered, and Section C outlines the intended implementation of these changes.

A. The Input/Ouput Model in TIM

To define the implementation of the input/output (I/O) submodel in TIM, a definition of the components, in matrix terms, is required. This portion of the section is based on Waslander (1975).[1/] In the basic I/O system, the following matrices are defined:

y = vector of domestic net output by industry

g = vector of domestic gross output by industry

q = vector of domestic gross output by commodity

f = vector of final demand by category

i = vector of intermediate commodity requirements

e = vector of final demand commodity requirements

B = input (use) matrix - commodity by industry (input requirements for a unit of output)

E = conversion matrix - commodity composition of f

D = output (make) matrix - market share matrix - proportion of commodity output produced by each industry.

Both B and E are partitionable into three submatrices each: an intermediate portion (B_i,E_i); a primary non-value added (chiefly taxes and subsidies) portion (B**,E**); and a value-added (i.e. factor-incomes) portion (B*,E*).

1/ CANDIDE Project Paper No. 18; CANDIDE Model 1.1, Volume I edited by Ronald G. Bodkin and Stephen M. Tanny, Economic Council of Canada, 1975. Chapter 10 "Sectors J and R: The Input/Output Submodels" by H. E. L. Waslander with A. Syed.

The derivation of the I/O structural identities can be viewed as beginning with the simple equivalence of the supply and disposition of commodities in the domestic economy. Using the notation above, this can be expressed as

$$(1)\quad q = i + e$$

However, B_i and E_i have been defined such that:

$$(2)\quad e = E_i f$$

$$(3)\quad i = B_i g$$

$$(4)\quad g = Dq$$

For the year of definiton (1971 for TIM), equations (2) through (4) are identities. Because the ultimate goal of the I/O system is the translation of final demand (f) into industry output (g), it is possible to combine the four equations to obtain

$$(5)\quad g = DB_i g + DE_i f$$

This gives a set of simultaneous equations, one for each industrial sector (78 in TIM). Thus, output requirements for a given industry are simply the sum of: output required to satisfy final demand and output required to meet the input requirements of all other sectors. Within TIM, this set of structural simultaneous equations is solved in the same manner as (and along with) any other equation in the model. However, in TIM, the measure of industry output used is Real Domestic Product (RDP, i.e. real value-added) by industry. The measures are defined statistically as the difference between the value of gross output for an industry (at constant prices) and the value of all intermediate inputs (also at constant prices).

In the base year (1971) RDP or net industry output is defined by the identity:

$$(6)\quad y = B^*g \qquad (B^* \text{ is a diagonal matrix})$$

Because of statistical and structural differences over time, y (net industry output) is only an estimate of RDP. Therefore, within TIM as in all other similar models, a set of stochastic equations is used to adjust the values of y, obtained within the I/O system, to equal the RDP values required in the rest of the model.

To develop an equivalent model for prices, the following row vectors of prices must be defined:

P_y = domestic value-added price
P_g = prices of gross industry outputs (i.e. ISPIs)
P_m = price of imports (by category)
P_f = price of final demand (by category)

To simplify the development, the role of indirect taxes and subsidies (non-valued primary inputs) will be ignored for now. First, it should be remembered that industry gross output is defined as:

$$(7)\quad g = qB_i + y$$

That is, industry output is the sum of intermediate and value-added output. By analogy, it is possible to define a similar equation for industry prices as:

$$(8)\quad P_g = P_q B_i + P_y B^*$$

This equation defines the industry gross output price (analogous to industry selling price indexes or ISPI's) as a weighted average of intermediate and value-added prices, where the weights are defined by the I/O structure. By analogy to equation (4), it is possible to define an equation for the price of domestically-produced commodities.

$$(9)\ P_{qd} = P_g D$$

However, in an open economy such as Canada's, imports are an important substitute for domestic production. Therefore, if we define M as the portion of supply for domestic consumption provided by imports, we arrive at a definition for the average commodity price in the domestic market as

$$(10)\ P_q = P_m M + P_{qd}(I-M)$$

As above, we are left using equations (8), (9) and (10) with a simultaneous system from which it is possible to eliminate the commodity dimension, by solving for P_q and by defining an industry equivalent of P_m as P_m^*.

Thus we arrive at

$$(11)\ P_g = P_y B^* + DB(MP_m^* + (I-M)P_g)$$

Finally, estimates of final demand prices at the <u>category</u> level can be defined as

$$(12)\ P_f = (MP_m^* + (I-M)P_g)DE^D$$

where E^D = domestic final demand converter submatrix.

Within TIM, indirect taxes (paid by industries) and subsidies are introduced by adjusting P_y in equation (11) and by "adding on" final demand indirect taxes in the definition of P_f in equation (12).

Thus within the TIM implementaton of the I/O system, the structure is defined by the simultaneous system of equations to derive gross output (g, eq. 5) and its price (P_g, eq. 11), and some additional identities to derive estimates of net industry output (i.e. RDP, y, eq. 6) and final demand prices (P_f, eq. 12).

From these equations it can be seen that two key I/O matrices are involved. These are:

i) DB - industry-by-industry technology matrix (82 x 82 - intermediate portion)

ii) DE - industry by final demand category - converter matrix (82 x 216)

The dimensions of these matrices in the current TIM implementation are shown in brackets. The matrices are treated in this fashion because the components (D,B,E) were not available separately due to confidentiality restrictions by Statistics Canada. The remaining sections of the Appendix will focus on the implications of changing these matrices.

B. Changing I/O Relationships

As outlined above, the key structural relationships in the I/O system involve two matrices, DB and DE. This section will consider the implications of change in either or both of these matrices

To produce a unit of output, firms within a given industry must supply capital and labour inputs (value-added) and must utilize inputs from other industries (intermediate requirements). The proportion of each of these inputs used to produce a single unit of output is defined by the DB matrix (in coefficient form). The intermediate portion of this matrix is square with respect to industries. A column in the DB matrix represents the recipe for producing the output of a given industry.

<u>Changing the materials input mix</u>

The economic implications of changes to DB must be discussed logically in terms of its two component commodity-by-industry matrices, D (make) and B (use). A logical change to D is required if the nature of joint production at the industry level changes. For example in 1971, 30.7% of the output of the rubber and plastics industry was tires and tubes and 8.1% was motor vehicle parts (presumably plastic). This output of parts represented only 5.1% of total parts output in the Canadian economy, and 3.3% of parts usage. In some future year, if relatively more auto parts are made out of plastic, this would imply a change in the market share matrix D. If the proportion of parts in the total value of the car remained unchanged, no change would be required to B. Within DB, such a change would be reflected by a proportional increase in the purchases from the plastics industry and a proportional decrease in the purchases from the parts industry.

However, such a scenario also implies a change in DE if some portion of these new plastic parts are going to be imported as automotive parts. Thus, in introducing technological change, it is necessary to identify which of TIM's industries <u>makes</u> the product in question.

An alternative scenario of change in the I/O structure is that the recipe for auto parts manufacture is altered. In 1971, for every $100 of output, the parts industry purchased $16.26 from the iron and steel industry, but only $0.04 from the chemical industry. If the parts recipe changes, and manufacture within the parts industry moves towards more plastic parts, there will be a proportionate change in those shares to reflect more usage of resins and less steel. This is equivalent to changing B. However, instead of changing the recipe for making autos, now only the recipe for making parts is changed.

In order to implement such technological changes, new investment might also be required. In 1971, out of every $100 investment in machinery and equipment in the automotive industry, only $6.87 was spent on electrical products, but $18.96 was spent on railway rolling stock. Obviously, at least for the time period required to implement a technological change, the recipe for machinery and equipment investment by the transportation equipment sector might be different. This implies at least a transitory change in E and hence in DE.

Introducing a new industry

An alternate change in the I/O structure is to introduce a new commodity (product or service). As an example, consider the introduction of a new business service such as (partial) electronic funds transfer at the retail level. Such a service might be part of the package of services offered by the business services sector. However, it would be used by only some of the normal customers of that industry. Also, it would have a substantially different production recipe of input requirements as compared to other types of business services. Average adjustments to the D and B matrices are clearly possible. However, such an implementation approach would result in a number of anomalies. For example, the construction of $100 of dams results in a requirement for $8.03 of business service output. However, none of this requirement would be likely to include the EFTS component and its production requirements. Yet, average changes to DB would result in such spurious results.

When such highly specific technologies are postulated, a more appropriate approach is to create a new industry which supplies this product, EFTS. This is analogous to adding a new row in DB and DE and a new column in DB. For accounting consistency in the model, its value-added could be aggregated with business services. However, in all other respects, it would be an independent industry.

Such an introduction would require the definition of an appropriate recipe for EFTS (i.e., DB column). Also, adjustments to the recipes of purchasing industries would be required.

An appropriate change might be to split the original business service coefficient and allocate some portion to EFTS. Perhaps value-added might also change.

Additionally to reflect the specifics of the investment program for the implementation of such a change, a separate final demand investment category(ies) would probably be advisable.

The major advantages of being able to make such specific <u>structural</u> changes to the I/O system can be readily seen in the equations of Section A. First, greater consistency of industry output through appropriate inter-industry responses is obtained. Secondly, parallel consistency in the formation of industry and final demand is obtained. Such consistency is impossible to obtain in any other environment. The advantage of that consistency is more appropriate macro- and sectoral-responses in investments, prices, other final demand, and all other aspects of the macroeconomy.

C. Implementation Specifics

The exact mechanics of the implementation will depend on the complexity of the required changes to the I/O system and on the desired ease of use. The following outline of proposed capabilities could be considered the minimum (easily) achievable set:

A) Reallocate a group of existing row coefficients subject to a column coeffecent of 1.0 and perhaps a group constraint of the original coefficient sum.

B) Direct a portion (level or share) of an existing final demand category to a specific recipe in DE.

C) Define a new industry (i.e. row and column addition to DB and row addition to DE).

PROPOSAL TO ASSESS THE MACROECONOMIC
IMPACT OF NEW INFORMATION TECHNOLOGIES:
PREPARED FOR DEPT. OF COMMUNICATIONS