A FEASIBILITY STUDY FOR ASSESSING THE MACROECONOMIC IMPACT OF NEW INFORMATION TECHNOLOGIES

Prepared for

the Department of Communications

Author:

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Reviewed by:

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Informetrica LIMITED • Ottawa, Canada • Effective Economic Research

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CHAPTER I

Introduction

This report assesses the feasibility of conducting a macroeconomic analysis of the impact of new information technologies. It was also intended to include the role of alternative government policies in affecting the rate of diffusion and implementation of the new technologies. The work on this contract was funded jointly by the Cable Telecommunications Research Institute and the Department of Communications, and may be split into two parts. The first phase of the study includes a review of the relevant literature in the area, and lengthy discussions and interviews with experts, in the various technologies, included under the umbrella of "new information technologies". The second phase draws on the findings of the first - to the extent that this is possible - and examines four likely scenarios of technological change in specific sectors. One of these scenarios is used in a demonstration impact simulation with TIM (The Informetrica Model), a disaggregated econometric model of the Canadian economy.

The Role of a Macroeconomic Analysis

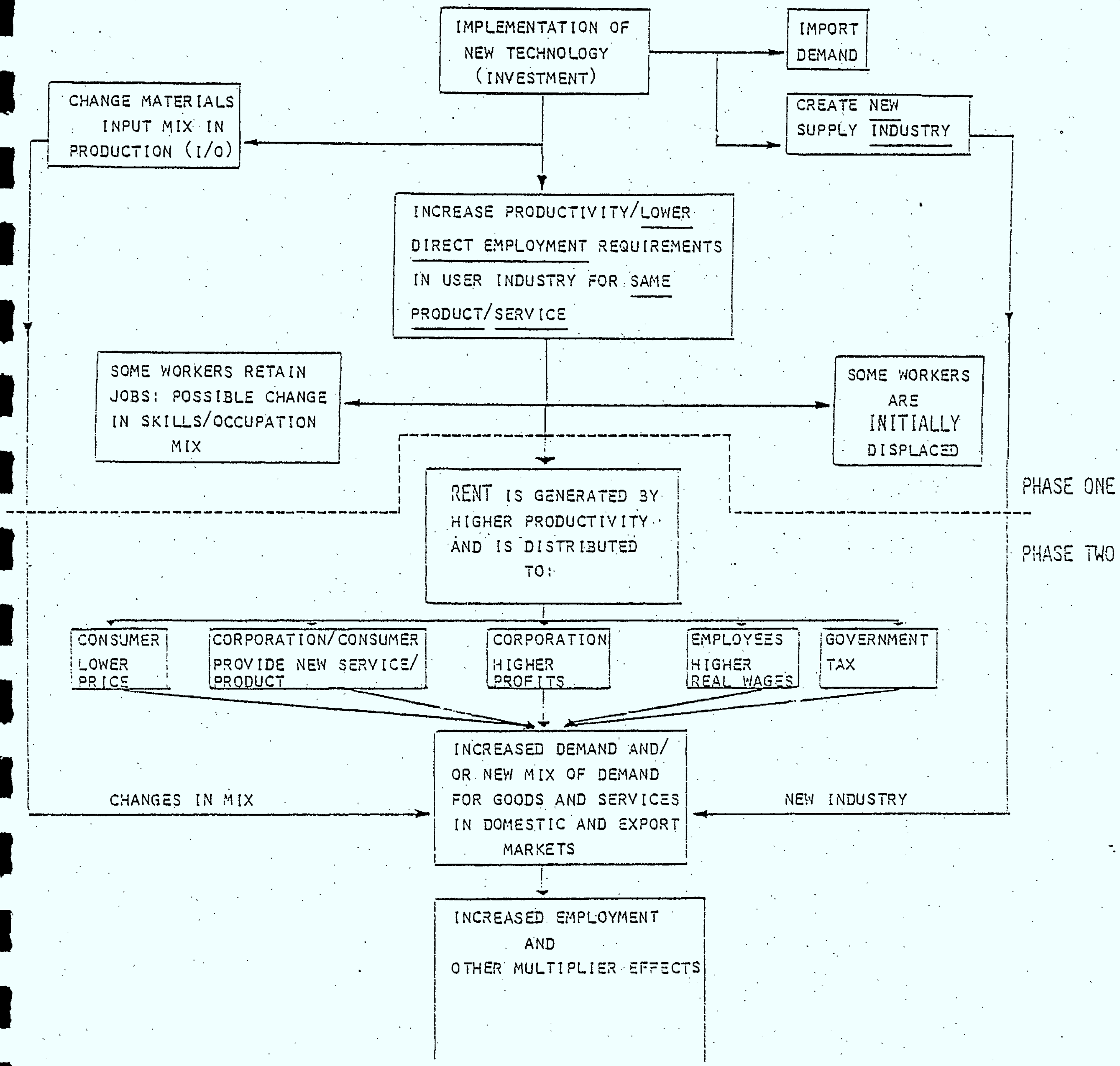
Why is a macroeconomic impact analysis desirable, and what insights will it provide, in addition to the existing analyses and views of the experts? Most of the work in this area has (of necessity?) focussed on qualitative assessments of the impact of specific new technologies. With limited information, attempts at quantitative sizings of the impacts have been carried out in a partial-equilibrium framework. The most common approach has been to extrapolate the experience of a single industry, arriving at a "net" impact, which more often than not implies a socially unacceptable level of unemployment.

In terms of the diagram, on the following page, most analysis does not cross the dotted line and remains in Phase One. The ultimate impact of a technology is viewed as the displacement of workers, who in this partial framework constitute a growing stream of new entrants to the pool of unemployed.

In any investment appraisal a firm must be satisfied that the investment will generate some (minimum) acceptable rate of return, or the investment is not made. In the realm of new technologies, the additional productivity gains or cost-savings which technology permits, imply a much higher rate of return to the investor. What a firm does with the increment to its normal return, or what it does with the "rent" is crucial to any internally-consistent impact analysis. This is, in part, the focus of Phase Two.

The diagram is not exhaustive and there are any number of possible destinations or combinations of destinations for this so-called "rent". Suppose, for example, that prior to investing in a new technology, (as embodied in an industrial robot), <u>total</u> production costs were $1.00 per unit. With the new technology, total production costs for the <u>same level of output</u> are now $0.90 per unit. Where does the $0.10 per unit go? The entrepreneur may be restricted in his choice of "destinations" by market forces. In a purely competitive market, where all firms adopt the same

THE IMPACT OF 'NEW TECHNOLOGIES'



technology and there are no barriers to entry, the $0.10 would go directly to the consumer through lower price. But in a mixed economy, the entrepreneur, more realistically, has several options open to him. And the selection of any single option or combination will result in increased demands somewhere in the economy. In the same way, a new supply industry will place demands on the economy for goods and services, and the adoption of a productivity process which dramatically alters the materials input mix will shift the existing pattern of demands.

The net impact of these events will be to dampen the initial level of unemployment which resulted from the new technology. For example, some or perhaps all of the workers initially displaced will be re-employed, or some other group of unemployed will find jobs. The new demands for employment and the associated multiplier effects will serve to mitigate the initial "undesirable" results. In this way, a macroeconomic (or a general equilibrium) approach provides a balanced and consistent framework for a more realistic appraisal of the impact of new technologies.

The rest of this document considers: (i) the information requirements for a macroeconomic impact study; (ii) alternative scenarios of the implementation of new technologies in specific sectors, in a longer term framework, 1980-1990; (iii) the methodology to assess these (or like) scenarios using the macroeconomic model TIM (The Informetrica Model); (iv) a demonstration impact simulation of one of these scenarios; and (v) an outline of the information gaps which would have to be filled, in order to undertake a realistic macroeconomic impact study of new information technologies.

CHAPTER 2

Findings of the Literature Review and Interviews with Experts

The literature review and interviews were undertaken to determine those technologies which would have the most significant economic impact over the next ten years. It was felt that these two sources would provide a basis for the information requirements of an impact study - the literature through evidence of major concerns in this area and examples of current applications of technologies; and the interviews through the experts' knowledge of the technology and its uses and impacts.

For the most part, the literature is directed to qualitative analysis and discussion of wide-ranging technological changes. Usually specific case studies are cited, but the analysis is typically partial and often one-sided, focussing on who will pay the price for the technology (i.e. who will be immediately displaced) but not on any benefits which may accrue from adopting the technology.

The Literature on New Information Technologies

The literature on the new era of technological change is vast, and even by restricting a survey to those studies produced within the past year, there is no lack of discussion. As many of the major works have been very well reviewed elsewhere[1/], this section

[1/] Zeman, Zavis P., "The Impacts of Computer/Communications on Employment in Canada; An Overview of Current OECD Debates".

will briefly outline the trends in two areas: (a) work in the Canadian context, and (b) other studies, particularly in the U.S. and the U.K. This review was undertaken with a view to determining what are the major issues and what information could be obtained for use in a macro analysis.

Dealing with the two areas in reverse order, discussions in the U.K. focus on direct employment impacts in particular, although other social and economic implications of the new technologies are not ignored. However, in terms of the "adaptability" of these discussions to a macro environment, there exists a large gap. Most of the studies use case histories as examples[1/] to support their analysis, but none have been able to get beyond the "Phase One" level of analysis mentioned in the introduction above. Even at the micro level the case histories are often anecdotal, with little quantitative substantiation of the nature of the change which occurred. For example, in the few instances where the direct cost savings to a firm is cited[2/] there is no subsequent statement along the line "this permitted the firm to: increase profits; maintain its product price, etc.".

These comments should not be interpreted as attacks on the existing literature, which provides crucial insights into many of the broad social and economic considerations, but rather as a more general comment on the focus of "debates" in this area to date.

1/ e.g. Barron, Iann and Roy Curnow "The Future with Microelectronics" page 181 ff.

2/ e.g. Fortune, December 17, 1979 "Those Smart Young Robots on the Production Line" (page 90-96).

As will be demonstrated below, in most instances very little quantitative information is available which would permit a detailed macro analysis at this time. In fact, the micro studies which would be the source for much of this detail are only now being undertaken.

Turning to the Canadian literature, there is no lack of discussion, but again the topics range from very broad policy issues to the attributes of a particular technology. The several publications by the Economics Branch at the Department of Communications[1/] provide a valuable overview to the potential impact of these information technologies on employment, capital and output trends in Canada. In the same vein, work has been done in the Canadian context to examine production functions separating "information labour" and "non-information labour" components[2/].

The work of Peitchinis[3/] at the University of Calgary has provided very important observations on the perception of direct job destruction and job creation as the result of technological change. His study focusses on changes in educational and skill

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1/ e.g. Andrieu, Michel and Shirley Serafini "Impacts of Electronics and Telecommunications on Production Process in Canadian Manufacturing".

Serafini, S., M. Andrieu and M. Estabrooks "Post-Industrial Canada and the New Information Technology".

2/ Warskett, George "The Role of Information Activities in Total Canadian Manufacturing: Separability and Substitutability".

3/ Peitchinis, Stephen G. "The Effect of Technological Changes on Educational and Skill Requirements of Industry".

requirements and his findings tend to confirm the notion that there have not been massive changes and dislocations resulting from technological change, but that shifts in future years might be more significant. One important comment, made by Peitchinis, and very relevant to the information requirements of a macro analysis is that "evidence of the extent to which the adoption of new process technology is taken for granted is the apparent failure to evaluate its manpower and other effects after adoption has taken place"[1/].

The overview of the OECD debate by Zeman[2/] provides a very concise picture of the varied conclusions concerning employment impacts of new technologies. From his review of the literature Zeman has concluded that "On the key question of the net job balance effect for the whole economy resulting from the new technologies, there exists no consensus in the literature"[3/]. While his specific conclusions have been supported by the findings of this study, one comment is worth repeating here: "In contrast to the great sophistication and variety of theoretical propositions concerning technological unemployment, the available empirical evidence is too weak to help the critical analyst to orient himself. The reviewer of the current literature cannot but be struck by the relatively

[1/] ibid. page 7.

[2/] Zeman op. cit.

[3/] Zeman op. cit. page 43.

poor factual base on which the present debates are conducted"[1].

Other studies of note in Canada tend to focus on particular technologies (EFTS, CAD/CAM)[2] or narrower research areas. For example, a series of articles by J. Crean[3] discuss electronic funds transfer and automation of banking in Canada. Jack Scrimgeour[4] has covered many aspects of CAD/CAM in a wide range of articles on that topic. The "Office of the Future" was discussed by Robert Russel[5], and M. McLean[6] has focussed on the application of microelectronics. Other broader analyses include that of R & D and communications[7], and the use of national accounts and input-output techniques to analyze technological impacts[8].

1/ ibid. page 31-32

2/ EFTS: Electronic Funds Transfer System. CAD/CAM: computer-aided design/computer-aided manufacturing.

3/ Crean, J. F. in the Canadian Banker and ICB Review various issues.

4/ Scrimgeour, J. "CAD/CAM and its Impact on the Manufacturing Industry" and other articles.

5/ Russel, Robert A. "The Electronic Briefcase, The Office of the Future".

6/ McLean, J. Michael "The Impact of the Microelectronics Industry on the Structure of the Canadian Economy".

7/ Wills, Russel "Research, Development and Communication in the Canadian Economy".

8/ Jouandet-Bernadat, Roland "Macroeconomie de la Societe Informatisee".

Each author has contributed to his particular field but none has been able to approach the issues from the macroeconomic viewpoint. Part of this deficiency relates to the scarcity of information, and part to use of partial analysis.

Interviews with Experts

As it was initially thought that the experts in the different technologies would be able to provide information on which to base an impact study, each person was asked the set of questions below. The responses are outlined in this section, but in general terms these experts were unable to answer the questions because: (a) their technology had not been implemented or had not been tested in market trials; (b) the technology was currently in use, but data were not available; or (c) the technology was in use, and its impact had been analysed, but the analysis did not address these specific questions. If the impact of a particular technology had been considered in the context of the overall economy, the analysis was usually inconsistent and the resulting "macro" impact was the result of the amalgamation of several partial views of the economy.

Since the time frame for the analysis is a ten-year period, it was necessary to identify those technologies which were likely to have a significant macro impact during that time, and those technologies which would not. With so little precise information available, how was this selection made? Those technologies which currently enjoyed fairly widespread use and acceptance were automatically included in the group of technologies which would have an

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 INCENTIVES 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 DOMESTIC SUPPLYING INDUSTRY?

impact. Such things as CAD/CAM, process control, new business services, and PAY-TV fell into this category. The second group - i.e. those technologies which will be introduced within the ten-year period, but which will not have a significant impact - includes new home services such as videotex, and related services such as home-shopping which would also include advanced applications of electronic funds transfer. These groupings are shown in the table below. The list is not exhaustive, but is illustrative of major "technologies" or their applications, which might be handled in a macro framework.

There was a very large gap between the information which many of the experts thought was or "should be" available and what actually exists. One difficulty in obtaining the required information is that it has perhaps not been consolidated from the various areas of the firm. For example, one individual would not have all the pieces of data, but depending on his role in the appraisal of the investment decision, or the actual installation and use of the technology, or in examining corporate performance, he may have an answer to one or two questions. Another difficulty is the sensitivity of much of this information, in unionized and non-union firms alike. Management might not be willing to provide estimates which imply a reduction in all or part of the firm's labour force.

An additional reason for lack of specific information is that certain "technologies" will require coordination among users and suppliers and decisions on regulatory issues (in particular the question of carriers) before a clear picture of the new system

CLASSIFICATION OF TECHNOLOGIES

CLASS 1

- -- CAD/CAM
- -- Process Control
- -- Electronic Funds Transfer System
- -- Business Services (word processors, complex work stations)
- -- "Closed-User Group" use of Videotex and related "information systems"
- -- Microprocessors (embodied in consumer durables - implication for servicing requirements and impact on production, employment, no. of parts)
- -- Electronic Mail
- -- PAY-TV
- -- Video Cassettes/Discs
- -- Microcomputers for personal and business use

CLASS 2

- -- New Home Services (especially Videotex) can emerge. An example of this is a fully automated national electronic funds transfer system. Issues of compatability of the systems of individual chartered banks must be dealt with as well as the dedication of lines for communication, and selection of mode of operations at the retail level. With so many major issues unsolved a clear picture of that level of full automation of funds transfer does not exist. (It is possible to depict a much lower level of automation, however, such as full automation of services within each chartered bank or financial institution.) Similar and perhaps more serious difficulties exist for certain new home services, such as videotex. Without sophisticated market trials for this service, it is not possible to make even "informed guesses" of the quantitative parameters of this technology.

A third reason for lack of precise information on a technology is that "productivity" is not well-defined, particularly for office functions. Where introduction of a new technology may redefine the structure and role of a "unit" such as the office, consistent measures of change or impact are difficult. However, despite this difficulty, it is crucial to make some attempt to unravel the issues and analyse them in a consistent framework.

The remainder of this section briefly reports the comments of the experts on their particular technology. (A list of the people interviewed is found in Appendix B.)

CAD/CAM and Process Control

CAD/CAM (computer-aided design/computer-aided manufacturing) includes product design and analysis; customer order handling; production, material and inventory control, automated production (use of numerical control of tools, industrial robots), and automated material handling, among others. CAD/CAM may be differentiated from process control to the extent that sensor based inputs are the major source of information for process control, while "human" inputs are the major source for CAD/CAM. Process control has probably peaked in terms of the rate of implementation by firms, and also has much more modest economic impacts in terms of labour requirements than CAD/CAM.

While several Canadian industries already make use of CAD/CAM processes, the timing of the implementation of a new technology is likely to be a function of the "technological distance from the source". That is, large firms with their own R & D group, or with strong links to the source of R & D developments will implement new technologies more rapidly than smaller firms who rely on suppliers or other indirect sources of information for new technologies.

CAD/CAM applications will also differ depending on whether the process is being incorporated in an existing plant or as part of a system for an entirely new plant. These systems typically involve a high degree of user input. For example, the programming of an industrial robot will be very user-oriented. In terms of impact on employment, as CAD/CAM is used to process a small amount of complex information, it will not have as significant an impact as technologies which process large volumes of simple information. The developmental phase of CAD/CAM systems also requires a high proportion of very skilled people.

CAD/CAM systems will not cause shifts in the materials input mix of a production process, but rather impact the mechanical aspects of production. Until industrial robots are developed on a wide scale with pattern-recognition and tactile abilities, there is a definite upper limit to the role of industrial robots.

The price of CAD/CAM systems is unlikely to decline in real terms as a large portion of the system is the labour-intensive user-designed component, and as well no major technological break-throughs which would affect CAD/CAM seem eminent.

Electronic Funds Transfer System

The technology exists for a fully automated national electronic funds transfer system, and the automation of internal functions, by chartered banks and financial institutions, is the first major step in this direction. However, as the banks and financial institutions are at different stages of implementation of their systems, and use different "technologies", all would have to invest in ensuring compatability of their system with all others before a national system can be a reality.

EFTS in the market place (i.e. at the retail level) is also progressing along its own route. Credit checking facilities incorporated in POS (point-of-sale) terminals and the introduction of a machine which would link the retail outlet with the central information office of bank card companies are also moves to facilitate a fully automated system

These current developments will have already resulted in some impact on employment requirements, both current and forecast, within chartered banks in particular. It might be possible to consider the impact of automation by all banks and financial institutions of their internal functions, as this has a high probability of occurring within the next ten years. A "fully-automated" system is less likely, or at least one which will have a major impact, as there are still many issues to be resolved before such a system could be operational.

New Business/Office Services

Particularly in office services, rising wages are seen as the main incentive to investment in new office equipment. The view is that employment will be severely impacted by new technology. The automation of clerical functions and the improved productivity provided by word processors or complex work stations will lower employment growth in the office, but will also lead to a different mix of skills.

As the software component of the equipment becomes more important, the price of the new office 'systems' will rise or at least remain constant, in the face of declining hardware cost. The lack of marketing skills in Canada, as well as the low level of research and development are viewed as the major obstacles to developing a domestic supply industry (with export capabilities).

While the new office equipment will change skill requirements it will also affect the processes within the office, and the functions of the managerial and professional staff. New services (including 'closed-user group' use of videotex) will permit more efficient organization and manipulation of information and data.

Although such changes cannot be quantified in terms of their impact, the productivity gains from using the more 'basic' forms of the new technology should eventually show up. Take as an example, the Calgary law firm which through efficient use of word processors has been able to add three lawyers to its staff, although it now has six fewer secretaries[1/]. This is a clear example of more output for the same (or fewer) inputs. It is anecdotal, but probably characteristic of the nature of change which is occurring in this area.

Electronic Mail

Several stages of development of electronic mail are envisaged, although the ultimate appearance of electronic mail in the home will not occur in the next ten years. The major hurdles which must be overcome before any form of electronic mail is implemented in a major network is compatability of sending and receiving systems. In-house, closed-user group electronic mail or message systems are now a reality, and transmission of messages (or "mail")

1/ Canadian Office, February 1980, page 51.

by electronic means (by the Post Office, using existing telecommunications links) to a distribution centre (at which point normal Post Office distribution takes over) is also a reality. Capital investment in equipment and in communications lines by the carriers would be necessary. However, the major factor in delaying general use of electronic mail will be social and cultural reluctance to adopt this new technology. Until more specific information is available on the proposed components of an electronic mail system very little work can be carried out on the impact of this technology. A change in the proportion of mail flowing through normal channels and that going by electronic means would likely change the mix of occupations and skill requirements of the Post Office. The impact on the level of employment is not clear, but the cost of "mailing" to the user would be lower if electronic means were used, particularly if time for delivery is important.

New Home Services

While such services as security/burglar alarms, and energy conservation systems are currently supplied to homes via the cable network, larger more 'general' services associated with videotex are not likely to have a major impact on the economy within the next ten years. Videotex has not undergone extensive market testing in Canada at this date, and the types of services (or databases) which would be provided by such a system have not been well defined. For example a system which used the Department of Communications' Telidon technology would provide access to a bank of information. The type of information which would be provided and the payment arrangements are still in the formative stages of development. The bank of information will to some extent define the "audience" and potential users of this service. Additional features such as "home shopping" or electronic funds transfer or mail, using the Videotex system, will require significant investments by "carriers" of the information flows and again these are not likely to enjoy widespread use or be significant in the macroeconomy by 1990. It is not possible to make any comments on the employment generation by (domestic) supply industries, or by "information brokers" who prepare and update information bases, until there is information on the type of equipment, the source of supply, the price, the price of the services, etc. For this reason the videotex-related home services cannot yet be included in an impact study.

There are, however, other consumer products and services which currently enjoy wide acceptance in Canada and/or the United States. These include: PAY-TV, video cassettes, and home computers. To the extent that the associated hardware, or the programming content of the new products are domestically produced there will be some employment generated in "supplying" industries. As the consumer faces both a budget and time constraint in his purchase and use of these items, they will compete with each other and with other new and existing leisure activities. Thus to the extent that new products and services substitute for existing (e.g. video cassettes for movie theatres) there will be some negative employment impact in the "declining" industry. Information on expected market penetration, source of supply, price and the change in mix of consumer expenditures would likely provide sufficient detail on which to base a macroeconomic impact of these new goods and services.

CHAPTER 3

Alternative Scenarios of the Implementation of New Technologies

From the previous chapter it is evident that lack of precise information is a serious problem for a macro study. While it was possible to identify many technological changes which would likely occur within the next ten years, there is no information which would permit us to rank or quantify the impacts. Very few of the people interviewed felt that government policies would be effective in altering the rate of implementation of any new technologies, but rather other considerations, in particular domestic and international competitiveness, would play the major roles. From the myriad of likely changes, and with a view to the nature of the concerns expressed (impact on employment, international trade, new products, etc.) four scenarios have been postulated. These scenarios include technological change of different types with direct impacts in different areas of the economy. These are hypothetical cases, illustrative of the kinds of impact studies it is possible to carry out, of the nature of the information required, and of the implementation procedure in a macroeconomic model.

In this chapter the four scenarios are described in a macroeconomic context. That is, assumptions are made concerning what we have elsewhere called the "distribution of rents". In this way we have the necessary set of information to trace the impact of a particular technological change through 'Phase Two' of our framework and to consider the multiplier effects. It has been necessary to make certain simplifying assumptions concerning the rate of implementation and length of time required to "fully implement" a new system.

While recognizing that technological change is a continuous process and in fact rarely involves quantum shifts, for purposes of this feasibility study we assume that a single technological change occurs (e.g. use of industrial robots or other computer-related devices in a manufacturing process), and that after a certain number of years this new procedure is fully implemented. This permits, in a macro-framework, an analysis of the impact of the change as the various sectors adjust to the change with greater or lesser rapidity.

The four hypothetical scenarios are A. Automation of Production Processes in the Textile Industry; B. Office Automation; C. The Automation of Internal Functions of Financial Institutions (e.g. fully automated operations of a chartered bank across its branch system, but not between chartered banks), and D. Introduction of New Consumer Products/Services. The remainder of this chapter deals with the assumptions of each scenario and then finally with the role of government policies to promote technological change.

A. Textile Industry: Increased Automation of Production Processes

This scenario hypothesizes a significant increase in the automation of production processes in this industry. The precise method of achieving this change is not specified but could include such computer-aided-manufacturing devices as industrial robots, or improved process control, etc. The first consideration is the magnitude of investment required to purchase the technology. Since no quantitative information is readily available on this investment, an impact simulation would target for a specific capital/output ratio, where "capital" is restricted to machinery and equipment, as this is the most relevant form of capital for the technological change we are discussing (as compared to investment in non-residential construction).

In order to determine an appropriate increment to investment, a target capital/output ratio would be hypothesized, and investment would be increased over, say, a five year period to achieve that ratio. Two additional questions remain concerning investment. The first is the source of the machinery and equipment purchased. Is it supplied domestically or from abroad? The second question concerns the scrappage rate of capital in the industry and is slightly more complex. Does the availablity of this "new technology" as embodied in the machinery and equipment, cause the industry to scrap existing stock at a much more rapid rate than otherwise? This would lead to significant changes in the <u>vintage</u> of the capital stock, but may not require any change in the capital/output ratio. If the industry, however, scraps its stock at its "normal" rate, and increments its stock through investing in the new technology, we are still in the world we set out above, with some (higher) target capital/output ratio. While this latter issue is an important consideration in the analysis, it is perhaps less crucial to the outcome than the assumptions concerning productivity and "rents".

Implementation of this "new technology" will result in productivity gains for the industry. These gains could be achieved in two ways - fewer production workers or less material inputs for the same level of output. These changes could be experienced in both the textile and clothing industries. It is conceivable that with such shifts in the nature of the production process relatively more "information workers" would be required than previously. We assume, however, that this would not offset the productivity gains achieved elsewhere.

Since the textile industry is in a vulnerable position vis-a-vis international competition, the "rent" question is a very important one. (This discussion could apply equally well to any other industry which either exports a substantial share of its total production, or competes intensively with imports in the domestic market.) The industry is in a position, having invested in the new technology, to produce the same level of output at a lower cost, and still achieve the same rate of return on its investment as previously. If the industry maintains its price to consumers it will have additonal profit or return on its investment, which may be directed towards higher real wages for the (remaining) employees, or which may remain in the industry's profits to be distributed to owners or shareholders or reinvested. However, as this industry is highly competitive in an international environment, and as it is unlikely that the Canadian industry would update its technology in isolation, the most plausible distribution of this "rent" is to consumers in the form of lower prices. These lower prices would at least maintain, but possibly improve the domestic industry's position against imports and would have an impact on the balance of payments in textiles and clothing.

B. Office Automation

Technological change in "the office" is a more nebulous concept than automation of a factory's production process. But as this is an area of major concern, we felt it important to at least put forward some suggestions as to how this problem might be tackled. The major difficulty in discussing office automation is its definition. The introduction of complex work stations and the ability of managers to access files and information instantaneously, will result in not only productivity gains at clerical levels, but new roles for managers and a change in the decision-making process. Many of these shifts in attitudes and work environments cannot be quantified. However, for many of the clerical functions there will be measurable productivity gains. Bearing in mind that these problems exist, we will continue to examine this scenario in terms of investment requirements, productivity gains and rents.

Investment for office automation will be most likely to occur through machinery and equipment purchases. This investment will result in a direct substitution of new capital stock for old, leading to a complete shift in the vintage of capital stock. The time frame for a change is less clear - particularly since there are many office functions which lend themselves to automation, and which may be automated independently of each other. If the investment is to be sourced, the domestic and imported components must be known. A more interesting question deals with the equipment itself. There are many indications that the software component of office equipment will grow at a more rapid pace, in terms of cost and importance, than the hardware. This will lead to a change in the configuration of the supply industries as software becomes a more important product and they contribute more value-added to the office equipment or system they produce. Alternately, the change could occur in the user industry, if they design their own software to be used with the hardware they purchase.

In terms of productivity gains, these are difficult to quantify apart from the purely clerical, manual functions which may be automated. Office automation may also lead to other cost savings- more efficient postage cost determination; less expensive copying charges; more efficient information storage and retrieval (e.g. microfiche versus paper). These gains may not cause a change in labour requirements, but do provide the user with similar "rents". In broad terms these result in more output for the same input, as time and material resources are used more efficiently. How can this be expressed in economic terms? Office automation impacts <u>all</u> industries to a greater or lesser extent, and may not <u>directly</u> impact the end product of the industry. However, lower operating costs for office functions will show up initially as increased profit, although the "rents" may be captured in other ways and before they reach the user industry.

The supplying industry (particularly if a domestic supplier is protected by tariff barriers) may be able to capture the bulk of the rents through higher prices. If the supplier does not succeed in taking a chunk of the rent, the operators of the new office equipment may demand relatively higher wages as they are more highly skilled operators. The net result will be a general increase in productivity for the industry as a whole, as productivity rises in the office functions. If the user industry does not return the rent to the supplier by paying a higher price, or pay higher wages to its employees, corporate profits are likely to increase and these may be distributed to shareholders, or selling prices of the user industry will be lower.

C. The Automation of Internal Functions of Financial Institutions

This particular scenario deals with the automation of functions within banks and other financial institutions. Included in this particular case are inter-branch communications facilities as currently exist in several chartered banks, as well as automation of internal banking functions such as recording accounts, calculating interest, cash balances, etc. However, this scenario stops short of a fully-automated national EFTS situation. It would not rule out automation of credit checking and authorization for major credit cards.

Much of the change put forward in this simulation is underway at the present, which makes the scenario more interesting as certain impacts may already be observed in the economy. Before citing examples from Canada's current experience in this area, we will examine investment, productivity and "rent" implications of this technology.

Similar considerations on the investment side apply to this case as to the previous two. How much investment in machinery and equipment, and in non-residential construction (to house new computing centres) is required? Will this investment be domestic or foreign-sourced? And what will be the software component of the machinery and equipment investment? Will the software be provided by the supplier of the hardware or will the user develop his own software? (If we were to consider a fully-automated national electronic funds transfer system, additional investment would be necessary for centralized clearing facilities, to achieve compatability of individual systems, for communications links and for additional transactions terminals at the retail level).

With these automated systems in place, productivity gains may be achieved directly by eliminating many of the manual calculations in a bank. There is evidence now that automation of functions has permitted new services to be introduced. An example is the new daily interest savings account. Increased competition from the new services will possibly lower cost of service to the consumer. As in previous examples, employees' wages might also increase if more skills are required to operate the new equipment.

D. Introduction of New Consumer Products/Services

This last hypothetical scenario examines the introduction of new consumer products, embodying new technologies. Examples of such products would be: home computers; video cassettes; video discs; new cable services (including security services; energy conservation); and PAY-TV. Since the consumer is the purchaser or "investor", the concepts used in the previous cases alter slightly in this example. The initial consideration is the location of supplying industries. These may constitute new industries in the economy, supplying new products. What is the domestic/foreign content of the hardware and software embodied in the consumer products?

From the consumer's viewpoint the purchase of a durable good such as a home computer or video-disc constitutes an investment. Given the consumer's budget constraint, these purchases will likely displace expenditure on other goods. An additional constraint for the consumer in this instance might be leisure time, as most of these products vie for leisure time. To the extent that any of these new products or services allows the consumer to spend his leisure time more productively - e.g. giving the consumer the capability of watching specific television programs or movies at his convenience - they may be said to result in productivity gains, or provide some "psychic rent" to the consumer.

Employment will be created in the supplying industries and in servicing the new equipment. However, the trade-off made by the consumer by - for example - purchasing a video-cassette system rather than going out to movies, will cause certain industries to decline relatively.

The Role of Government

What options are open to government to promote more rapid development of new technologies (establishment of domestic supply industries), and to affect the rate of diffusion and implementation of these technologies? Very few of the experts interviewed felt that government policies would influence business decisions on whether or not to invest, and on the timing of the investment. Ultimately the firm's decision would be based on questions of competition and standard investment appraisal criteria. The more important issue of the implementation of new technology was, for most people, not the source of supply of the technology (domestic or foreign), but rather when and if the new technology is adopted in Canada.

One area of government "involvement" which was discussed with the experts, was the problem of very rapid obsolescence of investment goods in areas where new generations of equipment were appearing in quick succession, and with little change in price. Firms might be reluctant to invest, as a new generation of the product could appear well before their investment has been fully depreciated. Many suppliers are circumventing this problem by leasing their products, but if their leasing charges are themselves based on a relatively rapid depreciation of the equipment, the user still bears part of these costs.

While government incentives to research and development are assumed to be an integral component in the promotion of technological change, there is some evidence that this policy may, in fact, confer very few benefits to the economy, in terms of increased R & D expenditure, although the small change in R & D expenditure does lead to higher output. Policies which promote R & D through increasing the investment tax credit on R & D, or increasing the capital consumption allowance (on total or incremental R & D expenditures) may, thus, be expected to have relatively small impacts on the level of R & D expenditure. It is also noted that to the extent that R & D expenditure is increased there will be a further (slight) decrease in tax revenues.

As there was no consensus on the positive impact of government policies in promoting new supply industries, or the rate of adoption of new technologies, this is one area which must be more carefully researched before reasonable assumptions can be made in an impact study.

CHAPTER 4

Implementing Alternative Scenarios Using TIM

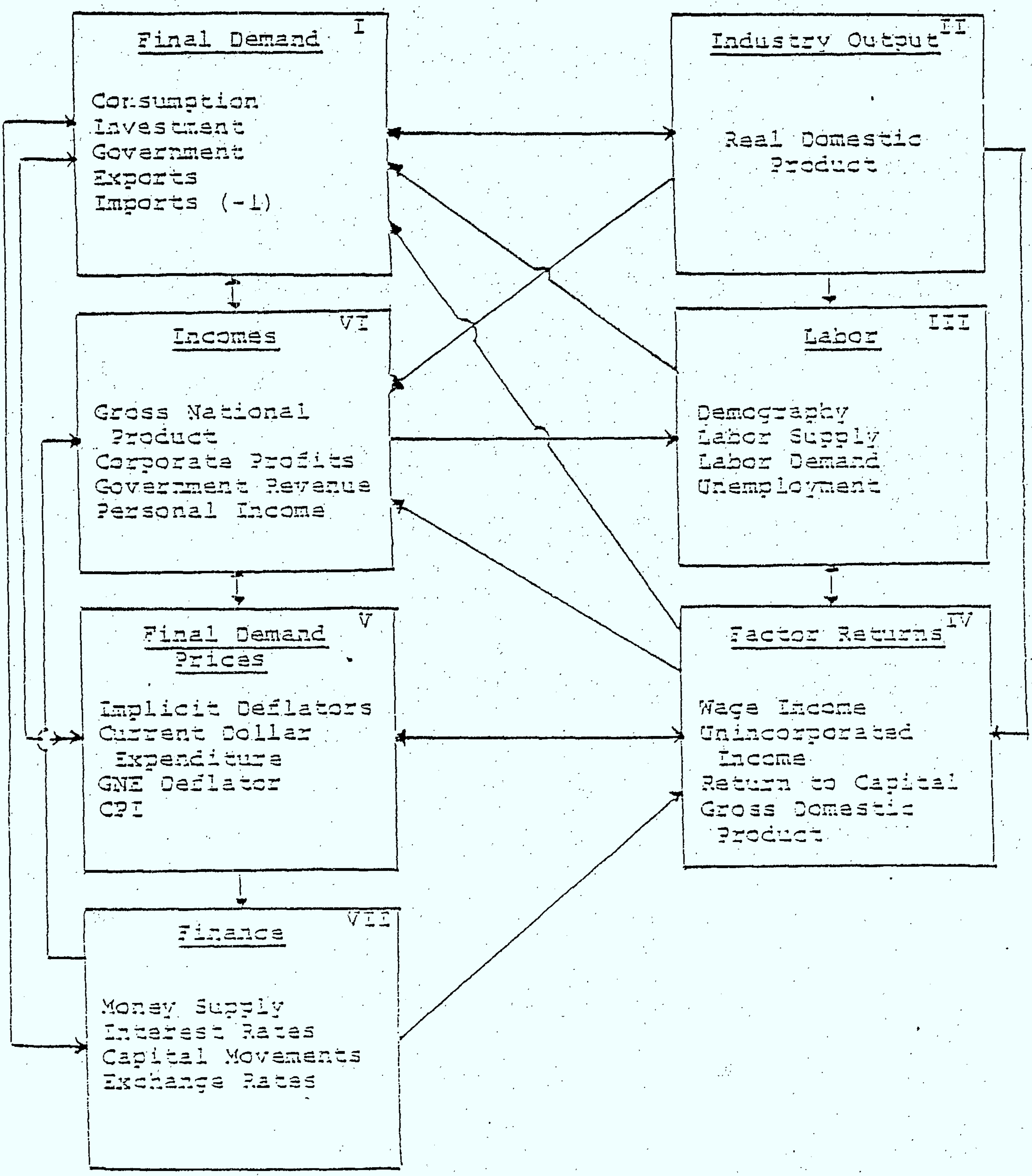
The Structure of TIM

TIM is an annual macroeconomic model of the Canadian economy.[1/] Its structure is similar to the CANDIDE family of models, although it has been completely reestimated by Informetrica and employs the 1971 Input/Output submodel in a different manner than the CANDIDE models. TIM, and all other major macroeconomic models, detail seven basic sectors of the economy: (a) final demand (expenditure by end use sector); (b) industry output; (c) labour supply and demand; (d) returns to factors and industry domestic output; (e) final demand prices; (f) incomes (by sector and aggregate), and (g) financial variables and capital flows. The inter-relationships of these sectors are shown in the diagram below. An additional "sector" of the model is the input/output submodel which provides the linkage between final demand and industry output and between industry and foreign prices and domestic final demand prices.

The interdependence of the sectors is evident from the diagram. In the TIM model, as in all "macro models" the variables in all sectors are determined simultaneously. Changes in a single sector - for example, an increase in investment - are reflected simultaneously in other sectors. Lagged impacts are built into the model system, to the extent that equations include lagged explanatory variables. Thus the possibility that a response to a particular

[1/] The reader is referred to "The Informetrica Model", by Paul Jacobson, Informetrica Limited October 1979, for a more detailed description of the model.

INFORMETRICA MODEL - SECTORAL LINKAGES



change in the economy will not show up instantaneously is included in the model, as reflected in the equations which are based on historical data and response lags. As well as being a simultaneous model, TIM also has dynamic and nonlinear properties. As a dynamic model, the solution values of a given year are partially determined by solution values of previous years. The nonlinear equations of TIM have the effect that the size of a change in a particular year depends on the solution values for that (current) year.

The diagram of the sectoral linkages is, in many ways, analogous to the impact chart which was described in the introduction (page 2). To be a true simultaneous system the impact chart should have another link from the bottom box of "multiplier effects" back to the top of the flow, although the induced investment from the initial impact will not necessarily be in a new technology.

Since TIM is based on historical relationships, any change which is made to the assumptions or parameters of the model, will - in the absence of additional information or other changes - feed through the model at the same pace and with the same impacts as occurred during the sample period used for estimating the model. If there is reason to believe that the historical patterns of demand and response, or the historical input mix for final demand may have changed, or are no longer valid, in the "new" forecast being hypothesized, certain types of information or detail are necessary to impose the new pattern on the model. Using investment in the textile industry as an example,1/ suppose that investment in the industry is increased significantly in a particular year, relative to the "base" view of the economy. If this investment is simply added to the assumptions

1/ See Chapter 5 for "demonstration" simulations of such investment.

of the simulation (as an exogenous change, or constant adjustment to an endogenous term), it will work through the normal (historical) channels of response. The mix of goods and services purchased will reflect what that mix was in the historical period and output and employment will rise, as a direct result. There may be some productivity gain and ultimately real incomes will increase in general as the multiplier effects show up. But what can be done if there is a priori knowledge that this investment does not involve purchase of the normal mix of goods and services for textile investment? Rather the investment is in specific high technology equipment, and the direct impact of this investment will be to reduce the industry's employment requirements for a specific level of output. The only way that such impacts can be imposed on the model is by making use of such additional information to adjust the conventional direct impacts, to achieve those which are expected to occur. This, in part, explains the information requirements, particularly to the extent that these exceed simple knowledge of the magnitude of investment. The textile example is described technically, in terms of an implementation using TIM, below and the illustrative simulations with the model consider both the case of a "normal" increase in investment, and an increase of identical magnitude but which is directed towards high technology machinery and equipment with significant labour productivity gains.

The questions for the technology experts included information on the direct impact of investment in new technology, to the extent that this impact differs from the normal historical response. Until such detail is available, there are very few ways to define or simulate the impact of investment in such technologies.

The next section provides a technical discussion of how each of the four scenarios, set out above, would be described as a simulation using TIM. The specific nature of the changes required, and the variables which would be adjusted (where known) are identified.

Implementation of the Scenarios

Automation of the Textile Industry

Investment in new machinery and equipment by the textile industry is the first and driving assumption in this scenario. This machinery and equipment embodies a new technology which results in substantial improvement in labour productivity. In the TIM environment, the relevant investment variables are M67IMK (investment in machinery and equipment, $1971; knitting and clothing) and M05IMK (investment in machinery and equipment, $1971; textiles). Since we have hypothesized that the investment is <u>incremental</u> to that in our reference view of the economy, each variable would be adjusted by the appropriate 1971$ amount, through a constant term adjustment.[1/] If no other compensating adjustments are made, this investment will lead directly to increased industry output and increased employment. While investment is broken down for approximately 45 industries (not including government), estimates of employment and wage bills are available for only the 12 major industry groups. For this reason, employment in the textile, knitting and clothing industries, and their wage bills are part of total manufacturing employment and wage bill, and do not appear explicitly in the model.

[1/] A constant term adjustment is a regularly used procedure for changing the solution value of a variable to correspond to the particular assumptions of the simulation.

Since this scenario assumes a significant improvement in labour productivity resulting from the investment, manufacturing employment (both man-years MAET and hours, MAETHR) must have offsetting negative adjustments to ensure that the direct impact of the investment is a decrease in manufacturing employment related to textiles and clothing. A further refinement in this particular scenario is that the "rent" generated by this productivity improvement is passed to the consumer in the form of a lower price. This implies that the wage bill in the textile industry drops as wage rates are unchanged but employment is lower. Within TIM, this occurs automatically as employment declines, however, the lower employment and wage bill in the textile and clothing industries appear as part of manufacturing, and this change at the aggregate level of manufacturing must be redirected to the textile and clothing industries, through changes to the gross domestic product of the two industries (MA67YG, GDP knitting and clothing; MA05YG, GDP textiles). This adjustment ensures that the lower wage bill for manufacturing does not impact all manufacturing industries, but only those designated. This will in turn lead to lower domestic prices and induce an increase in demand for domestically-produced textiles and clothing with an offsetting drop in import demand for those commodities (TEULMK, textile imports from U.S., $1971; TER4MK, textile imports, ROW, $1971).

The multiplier effects which result from the increased demand for domestically-produced goods and from the higher real incomes due to lower textile and clothing prices, will most likely lead to a net increase in manufacturing employment once the induced impacts have occurred. However, the source of this outcome will be different than if a normal "historical" investment expenditure had been assumed.

Office Automation

Technological change in the office is a much broader concept to deal with than a similar change in a particular industry. The nature of the office-related machinery and equipment investment by all industries will change. The trend will be towards a different mix of investment goods, with a relatively higher proportion of value-added embodied in the goods. These new investment goods will improve both capital and labour productivity in an industry, although the improvement will be concentrated in office functions. This particular scenario provides a useful example of the need to adjust the Input-Outpu table to accommodate the assumptions.

In this case a new supplying industry would be added to the input-output table, to produce the new "office equipment". The input requirements of this industry could be such as to include a high proportion of value-added, assuming, for example, that the software component of this equipment becomes an increasingly important share of the product. All industries would purchase from this industry as part of their requirements for investment in machinery and equipment. (The reader is referred to Appendix A for a technical discussion of such changes).

Since the price of the new office equipment is expected to rise less rapidly than other prices (at least in the near term), the real (1971$) investment by industries may be increased to reflect the the relative price change. In order to capture the productivity impact, existing employment functions may be adjusted, or these functions could be reestimated, separating the different types of investment - machinery and equipment and structures. This approach would be similar to the concept of the information/non-information labour and information/non-information capital used in estimations of production functions.[1/] This approach would require a significant additional amount of information over what currently exists.

The Automation of Internal Functions of Financial Institutions

Financial institutions would be required to make investments in machinery and equipment, and structures (FIIMEK and FIICOK, investmen by finance, insurance, real estate in machinery and equipment and construction respectively, 1971$) to meet their requirements for automation. In the case of machinery and equipment investment, it may be desirable to adjust the current mix of goods in the Input-Outpu table to take account of the new types of terminals and other hardware purchased by the industry. If the financial institutions provide their own software, this will be evident in their employment (skill/occupation) requirements. If they "purchase" the software as part of their investment, similar adjustments to the supplying industry of these products will be required, as above for office automation. The industry must also purchase (as opposed to "invest in") communications links. These purchases would be from the telephone/telegraph companie and would necessitate a change in the Input/Output configuration of purchases by the financial community.

1/ See Warskett, George, "The Role of Information Activities in Total Canadian Manufacturing: Separability and Substitutability".

Employment (FIET: total employment, man-years, finance) may be lowered if labour productivity improves. In the TIM model this will lead to higher profits (FIRC: return to capital, finance, insurance and real estate), but a downward adjustment to profits can be made if it is assumed that consumers receive the "rent" in the form of lower prices.

Introduction of New Consumer Products/Services

The first decision in this scenario is whether the new products or services are imported or produced domestically. If they are produced in Canada, are they sufficiently similar to electronic products to be included in that industry, or is it necessary to create a new domestic supply industry in the Input-Output table? Consumer expenditure must be redistributed to these new products or services and away from others. As with the supply industry, this new consumer expenditure could be considered an increase in the existing "household appliances" category, or a new type of consumer expenditure could be established.

To the extent that significant changes occur in the mix of consumer expenditure, towards the new items and away from existing consumer expenditure categories, the appropriate industry employment and output adjustments will occur automatically, in response to the shifting demand patterns.

CHAPTER 5

A Preliminary Simulation: Increased Automation in the Textile Industry

This chapter, and the two simulations described here, serve three purposes: (1) they demonstrate the use of a macroeconomic model such as TIM, for impact analysis; (2) they illustrate the impact of "high productivity", "new technology" investment; and (3) they show the difference between this new type of investment, and what has elsewhere been termed "normal" investment. It is important to recognize that any "base" forecast of economic performance already incorporates productivity improvements to both labour and capital. Secondly, the impact of an increase in "normal" investment will further ameliorate productivity, although perhaps not to the same extent as the introduction of a new technology. These two points raise an important question, which remains unresolved, at this stage. That is: how much of the new technologies, and their implicit productivity gains are already included in the base forecast?

The impact of increased investment by a particular industry, can be traced through the economy in a manner analogous to the two-phase diagram which appeared in the Introduction. The direct impact of investment by the textile industry is increased demand to suppliers of the investment goods and services and increased productive capacity, or a direct improvement in productivity in the textile industry. The suppliers of the investment goods are now in a position to increase their output and demand for inputs, and similarly the textile industry is in a position to increase its output and hire more (or less) people, (depending on the labour requirements to operate the new machinery and equipment) or sell its product at a more competitive price. These may be considered indirect effects and are replicated in a model through input-output relationships. The final impact which closes the chain of events as a simultaneous system, is the induced impact, which results as employees or consumers spend their increased incomes, or corporations invest more, from their increased returns. This final set of reactions results in the multiplier effects commonly analysed in a macroeconomic impact. That is, the change in the economy's real output (or Gross National Expenditure) is greater than the real investment which initiated the change.

For this demonstration of the use of TIM, two simulations were run to illustrate (a) the impact of a "normal" investment expenditure by the textile, knitting and clothing industries, and (b) the impact of the same magnitude of investment directed towards "new technology", high productivity machinery and equipment. In both cases, the textile industry and the knitting and clothing industry were assumed to each increase real investment in machinery and equipment by 10% per annum (over base case levels) for five years, 1980-1984. In the first instance, the investment feeds through the model in its "normal" fashion, while in the second instance a substantial productivity gain was assumed, and the additional workers in the textile and knitting and clothing industries, as a result of the investment, were cut by about 50%. Furthermore, the benefits from this productivity improvement in the second case were assumed to accrue to consumers through lower prices.

Each simulation is discussed separately below, and is compared to the base case (The National Forecast Service, Post-Workshop - II December 1979). (A set of detailed comparative results has been provided to the Department of Communications under separate cover.) Summary tables for each case appear at the end of this Chapter.

"Normal" Increased Investment by the Textile Industry

Investment in machinery and equipment by the textile, and knitting and clothing industries is increased by a total of $13 million (1971$) each year from 1980 to 1984. This represents an additional 10% investment annually in machinery and equipment for each industry. The resultant impact is discussed in general terms, with specific industry-related detail where appropriate.

By 1984, the cumulative increase to investment is $65 million (1971$). Focussing on the impact in 1980 and 1984, GNE (real Gross National Expenditure) is $20.8 million (1971$) above the base case in the first year of the impact, and $104.6 million higher in 1984, the peak impact year. This difference is the result, in 1980, of the following increases: $2.4 million in consumption; investment, $14.1 million; $0.3 million in government expenditure; $0.2 million in exports and -$1.7 million in imports. By 1984 consumption is $19.4 million higher than the base case; investment, $34.3 million; government expenditure, $5.1 million; exports, $6.1 million; and imports, -$29.1 million.

On the consumption side, the response is attributed to increased real incomes as opposed to particular relative price declines. For this reason, the change is centred on highly income elastic expenditure items, such as recreational equipment, new cars, hotels and restaurants and other purchases of durables and services. Since there is no specific consumer price response in textiles or clothing to the incremental investment in those industries, consumer expenditure on these items is not greatly altered from the base case.

Of the change in total investment, the bulk of tit is in machinery and equipment, or $13.4 million in 1980 and $25.8 million in 1984. The change in government expenditure (on goods and services) is fairly evenly distributed across the various categories, in response to increased demand for services by consumers. The minor change in exports results from increased capacity of certain industries, and a slight advance due to the "normal" productivity implicit in any investment. The major change in imports is a drop in clothing imports, due to increased domestic capacity in both knitting and clothing and the textiles industries. Part of this drop is offset by small increases in other imports, such as industrial machinery, to meet the demands of the incremental investment.

Real domestic product for the total economy is up $19.6 million in 1980 relative to the base case and $103.6 million in 1984. Slightly more than half of this change is in the manufacturing sector: $11.3 million in 1980 and $56.8 million in 1984. The two industries in which investment was increased MA05Y (RDP, textile industry) and MA67Y (RDP, knitting and clothing industry) show output increments of $2.5 million and $0.8 million respectively, in 1980, and $14.2 million and $6.6 million in 1984. While consumer expenditure on clothing has not changed much in this particular simulation, clothing imports are lower, with the result that the domestic industry supplies a greater share of the market. As well there is an increased indirect demand for textile and other knitting and clothing products due to the higher level of economic activity more generally. Industries which supply inputs to the textile and clothing industries also show a significant rise in output - in this case the chemicals industries (for man-made fibres).

On the employment side an additional 1,000 man-years of employment result from the incremental investment in 1980, and by 1984 the increase over the base case has risen to 5,156 man-years. Although there is no further exogenous addition to textile or clothing investment after 1984, the economy continues to perform at higher activity levels, as productive capacity has increased and additional demands are placed on the economy by higher consumer and industry expenditures. Most of the employment creation is in manufacturing. For the remaining six years of the simulation 1985-1990, after the investment phase, another 4,500 man-years of employment are created annually compared to the base case. Overall labour productivity is improved, relative to the base case, in all years, although no specific assumptions were made concerning the implicit labour productivity of the additional investment.

With increased employment, the wage bills in most industries rise compared to the base case. As well, the wage bill per man-year employed is higher in this simulation, resulting in increased personal income. In current dollars, disposable income is $6.1 million above the base case in 1980, $41.2 million higher in 1984, and $84.8 million greater in 1990. In constant, 1971$ terms, however, this translates to $4.0 million in 1980, and $28.2 million in 1984, but there is no difference compared to the base case in 1990, by which time slightly higher prices have offset the nominal increment to incomes. Industry profits (or return to capital) are higher, particularly in manufacturing, during the entire period 1980-1990. Government revenues are up, due to increased taxes from a stronger economy.

On the prices side, the productivity improvement which was initially the result of investment in the textile and clothing industries, but which became more widespread through the multiplier effects, caused slower growth in prices in most industries relative to the base case. The total impact on prices is fairly small, but reverses itself by the late 1990's when prices (both at the industry and aggregate level) begin to creep slightly above base levels, due to increased demand and higher utilization of the increased productive capacity of the economy. As a direct result of increased investment in most industries, unit labour costs are slightly below base case levels, although in manufacturing, wholesale and retail trade, and services, these differences become positive later in the forecast period, as the relatively higher implicit wage rates offset the impact of productivity gains on unit labour costs.

Finally the net impact on the government and merchandise trade balances (in nominal current dollars) are considered. Although government expenditures on goods and services have increased to meet the needs of the larger economy, government transfer payments have dropped by a greater amount, as the unemployment rate has decreased. The net impact is a decline in total government expenditures relative to the base case, which, coupled with improved revenues, lowers the overall government deficit which persists through most of the period. In current dollar terms, the overall government balance is improved by $19.1 million in 1980, $118.9 million in 1984 and $189.4 million in 2000. On the merchandise trade balance, lower imports and higher exports contribute to a $1.7 million improvement in 1980, $77.2 million in 1984 and $148.6 by 1990. Approximately the same magnitude of improvement is seen in the current account balance, although over the longer run, service payments decrease and further contribute to the balance, which is $2.7 million higher in 1980; $87.6 million in 1984, and $168.0 million by 1990.

Increased Investment by the Textile Industry in High Productivity, New Technology

This simulation assumes an identical increment to investment as in the above "normal" investment case: that is, an annual addition of $13 million (1971$) from 1980 to 1984 inclusive, in the textile, knitting and clothing industries. Unlike the previous simulation, the further assumption is made that this investment is in a particularly new technology, and the "rents" generated by this investment are directed to the consumer through lower prices for textiles and clothing.

In order to effect a "super normal" productivity improvement, the impact on manufacturing employment (both man-years and hours) was adjusted downward. Since employment is not available for detailed manufacturing industries, it was assumed that the textile and knitting and clothing industries accounted for the same proportion of total manufacturing employment as represented by those industries' share of manufacturing RDP. This employment impact - attributed to those two industries - was reduced by approximately fifty percent in this productivity simulation. It is crucial to note that this productivity gain is an assumption only, and that it is not based on any specific analysis. It is an assumption which also critically affects the impact. The "second half" of this productivity simulation is the "distribution of rents". This was achieved by insuring that the lower wage bill in manufacturing, which resulted when the employment impact was dampeued (relative to the "normal" investment impact) was directed to the textile and knitting and clothing industries. The Gross Domestic Product of each industry was reduced by a share of the total decrease in the wage bill, as reflected by the employment of each industry. (The knitting and clothing industry employs roughly twice as many people as the textile industry.) This, in effect, lowers the output price of those two industries and is reflected directly in the consumer price of clothing.

An additional implicit assumption in this simulation, is that other countries have not adopted this new technology, as no change has been made to the import price for clothing. It would be expected that adoption of this technology by exporting countries would lower the import price to Canada and reduce the net impact on the economy.

The major difference between this and the "normal" investment simulation is that much higher real growth and lower prices result when the (larger) productivity improvements are included. The results of this simulation are also compared to the reference Post-Workshop - II December 1979 forecast.

In 1980 real GNE is $21.6 million above the base case, and $116.5 million higher by 1984. This increase is broken down largely between consumption: $2.6 million in 1980, $23.1 million in 1984; investment: $14.2 million in 1980 and $36.5 million in 1984; government expenditure (on goods and services) $0.3 million in 1980 and $6.7 million in 1984; exports $0.3 million and $7.5 million respectively and imports, down $1.9 million (1980) and $30.7 million (1984).

Real consumer expenditures increase in response to higher income, with notable changes in incomeelastic categories, but a much stronger gain in clothing expenditure is apparent in this simulation than in the "normal" investment case. Women's and children's clothing expenditures (1971$) are $1.65 million above the base case in 1984, and $2.8 million higher in 1990. This compares to increases of $0.6 million and $0.16 million in the same years for the "normal" investment case. The deflator CHC20P (women's and children's clothing) (1971=1.0) is down by 0.002 in 1984 and 0.0036 by 1990, relative to the base case. In the "normal" investment simulation where no particular adjustment was made to price, this deflator was down 0.0004 in 1984, from the base case, but 0.00035 higher by 1990. These changes are admittedly small, but the impact in terms of investment is also not great. However, the direct impacts in these two simulations do have the anticipated multiplier effects, and differences between the two sets of simulation results are evident.

Again investment in machinery and equipment accounts for most of the change in total investment: $13.4 million in 1980; $26.7 million in 1984. While the incremental investment ceases after 1984, there is still a considerable continuing impact on the economy, although the investment impact does taper off. By 1990, total investment is $12.3 million above the base case, of which $5.6 is in machinery and equipment.

A similar response on the export side, as in the "normal" investment is evidenced in this simulation, with real exports up $0.2 million in 1980, and $7.5 million by 1984. The import response is somewhat stronger in the "productivity" impact, as clothing imports drop more sharply. This is the result of both increased domestic productive capacity and a lower domestic price.

Real domestic product (total economy) is $20.7 million above base case levels in 1980, $115.2 million in 1984 and $95.2 in 1990. Approximately fifty percent of this gain is again in the manufacturing industry: $12.0 million in 1980; $61.8 million in 1984; and $54.6 million in 1990. The two industries of interest in this simulation, MA05Y (textiles) and MA67Y (knitting and clothing) rose $2.6 million and $0.8 million respectively in 1980; $14.3 and $7.2 million in 1984; and $15.0 and $10.6 million in 1990.

Because the real economy is relatively larger in this productivity impact than in the "normal" investment impact, a stronger impact on employment results despite the higher labour productivity assumed for the incremental investment. An additional 918 man-years employment are generated in 1980 (relative to the base case), rising to 5203 in 1984 and remaining at close to 4,800 to 5,000 man-years each year through 1990. This is marginally higher than in the "normal" investment case and occurs despite the assumption that about 500 jobs are directly lost each year in the textile industry. The total hours worked per man-year in the "productivity" simulation are slightly higher than in the "normal" investment case. To the extent that employers increase hours worked in the short-run, rather than the number employed, this is not an unreasonable result. However, fewer total hours per man-year would further increase the number employed. It is significant to note that the assumed "super" productivity gain did not result in lower employment relative to the "normal" investment case, but in fact provided significant real benefits to the economy, which more than compensated for the man-years "lost" through implementation of the new technology. The gains in employment in manufacturing are less in the "productivity" case than in the "normal" investment simulation, but are offset by larger improvements in employment in other sectors.

Before considering the impact on wages and incomes, the price side of the simulation is examined. A critical assumption in this productivity simulation is that along with the productivity gain, prices (to the consumer) for textiles and clothing are lowered (relative to the "normal" investment case). The resulting impact on consumer prices and consumer expenditure was noted above. However, with the general increase in productivity, there are no upward pressures on price in the economy, and in fact changes in most nominal measures of economic activity are not significant as compared to the base case. Most of the industry value-added deflators show marginal negative changes relative to the base case, and unit labour costs are slightly lower than base case levels. Since the CPI does not change significantly, there is little pressure for increased nominal wages. Despite this, it must be recognized that real wages per man-year do rise in this "productivity" simulation, even though there is no change in nominal wages.

On the income side, the stability of nominal wages, relative to the base case, results in no significant shift in nominal personal income, although real personal disposable income is higher than it would be in the "normal" investment case. In 1980 real disposable income is $4.4 million above the base case, in 1984, $33.7 million higher, and in 1990, $12.6 million. The wage bills of individual industries are increased relative to the base case only to the extent that employment has increased, and there is no change in the average implicit wage rate per employee. Some of the secondary benefits from general productivity improvement in manufacturing are captured by firms in increased profits. For most industries the change in profits in the "productivity" impact is comparable to the "normal" investment case. Of course, an alternative to our assumption of lower consumer prices would be higher corporate profits from the rents due to productivity gains.

Government revenues increase in this impact, as corporate tax revenues are slightly higher. However, since the impact on prices has been relatively small, the only major change in the government side is again in transfer payments. This is discussed immediately below.

With the increase in exports and net drop in imports, the merchandise trade balance is improved (in nominal terms) by $2.3 million in 1980; $83.4 million in 1984; and $171 million in 1990. The implications for the current account balance are: a drop in the deficit of $3.2 million in 1980; $96.5 million in 1984 and $198 million by 1990. On the government side, the slight change in the government balance is the result of lower transfer payments. As the unemployment rate is somewhat lower in the "productivity" case than in the "normal" investment run, transfer payments drop by more, and the improvement on the government balance is higher in this "productivity" run. In 1980, the government balance is $19.2 million above base case levels; in 1984, $120.9 million higher, and up $204.4 million in 1990.

Perhaps the most important conclusions to draw from the results of these two "demonstration" simulations are that: super-normal productivity gains need not lower employment, as they result in much stronger real growth, and less price pressure on the economy. Of course the assumptions are crucial to the impact results and the benefits would be dampened if it were assumed that all countries adopted the same technology. It is also possible to handle many other combinations or alternative distribution patterns for the "rent" which accrues from the new technology. The magnitude of the impact is a function of the assumptions and as a final note, the reader is cautioned that these are demonstration simulations only and are not meant to reflect actual technological change in either the textile or knitting and clothing industries.

TABLE 1 Summary Table of the Impact of the "Normal" Investment Simulation (Impact Minus Base Case)

(millions of 1971$ unless otherwise indicated)

	Increment to Investment	Gross National Expenditure (GNEXPK)	Consumer Expenditure (CZK)	Total Investment (TOTINV)
1980	13	20.7	2.4	14.1
1981	13	44.6	8.1	20.6
1982	13	65.9	12.5	24.9
1983	13	87.5	15.9	30.0
1984	13	104.6	19.4	34.3
1985	0	85.1	16.9	21.7
1986	0	79.2	13.2	17.9
1987	0	69.4	9.4	14.1
1988	0	62.4	5.9	10.0
1989	0	58.9	3.6	7.8
1990	0	61.9	2.8	7.6

	Exports (XPTTXK)	Imports (IMPTMK)	Government Current Expend. (GCURRK)	Personal Disposable Income (YD)
1980	0.2	-1.7	0.3	4.0
1981	1.0	-7.2	2.5	13.3
1982	2.4	-15.3	3.5	19.6
1983	4.2	-23.7	4.0	24.2
1984	6.1	-29.1	5.1	28.2
1985	7.6	-36.1	5.3	21.7
1986	8.4	-39.3	4.9	13.9
1987	8.4	-38.7	4.9	8.5
1988	8.3	-39.7	4.1	3.2
1989	8.1	-39.2	3.5	0.4
1990	8.1	-39.9	3.0	0.0

TABLE 1 - Continued

	Total Economy RDP (TEY)	Manufacturing RDP (MAY)	Textile RDP (MA05Y)	Knitting and Clothing RDP (MA67Y)
1980	19.6	11.4	2.6	0.8
1981	42.3	22.9	5.6	2.1
1982	64.1	34.9	8.7	3.7
1983	86.3	47.6	11.5	5.6
1984	103.6	56.8	14.2	6.6
1985	87.2	47.5	14.3	6.7
1986	82.4	46.6	14.1	7.4
1987	73.2	42.2	14.5	6.8
1988	68.3	41.1	14.7	7.1
1989	65.0	40.6	15.0	7.4
1990	68.8	43.8	15.0	9.0

	Total Employment ('000 man-years) (TEET)	Employment: Manufacturing ('000 man-years) (MAET)	Unemployment Rate (percent) (URATE)
1980	1.0	0.7	-0.008
1981	2.1	1.3	-0.017
1982	3.2	1.8	-0.025
1983	4.3	2.4	-0.032
1984	5.1	2.9	-0.038
1985	4.6	2.4	-0.034
1986	4.7	2.5	-0.035
1987	4.5	2.5	-0.033
1988	4.5	2.6	-0.033
1989	4.6	2.7	-0.032
1990	4.8	2.9	-0.033

TABLE 1 - Continued

	Gross National Product (million $) (GNPC)	Government Balance (million $) (GOVBAL)	Current Account Balance (million $) (CURBAL)
1980	40.8	19.2	2.7
1981	87.6	35.7	15.8
1982	135.6	59.8	38.2
1983	190.8	91.4	66.2
1984	242.7	118.9	87.6
1985	192.6	104.8	118.2
1986	206.9	122.4	136.2
1987	212.4	127.4	141.7
1988	233.8	141.7	152.4
1989	271.6	159.6	157.4
1990	339.2	189.4	168.0

Table 2 Summary Table of the Impact of the "Productivity" Investment Simulation (Impact Minus Base Case)

(Millions of 1971$ - Unless Otherwise Indicated)

	Increment to Investment	Gross National Expenditure (GNEXPK)	Consumer Expenditure (CZK)	Total Investment (TOTINV)
1980	13	21.6	2.6	14.2
1981	13	47.3	8.9	21.0
1982	13	71.2	14.0	25.8
1983	13	95.8	18.5	31.1
1984	13	116.5	23.0	36.5
1985	0	99.9	21.5	24.6
1986	0	96.0	18.4	21.2
1987	0	88.3	15.7	17.7
1988	0	82.8	12.7	13.8
1989	0	82.8	11.8	12.1
1990	0	89.0	12.0	12.3

	Exports (XPTTXK)	Imports (IMPTMK)	Government Current Expend. (GCURRK)	Personal Disposable Income (YD)
1980	0.3	-1.9	0.3	4.4
1981	1.4	-7.6	3.0	14.6
1982	3.0	-16.0	7.1	22.0
1983	5.2	-24.9	12.2	28.2
1984	7.5	-30.7	18.9	33.7
1985	9.4	-38.2	26.3	28.6
1986	10.7	-41.9	33.8	21.6
1987	11.0	-41.3	41.7	17.4
1988	11.4	-42.8	49.1	12.7
1989	11.6	-42.2	56.3	11.7
1990	12.2	-43.7	63.4	12.6

Table 2 - Continued

	Total Economy RDP (TEY)	Manufacturing RDP (MAY)	Textile RDP (MA05Y)	Knitting and Clothing RDP (MA67Y)
1980	20.7	12.0	2.6	0.8
1981	44.9	24.2	5.6	2.2
1982	69.1	37.2	8.7	3.9
1983	94.4	51.2	11.5	6.0
1984	115.2	61.8	14.3	7.1
1985	101.6	53.6	14.3	7.3
1986	99.1	53.6	14.1	8.2
1987	91.3	49.6	14.5	7.7
1988	88.5	49.3	14.6	8.2
1989	89.2	50.6	15.0	8.8
1990	95.2	54.6	15.0	10.6

	Total Employment ('000 man-years) (TEET)	Employment: Manufacturing ('000 man-years) (MAET)	Unemployment Rate (percent) (URATE)
1980	0.9	0.6	-0.009
1981	2.1	1.1	-0.025
1982	3.1	1.6	-0.049
1983	4.2	2.2	-0.080
1984	5.2	2.6	-0.118
1985	4.8	2.1	-0.151
1986	4.9	2.2	-0.186
1987	4.8	2.1	-0.219
1988	4.9	2.2	-0.252
1989	5.0	2.3	-0.286
1990	5.4	2.5	-0.320

Table 2 - Continued

	Gross National Product (million $) (GNPC)	Government Balance (million $) (GOVBAL)	Current Account Balance (million $) (CURBAL)
1980	41.7	19.2	3.2
1981	88.2	35.0	17.5
1982	134.7	59.5	41.8
1983	187.4	91.9	71.9
1984	235.4	120.9	96.5
1985	180.0	108.4	129.9
1986	189.7	127.4	151.0
1987	193.5	134.4	159.1
1988	211.0	149.7	173.6
1989	249.9	171.3	181.7
1990	318.9	204.4	198.4

CHAPTER 6

The Feasibility of a Macroeconomic Analysis of the Impact of New Technologies and the Role of Alternative Government Policies.

The purpose of the report is to assess the feasibility of carrying out a macroeconomic analysis of the impact of new technologies. The previous chapters have dealt with the findings of a literature review and of interviews with experts; a demonstration of the way in which alternative "technology" scenarios could be implemented in a "macro" framework, and finally a demonstration of the type of impact simulation which might be run. The basic information requirements for a macroeconomic impact were established, and it was recognized, in Chapter 2 that this information is not readily available for any of the technologies under consideration. The technicalities of implementing such impacts using TIM are described in detail in Chapter 3 and in Appendix A. While no particular difficulties are anticipated, the "programs" necessary to set up a new industry in the Input/Output Tables, or to adjust coefficients in the table do not currently exist. This chapter details the several stages of a full assessment of the macroeconomic impact of new technologies, that is, an analysis which is based on factual information and which can make use of new industries or changing coefficients in the Input/Output Table. However, part of the "impact" deals with the role of alternative government policies in influencing the rate of implementation of the new technologies. The ability of TIM to include such policies is the first topic discussed here.

Alternative Government Policies

Government policies can affect the adoption or rate of implementation of new technologies either from the demand or the supply side. Several mechanisms are available to government on both sides, and it is possible to introduce most of these policy changes in TIM.

On the demand side the major influencing factor is the price of the new investment (i.e. technology). Government can intervene to affect the price through: (1) changing (lowering) tariff and non-tariff barriers on imports of investment goods; or (2) reducing or removing manfuacturer's sales tax. Either measure may be introduced "across-the-board" or selectively to achieve specific relative impacts. Other measures which will influence investment might be export incentives to industries most likely to purchase the "new technology", thereby increasing their potential market, or better information of available new technologies. This latter "policy" represents a qualitative rather than a quantitative factor, and could not be readily introduced in the TIM framework. While it is possible to introduce these kinds of policies in an impact, more specific industry information would be required so that the policy could be directed to the appropriate industry. In addition an independent assessment of the magnitude of the incentive required by industry to invest more rapidly would be useful.

Turning to the supply side, the major concern would be incentives to investment to establish a supply industry.

Such incentives typically include increased capital consumption allowance; greater investment in research and development; particular tax concessions to the supplying industry once production begins. In the realm of new technologies, a further and perhaps more important incentive to investment in a domestic industry to supply new technologies would be protection from foreign competition through tariff or non-tariff barriers. However, such protection would raise the price of the technology to domestic users and offsets other stimulus to encourage implementation of the technology. While one of the objectives of establishing a domestic supply industry might be eventual production for export markets, some of the incentives for investment might not be compatible with future export of the product, in the current global trade climate.

It is possible to include such policy measures in TIM, but currently not enough specific information is available on the technologies themselves to provide meaningful results in any impact study.

Tasks Required for the Analysis of a Macroeconomic Impact of New Technologies

It is clear from previous chapters that a macroeconomic impact of new technologies is not feasible today, due to the large gaps in information which exist. This section proposes three "tasks" or projects which would be prerequisite to the macro impact analysis. New technologies may be "categorized" by user, whether industry or consumer. This is a convenient distinction, since it permits a separate analysis on the demand side which may include specific constraints facing the consumer (income/leisure time) which may not be relevant to industry. From the interviews and literature review, it appears that the greatest information gap and most uncertainty exists for consumer-oriented new technologies. The first two of the three tasks set out below would be one-time projects which would provide the necessary analytical and modelling devices to fully implement the assumptions of a new technology impact. The size of the third task, or set of tasks, would be a function of the amount of detail desired and the number of demand (or supply?) industries to be included in the impact. The estimates of man-days and costs are rough estimates only and should be viewed solely as an initial sizing of the project.

Task One

Develop the analytical tools or modifications to TIM which would permit the introduction of a new (phantom) industry in the Input/Output Table, and which would permit changes to the coefficients in the table. This would allow implementation of the changes discussed in Appendix A. The introduction of a new industry provides significant benefits to the precision of the analysis, and the adjustment of I/O coefficients may be crucial for certain new technologies. The cost (in 1980 dollars) is estimated as: $21,000.

Task Two

If consumer use or purchase of new technologies is a major concern, it will be important to model the consumer choice question to include the leisure time constraint as appropriate, in addition to the ever-present budget constraint. This would likely result in a more accurate estimation of the micro level of consumer expenditure and thereby provide more precise information for the macro impact, and particularly for the secondary impacts due to relative shifts in consumer expenditure (e.g. away from movies towards video-discs). With the expected increase in consumers' leisure time, "recreational" or leisure expenditures will become a larger or more important share of the individual's budget, and with a greater selection of goods and services, his choice will likely become more complicated rather than less. Re-estimation of the consumer expenditure "sector" of TIM to include leisure constraints is estimated to cost: $25,000.

Task Three

The prime requirement for an analysis of the impact of new technologies is information on the technologies themselves. In most instances it is probably more fruitful to focus on a particular industry and the technologies it will adopt, rather than on a technology and its many users.

Analysing the impact of new technologies by consumers requires a micro analysis of the new technology in terms of:

where it substitutes for other goods or activities in the consumer's budget; does it require complementary goods or services; what are the incentives for the consumer to make this particular purchase or investment? The micro analysis would then yield the assumptions for the macroeconomic impact. The manner in which these assumptions would be implemented in the macro framework were set out in Chapter 4, however, the micro base for the information must first be established.

On the industry side, the focus is initially on user industries. A case study approach is suggested here, to identify a particular industry and determine the specific technologies which it has, and is most likely to adopt, and the impact of these technologies. In other words, use an in-depth case study to acquire answers to the questions set out on page 11. Again this would provide the micro analysis and information for the assumptions of a macro impact. The micro analysis would identify the nature of the technology, the amount and timing of required investment, the impact of the technology on the industry's labour requirements, on its materials input mix, and would assist in identifying the distribution of "rent" from the adoption of the technology. This information would provide the basis for the macro impact of the technology on the user and other industries' RDP, on inter-industry demands, on wages, incomes, employment, etc. Given the minimal technology/industry-specific information currently available to meet the input requirements of a macroeconomic impact analysis, each industry study would be a sizable project on its own if the results are to be useful.

These two areas cover the demand side of the analysis only, and the third section of this task is a similar study of supply industries of new technologies. This part of the task would determine whether or not supply industries would be located in Canada, and under what conditions. The location of specific industries in Canada might well be contingent on a specified level of demand, however, "sensitivity analysis" to determine the differential macro impact of domestic or foreign sourcing of supply would be an integral part of this section.

Other studies currently underway, such as that of the Technological Change Group at the Economic Council of Canada might provide inputs to particular industry case studies, or determine the relative importance of specific industries in adoption of new technologies, if the industry studies are selective in coverage.

Each study in Task Three, that is, of the consumer demand, of individual industry demand and of industry supply is estimated to require approximately six man-months plus computer resources for the macroeconomic impact, or a cost of about $50,000. Each study would include (1) a micro analysis, which would provide the basis for (2) a macroeconomic impact of the adoption of new technologies by that sector (consumers) or specific industry. The analysis of supplying industries would follow the same format.

If several industries were studied it would, of course, be possible to consider the impact of the implementation of several technologies by several industries.

CHAPTER 7

Conclusions

In the previous chapters it was concluded that it would be difficult, but feasible with some resources, to undertake a macroeconomic impact of new technologies right away. The tasks which must be completed before a tenable impact study is possible, were detailed in Chapter 6. These tasks would serve to bridge the gaps in existing information and to provide the necessary inputs and assumptions for a macroeconomic impact.

However, during the preparation of this report, through the literature review and during interviews with experts, it became obvious that current thinking on the impact of new technologies and previous attempts to quantify these impacts, were plagued by inconsistencies in the assumptions and in the results. The analysis was, for the most part, partial and the issue of "rents" was typically ignored. In many ways, the lack of an integrating analytical framework is itself the cause for the lack of information for a macro impact. A macroeconomic model provides such an integrating framework as it forces consistency both at the micro level in the assumptions of the "parameters" of the new technologies, and in the impact of the technologies, as derived from the model impact.

In this respect, the continued use of macroeconomic analysis in this area is encouraged, even with minimal information inputs, as it forces the analysis into a consistent framework, and should go a long way towards removing or disproving many of the contradictory and speculative assertions on the detrimental impacts which "will" occur. Static or partial equilibrium analysis only gives part of the impact, and to date the focus of the discussion has centred on such impacts. Extrapolation of these results clearly leads to contradictory conclusions, and unacceptable impacts and policy dilemmas. The use of macroeconomic analysis forces consistency and allows simultaneous consideration of alternative policy measures to influence the adoption or impact of new technologies.

The costs of not adopting a macroeconomic framework for analysis would appear to be considerable, in terms of the uncertainty, the inconsistencies and the speculative nature of other assessments. For that reason, even an imperfect approach, using less than the optimal information on new technologies, but using a macroeconomic framework, would appear preferable. The tasks set out in Chapter 6 have been staged so that each task will individually contribute to the understanding of new technologies, and (particularly for Task Three) projects may be undertaken independently of each other. In all cases, the use of a macroeconomic framework will assist in integrating assumptions and providing a consistent approach to the issues.

APPENDIX A

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*).

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[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:

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

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:

$$(8)\quad P_g = P_qB_i + P_yB^*$$

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.

Changing the materials input mix

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 makes 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 structural 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 coefficent 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).

APPENDIX B

List of Experts Interviewed for this Report

Department of Communications	-	Hans Brune
	-	George Collins
	-	Gaston Dallaire
	-	Bev Hillman
	-	George Jull
	-	David McKendry
	-	Teresa Plowright
Industry, Trade and Commerce	-	Jack Scrimgeour
Post Office	-	Harold Nightingale
Economic Council of Canada	-	Russel Wills
Bell Northern	-	Gordon Thompson
Science Council	-	Arthur Cordell
Silverman Consulting Services Ltd.	-	Saul Silverman
Tamec Consultants	-	Michel Lafontaine
CTRI	-	Joe Halina

APPENDIX C

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