TOTAL FACTOR PRODUCTIVITY
OF CANADIAN TELECOMMUNICATIONS CARRIERS

PROJECT REPORT

TO

THE DEPARTMENT OF COMMUNICATIONS

AND TO

MEMBERS OF THE CANADIAN TELECOMMUNICATIONS

CARRIERS ASSOCIATION

BY

THE CO-CHAIRPERSONS OF THE

JOINT

DEPARTMENT OF COMMUNICATIONS

CANADIAN TELECOMMUNICATIONS CARRIERS ASSOCIATION

PROJECT

R.E. OLLEY, CTCA
C.D. LE, DOC

FEBRUARY 1984

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January 1984

Letter of Transmittal

Messrs. Ken T. Hepburn
Assistant Deputy Minister
Technology and Industry
Department of Communications

March 12, 1984

Dale Orr
Assistant Vice-President and Chief Economist
Bell Canada
Representative, Canadian Telecommunications
Carriers Association

Dear Sirs,

We are pleased to submit to you herewith the final report of the Joint Department of Communications/Canadian Telecommunications Carriers Association Project on Total Factor Productivity.

This project was launched in 1979 with the following objectives: (i) to establish a common methodology across telecommunications carriers for constructing measures of total factor productivity and for collecting related data; (ii) to explore the usefulness of total factor productivity in management, policy making, and regulation as a global measure of productivity performance; and (iii) to create a set of comparable data and analyze some of the key properties and limitations of these data when they are used for analytical purposes. The present report summarizes the findings obtained in the project.

Besides the analytical results achieved, the Total Factor Productivity Project marked an important step taken together by the Department of Communications and the Canadian Telecommunications Carriers Association to promote the standardization of data across the telecommunications industry and the application of total factor productivity measure by industry management, policy makers, and regulators. It is our hope that this initial step will be followed by actions by both the industry and the government to refine the productivity measurement methodology proposed in the report and to assist with its applications by the concerned parties.

We have been very much encouraged by the spirit of cooperation and the dedication displayed by members of the joint project team, without which the project could not have been carried out. As co-chairpersons, however, we are responsible for any error or omission that remains in the report.

We appreciate the opportunity of working in this project and are very much grateful for the constant support of the Department of Communications and the Canadian Telecommunications Carriers Association.

Yours truly,

Can D. Le — R.E. Olley

C.D. Le — R.E. Olley

Attachment

ACKNOWLEDGEMENT

The co-chairpersons would like to thank all members of the project team and the personnel of the participating companies which have been involved in this project. Their hard work and dedication are largely responsible for the progress accomplished in this difficult area.

Special thanks are addressed to Ferenc Kiss who has made a particularly important contribution to the project, especially with respect to the development of measurement methodology and the evaluation of interfirm comparisons of productivity, and to Michel Andrieu who made numerous suggestions to the various drafts of this report while serving as the co-chairperson of the project on behalf of the Department of Communications until the end of December 1983.

FOREWORD

Productivity performance has become a subject of increasing concern in this country, both in government and industry. Canada's poor performance in this regard over the last few years, both in absolute terms and in comparison with its major trading partners, has been a cause of alarm of policy makers and business executives alike. This concern reflects the central role that productivity increases play in the long term for improvements in standards of living and for maintenance of the competitiveness of Canadian industries in the face of foreign competition.

Productivity consciousness is particularly important in industries such as telecommunications which are subject to regulation and where the working of normal market forces is restricted as a result. Because the pursuit of non-economic objectives of a social and cultural nature may sometimes be in conflict with purely economic ones and because regulated firms are relatively immune from the discipline of the market place, at least in the short term, it is particularly important that the significance of productivity performance in these industries be fully recognized by decision makers, both in government and in business.

It was with these concerns in mind that the Department of Communications (DOC) and the Canadian Telecommunications Carriers Association (CTCA) launched a joint project on Total Factor Productivity in 1979. One main objective of this joint effort was to establish a common methodology across carriers for constructing measures of TFP and for collecting related data. Another major objective was to explore the usefulness of TFP in management, policy making and regulation as a global measure of productivity performance. A final major objective was to create a set of comparable data and analyze some of the key properties and limitations of these data when they are used for analytical purposes.

The present Report which we hereby submit as co-chairpersons of the project to the senior management of the DOC and to CTCA, summarizes the results of the work accomplished over the life of the project. Its findings, it must be emphasized, are of a technical nature. They do not constitute, nor should they be construed as, the expression of any official policy position by either of the sponsoring organizations.

Total Factor Productivity is a difficult and somewhat elusive subject and progress has not been easy despite the enthusiastic dedication of the project team and of the personnel of the companies which have participated in this effort. Nevertheless, we feel that substantial results have been achieved both in terms of establishing a common methodology to construct TFP indices and in identifying useful applications of these productivity measures. Further work is clearly required to build on this first step in a very complex area. We sincerely hope that this effort will be continued and that others will be inspired to contribute to this important field. We believe that it is more than worthwhile to do so.

R.E. Olley, CTCA
C.D. Le, DOC
Co-chairpersons of the project
February 1984

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EXECUTIVE SUMMARY

1. Background

In response to concerns regarding productivity declines in Canada in recent years, the Department of Communications (DOC) and the Canadian Telecommunications Carriers Association (CTCA) undertook a joint study of total factor productivity in the telecommunications industry of Canada. The objectives of this project were:

a) to improve the conclusions which can be drawn from the analysis of productivity data by creating measures of productivity which are in accord with existing theories and practices, can be readily calculated and maintained, and are consistent across the country;

b) to work towards the economic production of data which are well defined and have clearly understood properties and uses.

The project was carried out under the direction of two co-chairpersons, assisted by a Board of Control. The day-to-day work of the project was undertaken by a project team consisting of representatives of the DOC and the participating companies. It was managed by project managers appointed alternatively by CTCA and DOC.

The following five companies participated actively in the project: Alberta Government Telephones, Bell Canada, British Columbia Telephone, Teleglobe, and Telesat.

2. Concept

Regulatory authorities restrict the ability of public utilities to pursue the goal of maximum profit in the usual sense of that term as employed by economic analysts. Therefore the conventional measures of profitability under reasonable degrees of competition cannot be used to assess the economic efficiency of public utility firms. Given on the one hand the monopolistic position of these firms and, on the other hand, the constraints under which they operate, profit does not perform its normal role as an indicator of the economic efficiency of the firm. What is required is a direct measure of the overall economic efficiency of the firm or, failing that, of improvements in overall economic efficiency.

Total Factor Productivity (TFP) is a measure of the overall economic efficiency of a public utility. It is the ratio of total output to total input. Indexes of productivity measure the change in the ratio of output to input between different years. They indicate the rate at which the firm improves its ability to convert inputs of labour, capital, and materials into useful final outputs. The TFP index can be expressed as the ratio between the index of total output and the index of total input. For instance, the TFP index would show a 2% overall improvement in productivity from 1980 to 1981 if the output of a firm (Q) increased by 5%, while the total input (X) increased only by 3%. In a simple formula,

$$\text{TFP Index}_{1981} = \frac{Q_{1981}}{Q_{1980}} \Big/ \frac{X_{1981}}{X_{1980}} = 1.05/1.03 = 1.02.$$

3. Data Compilation

The methods of compilation of data described here are the result of lengthy discussions among the five participating firms. In addition they reflect the results of an extensive reworking and review for consistency, carried out by the CTCA. These methods represent a negotiated consensus on what was possible and appropriate for all firms to do given the variations between them in accounting practices, categorizations of inputs and outputs, availability of information, and other relevant matters. Compilation of the data raised the need for all participants to adapt their background data to greater or lesser degrees in order to achieve an acceptable degree of consistency. The measurement procedures are as advanced as currently possible in assembling productivity data. At the same time, the data handling processes are capable of being continued into the future, based on methods developed by this project, at very reasonable on-going costs for the participating firms.

4. Results

Total Factor Productivity measures were computed in the study for each of the five participating companies, for the terrestrial carriers and non-terrestrial carriers separately, and for the entire group. The following observations are worth mentioning here:

a) Productivity improvements have been very high in the Canadian telecommunications industry. The average annual productivity gain for the five participating companies that together account for over 80% of the annual operating revenue of the industry was 4.4% during the period 1974 to 1981. During the same period, the productivity of the Canadian economy as a whole declined by an average of 0.5% per year.

b) The measured productivity gains show very sharp year-to-year volatility. This is true for all companies and, to only a slightly lesser degree, for the totals. The measures are also volatile as between companies. While there are some years when the relative magnitudes of increase are similar between companies, in most cases there are significant differences. These variations in annual productivity gains are caused by different rates of movement of input and output indexes within and among companies.

c) There are substantial differences between firms in the overall size of their productivity gains. Among the terrestrial carriers, A.G.T., the smallest company in size and the fastest growing, has the largest productivity gains, while Bell, the largest in size and the slowest growing, has the smallest productivity gains. These growth patterns occur within a setting where increasing growth rates in output are almost always accompanied by increased productivity gains; thus the inter-firm differences in pattern are not intuitively surprising in economic terms. For the non-terrestrial carriers, Teleglobe and Telesat, high rates of output growth were accompanied by high rates of productivity growth.

d) Our analysis of comparisons of productivity indicates that some forms of comparison are possible and others are not. Inter-temporal comparisons can be made and are useful for a single firm or a single industry. Comparisons of inter-temporal movements are also useful but must be approached with caution. Meaningful inter-firm comparisons of productivity levels are not possible, given existing techniques and prospects for data assembly.

e) All of the productivity tables show a slowdown in productivity growth in the telecommunications industry in 1981, but nothing remotely resembling the productivity losses widely reported in the business press for the rest of the Canadian economy. For the two companies with longer data series (A.G.T. and Bell), there is an indication of decline in rates of productivity growth after 1975, paralleling the sharper declines in most industries of most of the North Atlantic nations.

5. Recommendations

Productivity measures are potentially useful when tracked over a period of time for managerial, regulatory, and policy making purposes. Given their relevance in telecommunications, they should be compiled on similar bases to enhance their comparability between firms, and to facilitate their aggregation into industry measures.

Accordingly, it is the conclusion of this project that the following recommendations are appropriate.

5.1 Recommendations to Industry

a) A small permanent working group should be formed to update the existing data bases in order to continue total factor productivity measurement in the future. Reliance on existing industry expertise would keep the related costs at a very low level. This working group could facilitate further data improvements and assist new participants.

b) Results should be made available to the industry and perhaps to the general public on an annual basis. The permanent working group could perform the related task.

c) Meetings should be organized at least annually for people working in, or otherwise interested in telecommunications productivity measurement. The purpose of the meetings would be to exchange views on productivity measurement, and on ways to use it for managerial and other purposes.

5.2 Recommendations to the Department of Communications

d) An extensive exploration of how to use productivity measures for rate adjustment formulae, or as the means to otherwise expedite the handling of repetitive matters in rate hearings, should be undertaken.

e) Productivity gains should be considered explicitly as part of the government's objectives for the Canadian telecommunications industry. Analyses of the productivity implications of policy proposals should be integrated to the extent possible into policy formulation wherever appropriate.

5.3 Recommendations to Industry and the Department of Communications

f) Regular meetings between industry and DOC officials interested in productivity measurement and analysis should be organized.

g) A joint industry-DOC committee should be formed to explore ways and means to identify and pursue joint initiatives which would enhance industry productivity. This committee would function as a productivity council for telecommunications.

All of these recommendations are made in full recognition that the high measured productivity gains reported here indicate that the telecommunications industry is already productivity conscious. The purpose of the recommendations is to indicate where it may be useful to take initiatives to help assure that opportunities to pursue productivity improvement are discovered and utilized for the industry.

CHAPTER 1

THE PROJECT

1.0 Introduction

Productivity gains are important in all industries, for a variety of reasons. Measurement of productivity is difficult and interpretations are complex to make. This study measures productivity in a large part of Canadian telecommunications, explains the common methodology employed for the various carriers, and assesses the principal ways in which productivity data may be interpreted.

1.1 Background

Productivity trends in Canada in recent years have caused a great deal of concern within business, government, public agencies, and the academic community. The reason for this concern is that increased productivity is the major means of increasing standards of living in Canada and it is also one of the most important underpinnings to increased competitiveness both in international markets and at home.

Recent Canadian productivity trends have been discouraging. Since the mid-1970's labour productivity gains have declined, to become negative in 1981 and 1982. Statistics Canada recently reported that labour productivity in both Canadian commercial industries and manufacturing dropped by the largest amount since the agency started to collect data on productivity in 1946.[1] Industrial output and the number of hours worked were found to have declined by 6.2% and 5.6% in 1982 respectively while output for each hour worked in manufacturing dropped 2.8% and unit labour cost rose 14.2% in the same year. Since labour compensation in manufacturing rose by only 0.2%, the increase in unit labour cost is attributable mainly to productivity decline. Similarly discouraging results are reported for total

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[1] Statistics Canada Daily, April 11, 1983.

factor productivity. For the Canadian economy as a whole, total factor productivity declined in all years but one since 1973.[1]

It is in this productivity-conscious environment that the Department of Communications (DOC) and the Canadian Telecommunications Carriers Association (CTCA) decided in 1979 to undertake a joint study of total factor productivity in the telecommunications industry in Canada. The study is based upon extensive empirical work already undertaken previously by the carriers but never before coordinated and expanded to the extent that is done here.

1.2 Objectives

As set out in the Memorandum of Understanding signed by the Department of Communications and the Canadian Telecommunications Carriers Association, the main objectives of this project were:

a) To improve the conclusions which can be drawn from the analysis of productivity data by creating measures of productivity which:

   i) are in accord with existing theories and practices;
   ii) can be readily calculated and maintained; and
   iii) are consistent across the industry.

b) To work towards the economical production of data which are well defined and have clearly understood properties and uses.

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1 A study by Data Resources of Canada reports the following annual total factor productivity gains for the Canadian economy as a whole;

1968	2.5%	1973	1.7%	1978	-1.0%
1969	1.5%	1974	-0.6%	1979	-1.5%
1970	1.0%	1975	-0.3%	1980	-2.1%
1971	3.0%	1976	2.0%	1981	-0.6%
1972	2.0%	1977	-0.0%		

For a description of methodology, see G.D. Vasic, "Energy, Productivity and Potential GNP", Canadian Long-Term Review, Fall 1982, Volume 6, No. 8, Data Resources of Canada, Toronto.

Thus, this project is primarily one of developing an appropriate methodology and of assembling consistent and clearly understood data according to the most up-to-date methods of data generation, bearing in mind the need for economical collection and manipulation.

1.3 Organization of the Project

It was originally the intent of the project to include as many telecommunications firms as possible. However, preliminary analyses of the availability and costs of data, and availability of personnel, indicated that the smaller companies might wish to stand aside and act merely as observers, at least in the initial phases of the project. It was expected that once it became clear how to produce consistent data, and how to obtain relevant component indexes and handle the administrative aspects of the project in a straightforward manner, then other companies may join. For this stage of the project, out of nine members of the Canadian Telecommunications Carriers Association, the following companies participated actively in the project: Alberta Government Telephones (A.G.T.), Bell Canada, British Columbia Telephone (B.C. Tel), Teleglobe, and Telesat.

The project was carried out under the direction of two co-chairpersons, one from the DOC and one from the CTCA, assisted by a Board of Control consisting, in its turn, of three representatives of the Department of Communications and three from the Canadian Telecommunications Carriers Association. The day-to-day work of the project was undertaken by a project team consisting of the DOC staff and consultants and representatives of the participating companies and their consultants. It was managed by project managers appointed alternatively by CTCA and DOC.

The organization of the project can be summarized as follows:

Board of Control - 2 members from DOC
- DOC Co-chairperson
- 2 members from CTCA
- CTCA Co-chairperson

Project Manager	- Alternatively appointed by DOC and CTCA, reporting to the co-chairperson and the Board of Control, for activities related to the project	
Project Team	- DOC Staff and Consultants - CTCA Staff and Consultants	Reporting to the Project Manager, for project tasks.

Working in tandem with representatives from the participating companies, it was possible to achieve three important objectives. First, company representatives could carry out their own work independently, and preserve the confidentiality of data or other matters where that consideration was relevant. Second, a process of mutual understanding could be developed which permitted a consensus to emerge among all parties as to what methods were workable and effective to apply. Third, comparability and compatibility between various companies' data could be carried to the highest possible levels without imposing undue burden on the companies. While control tended to be loose and progress sometimes slower than expected, the benefits were much increased understanding of data handling problems, and most importantly a genuine consensus on methods.

1.4 Organization of the Report

This Report consists of six further chapters, beyond this introduction. Chapter 2 presents the various concepts of total factor productivity, both from a practical and from a theoretical point of view, their methodology and their interpretation. Chapter 3 discusses the process of compilation of data and the problems encountered. Qualifications on the data collected are discussed to ensure that the exact meaning of each data item is well understood. Chapter 4 presents the results of the productivity calculations, both at the firm and industry levels. Possible applications of total factor productivity are discussed in Chapter 5, along with some analysis of applicable methodologies for the use of productivity measures in the management, policy and regulatory areas. Chapter 6 presents the conclusions of the Joint Project with respect to data compilation and applications. It also summarizes the results of analyses of the comparability of interfirm productivity data. The formal analyses are provided in Appendix C. The Report concludes with some practical recommendations for consideration by the Department of Communications and telecommunications carriers in Chapter 7.

We believe that this report has achieved its objective of making a substantial start in creating a consistent and readily applicable set of methods for productivity measurement. The present system can be refined, of course. The number of participating companies could increase, and we believe that it should. Further questions remain to be explored, and we hope that further analysis can and will occur. This project has, we believe, created the essential starting point for all such work, namely a common system of understanding, reference and application, along with an operational framework and a spirit of cooperation in attaining the project objectives.

CHAPTER 2

TOTAL FACTOR PRODUCTIVITY: CONCEPT, METHODOLOGY AND INTERPRETATION

2.0 Concept

Regulatory authorities restrict the ability of public utilities to pursue the goal of maximum profit in the usual sense of that term as employed by economic analysts. Therefore the conventional measures of profitability under reasonable degrees of competition cannot be used to assess the economic efficiency of public utility firms. Given on the one hand the monopolistic position of these firms and, on the other hand, the constraints under which they operate, profit does not perform its normal role as an indicator of the economic efficiency of the firm. What is required is a direct, aggregate measure of the economic efficiency of the firm or, failing that, of improvements in overall economic efficiency.

Total Factor Productivity is one measure of the economic efficiency of operation of a public utility.[1] Indexes of productivity growth over a number of years indicate the rate at which the firm improves its ability to convert valuable inputs of labour, capital and materials into useful final outputs. In Canadian telecommunications carriers, these measures have been developed to fairly high levels of sophistication building upon data bases and measurement originally created for Bell Canada in 1969.[2] Such measures are very useful and provide a great deal of information about the firm if they are used carefully and if they are not expected to convey an excessively large amount of detailed insight of the kind more properly generated by finer operational measures.

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1 There are, of course, numerous engineering, managerial, and operational measures of efficiency which may be employed. Firms in telecommunications use hundreds of these routinely. The total factor productivity measure parallels these measures in general concept, but is much more comprehensive, embracing all operations of the firm.

2 See R.E. Olley, Memorandum on Productivity, Canadian Transport Commission File 995, 1969, and case T-2/74, 1974.

The measurement of total factor productivity is complex, and may be implemented in many different ways. While there is often not a lot to choose as between one method and another, it is important to describe the method clearly to users, since each method conveys different properties specific to each measure. When comparing sets of productivity numbers, differences in the specific methods of handling the input data are very important for comparisons of two or more series of data. Sometimes professional judgment can determine whether the differences in data handling are consequential for the particular purpose at hand. For data intended for varied applications in management, policy, or other uses, it is important to have comparability in the methods of data compilation, because differences in methods will otherwise cause the data to be misleading in at least some contexts. Therefore, a very important part of this project's work was to assure comparability. The following pages describe the methods of measurement in some detail.

2.1 Methodology

Indexes of productivity growth measure the change in the ratio of output to input between different years. There are many ways to carry out such measures. These are not described in detail here because they are well documented elsewhere. The method employed here recognizes the costs of implementation and is, within that constraint, as close an approximation of the state of the art as is possible.[1] The methodology used to compute the rate of productivity growth of the Canadian telecommunications carriers in the present project is illustrated in Appendix B.

In the simplest case where only one output Q (say local services) is produced and only one input X (say labour) is used, the construction of the TFP index which measures the relative increase in productivity between the year of reference (say 1980) and the year for which a comparison is made (say 1981), is straightforward. The TFP index is then equal to the ratio

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1 For the background data the basic methodology is often a moving Laspeyres index based on the previous years' weights. Given the slow year-to-year change in weights for input and output values in telecommunications, this procedure normally closely approximates the Tornqvist methodology laid out below.

of the relative increase in output between the two years to the relative increase in input, that is

$$\text{TFP Index} = \frac{Q_{1981}}{Q_{1980}} \bigg/ \frac{X_{1981}}{X_{1980}},$$

where Q is usually measured in terms of constant dollar revenues and labour, X, is measured in number of hours worked. When more than one output and more than one input are used in constructing the TFP index it is necessary to develop indexes of output changes and of input changes before constructing the TFP index. This is best accomplished by means of geometric averaging of the relative changes in the individual outputs and inputs. The weight used for each output reflects its average contribution to total revenue in the two years. Similarly, the weight used for each input reflects its average contribution to total cost in the two years.[1]

For instance, in the two output case, say local (QLO) and toll (QTO), the output index for 1981 can be expressed as

$$\text{Output Index} = \frac{Q_{1981}}{Q_{1980}} = \left[\frac{QLO_{1981}}{QLO_{1980}}\right]^{FLO} \cdot \left[\frac{QTO_{1981}}{QTO_{1980}}\right]^{FTO},$$

where FLO and FTO are the relative shares of local and toll revenue respectively in total revenue for the two years together. The input index in a multiple input case can be built in a similar fashion. For instance in the three-input case, say labour (L), capital (K) and material (M), the input index can be expressed as

$$\text{Input Index} = \frac{X_{1981}}{X_{1980}} = \left[\frac{L_{1981}}{L_{1980}}\right]^{SL} \cdot \left[\frac{K_{1981}}{K_{1980}}\right]^{SK} \cdot \left[\frac{M_{1981}}{M_{1980}}\right]^{SM},$$

where SL, SK and SM represent the respective shares of labour, capital and material in total cost.

Once these two indexes have been developed, the TFP index can be constructed as before, that is

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1 See Appendix B for a numerical illustration of this process.

$$\text{TFP Index} = \frac{Q_{1981}}{Q_{1980}} \Big/ \frac{X_{1981}}{X_{1980}}.$$

It is to be noted here that "free" inputs and "free" outputs (externalities) are not reflected in this TFP index. This may be an important consideration when social benefits or costs are expected to vary from private ones.

2.2 Interpretation

Once a total factor productivity measure has been obtained, it is interesting and important to ask what accounts for the observed productivity gains. Sources of increased productivity may include economies of scale, technological change, shifts in input composition or quality, changes in output mix or quality, and many other things including increased availability of "free" inputs (e.g. warmer weather which may result in lower energy requirements and lower maintenance cost). Typically analyses of these matters are carried out making use of estimated mathematical relationships between outputs and inputs (production or cost functions).[1]

Different explanations of productivity gains have very different policy implications for a public utility. For example, if economies of scale are dominant, it might be desirable from a static efficiency point of view to let the firm operate as a regulated monopoly. On the other hand, if there are no economies of scale and if technological change and diversity of service are important then policies aimed at stimulating competition and featuring encouragement of technological improvements may be required. Information determining these and other matters is difficult to obtain, and often controversial as to both content and implication. The same considerations must be at play in comparing productivity gains, or levels, between two or more firms. Thus the difficulties encountered in explaining gains in total factor productivity for one firm are also integral elements in assessing productivity comparisons between public

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1 One very useful analysis of the sources of gains in productivity is to be found in Kiss, F. "Productivity Gains in Bell Canada", in Courville, L., de Fontenay, A., and Dobell, R. (Eds.), Economic Analysis of Telecommunications, (Amsterdam: North Holland), 1983.

utilities, and to an even higher degree than in the case for individual firms. Consistently measured series ease these problems somewhat, but by no means obviate them.

A second set of questions which may arise out of a given measured rate of productivity improvement is whether the observed gains are as large as they might have been expected to be under conditions of diligent management. Associated with these questions is the problem of whether the level of productivity (as opposed to the rate of improvement in it) is high enough. There are, of course, many engineering and operational measures of productivity levels which have been used in telecommunications over the years. These include employees per 10,000 telephones, investment per main station, and many more. All of these measures are partial productivity measures and are therefore capable of being misleading if they are not used carefully, and are not recognized to be partial.

Measures of total factor productivity, being comprehensive, leave no tangible dimensions of the firm's operation unmeasured. Thus they hold out the promise[1] that TFP may offer a method of meaningful comparison between firms if productivity as well as potential productivity can be measured for several roughly comparable firms.

A series of productivity measures for a single firm, over some period of years, has embedded within it, or underlying it, a more or less constant enterprise in terms of management process, basic technology, and other key variables. Of course market conditions change, technology and input mixes change, relative input prices change, and so on. But they may be presumed not to change very rapidly from year to year, even though they are not measurable in detail. Major shifts can be identified on the basis of observable shifts in the character of the firm's own data or environment. However, when two or more firms are to be compared as to productivity levels, these and other features of the economic nature of the firm take on very much increased significance for the meaning of resulting measures, or

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1 At this point, Bell Canada notes that considerable human and financial resources will probably be required to realize the potential of TFP measures in this area.

for even the possibility of useful comparisons. The margin for error in interfirm comparisons of productivity levels is vastly larger than it is for intra-firm comparisons of productivity movement over time.

One dimension of this problem is the issue of comparability in the technology of the firms being compared. Very little is known of the technology differences between the firms, hence comparisons between their productivity levels are very tenuous and unreliable. Probably it is even true that not much is known, in crisply measurable terms, of the technology of even one firm. While such ambiguity makes explanation of productivity gains difficult for a firm, it does not seriously impair their measurement; between firms, however, that same ambiguity impairs one's ability to measure relative levels in any meaningful way.

Inter-related with the previous problem is also a group of measurement problems which make inter-firm comparisons of productivity levels much more difficult than inter-termporal comparisons for any one firm. These problems can be grouped as accounting problems and measurement problems. Different firms use different accounting practices, for example, in respect of capitalized expenditures on materials or labour, and in general in categorizing both revenue and expenditure items. These can have very substantial but so far unexplored impacts on the resultant inter-firm comparisons of productivity levels, even when they have only a negligible impact on inter-temporal productivity gains measured for any of the firms taken alone. Direct measurement of prices and quantities of outputs and inputs have to be undertaken, and these have to be normalized (that is, made equal to 1.0) in some fashion. Just what the impact of any method of normalization is on the resultant measures is unclear, and whether it can be done at all without seriously impairing the measurement of levels is not a settled matter. For example, it is well known in comparisons of levels of income between nations that it makes a very substantial difference to the result how the normalization of prices is carried out.

These difficulties and their consequences for the interpretation of inter-firm productivity differences are laid out in detail in Appendix C, especially prepared for this Report by Ferenc Kiss, while on loan to the Department of Communications. With exactly parallel measures of productivity for different firms in the same industry, further research aimed at solving these problems may be possible; in any case the extensive set of problems involved in making detailed interpretive inter-firm comparisons may now be brought into much clearer focus. The consistently applied methodology of measurement, described above in Section 2.2 and in Appendix B, increases the usefulness of the measures presented in Chapter 4 for the various purposes to which those measures may be validly applied.

CHAPTER 3

THE DATA: METHODS

3.0 Data Compilation

This chapter describes the processes and procedures used in the compilation of the data which were utilized in the computation of partial and total factor productivity measures in the project. It addresses the measurement of inputs and outputs separately and explains the relevant qualifications to be attached to the data, and the weights to be attached to those caveats.

The methods of compilation of data described here are the result of lengthy discussions among the five participating firms. In addition they reflect the results of a review for appropriateness and consistency, and an extensive reworking, carried out by the CTCA.[1] These methods represent a negotiated consensus on what is possible and appropriate for all firms to do given the variation among them in accounting practices, categorization of inputs and outputs, availability of information, and other relevant matters. Most participants had to adapt their background data to greater or lesser degrees in order to achieve an acceptable degree of consistency. These data are reasonably consistent now, relative to current capabilities in assembling them. At the same time, the data handling processes are capable of being continued into the future, based on methods developed by this project, at very reasonable on-going costs for the participating firms.

Initially, the methods of compiling data were broadly codified in a set of worksheets made available to each of the participating companies. These worksheets, while they could in principle be treated as forms to be completed, were intended primarily to lay out a consistent format to be followed by each firm. Experience with compiling data for a small number of companies indicated that it was more efficient to utilize experienced personnel to supervise the final data assembly, rather than attempting the complete transformation of the worksheets into a detailed guide for data

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1 Review and reworking were conducted by Ferenc Kiss and Shafi A. Shaikh with the active collaboration of all five participating companies.

handling. Thus the worksheets represent only a first rough approach to thinking about measurement, but are not an efficient means for carrying it out, where the number of companies is small.

The discussion begins with input data, turning next to output measures, and finally to interpretation and limitations.

3.1 Input Data

Telecommunications companies use a wide variety of resources to produce their services. The resources that are consumed in the process of production are referred to as factor inputs or simply inputs. These inputs are grouped here into three broad categories; namely, labour, capital and material. Their costs are usually available from accounting records. The main purpose of input measurement is to generate categories which reflect the real change, that is the physical volume change in each input, net of the cost increases that are due to changes in the prices of resources.

3.1.1 Labour

The volume of labour input is measured by the number of hours worked by the employees of each company in the process of producing telecommunications services. The number of hours worked is measured or estimated in several steps which are common to all five participating companies. The number of hours paid is derived first, either directly from the individual workers' records (as in the case of A.G.T.) or from the estimated numbers of "scheduled" hours which is the product of the number of employees and the number of hours worked by an employee during the year. The former is available from the companies' records. The latter is derived from the number of workdays and the number of hours worked per day. Secondly, all hours paid but not worked (statutory holidays, vacation leave, scheduled days off, sick leave and other paid absences) are removed from the total number of hours paid to arrive at the total number of hours worked. Capitalized hours are also removed because these hours are spent on the construction of telephone plant and not directly on the production of telecommunications services, and because they are taken into account as part of the capital input.[1] The number of capitalized hours is estimated from capitalized wages which are available from the internal records of each company. In the derivation of capitalized hours, each company assumes some form of equality between the hourly costs of capitalized and expensed labour. The detailed methods of estimating capitalized hours differ from company to company according to the availability of recorded information, but these methods create no problems of comparability.

The cost of labour is calculated as the sum of all employee related expenses, including wages, salaries, payment for time not worked, company fringe benefits, and all taxes and contributions the companies are obliged to pay on behalf of their employees. The price of labour is thus the hourly rate of all employee-related expenses in each class of labour.

The labour input data of the participating companies result from a fundamentally similar measurement process. This ensures their comparability. The hours worked and the labour costs have the same definition and measure for each company. Most of the remaining differences are related to the different levels of data disaggregation among companies as well as between sub-periods of time within some of the participating companies. These differences result in some variation of aggregation procedures but they are unlikely to create a serious lack of comparability among the labour volume indexes of the companies. Some differences in disaggregation can be eliminated in the future, others will always be there due to the fact that large companies with many thousands of employees can form more employee groups than small companies with only one or two thousand employees.

Labour costs and the number of hours worked are available or estimated for a varying number of classes of labour. A.G.T. has detailed data for 49 classes of labour for the period 1975 to 1981, reflecting 11 full-time occupational groups, with four or five sub-groups to account for seniority

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1 Being the difference between total and capitalized hours worked, the number for expensed hours worked is sensitive to real changes in the use of employees (as opposed to contractors) in construction as well as to changes in accounting policies and practices which determine the working definition of capitalized labour. In order to eliminate the distorting effect of accounting changes, adjustments are made. See section 3.5 below for details.

in each occupational group, and a single group for all part-time, casual and occasional employees. Since no disaggregation is available for the years prior to 1975, the impact on the labour volume index of mix changes is estimated statistically. Bell Canada has data for a total of 27 labour classes (26 full-time and 1 part-time), going back to 1967. There are six full-time occupational groups and four or five sub-groups in each, reflecting seniority. Data on occasional employees are not collected. B.C. Tel breaks down its labour into 9 occupational groups for the period 1971 to 1981. Further breakdown is not available. Teleglobe, with fewer employees, produces labour data for 6 occupational groups, while Telesat has no labour breakdown that would be suitable for productivity measurement at this time.

The main reason for collecting labour data in detail is to permit the calculation of a weighted labour volume index for each company. This index is the weighted average of the annual rates of growth of expensed hours worked in each labour class of the given company. The weight is the percentage share of each labour class in the total labour cost of the firm. Information on labour price is required for the calculation of labour cost shares. The labour volume index calculations follow the Törnqvist method illustrated in Appendix B.

Weighted labour volume indexes recognize quality differences among different types of labour, at least to the extent these quality differences are reflected in hourly remuneration. The only company which did not provide weighted data was Telesat, where disaggregated information was not available. Telesat's labour volume index is the ratio of total expensed hours worked in two consecutive years.[1]

3.1.2 Material

Material input is a rather heterogeneous category. In addition to materials such as maintenance material, vehicle maintenance parts,

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1 It is an unweighted index which understates the volume increase in labour if the volume increase is accompanied by a change in labour mix in favour of highly paid labour, and overstates the labour volume increase if the mix changes in favour of employees with relatively low hourly remuneration. The existing crude disaggregated data for 1974 and 1980 indicate only a very slight bias.

stationery, and cleaning materials, it also includes some tools, fuel and utilities, postage, printing, travel and transfer expenses as well as various rental costs. A.G.T. and Bell Canada break down total material expense into 9 individual categories. These are generally but not fully comparable between the two firms. In both companies, changes over time in classification cause some measurement difficulties. No breakdown of total material cost is available for B.C. Tel., Teleglobe and Telesat.

Current dollar material costs are deflated into constant dollars by various price index numbers. Bell Canada uses a large number of internally measured price indexes and also some Statistics Canada price indexes to measure price changes for as many items of materials as possible. These items are grouped into 9 classes, the individual price indexes are averaged together with Bell-specific material expense weights and the resulting 9 price index numbers are reported. A.G.T. uses Statistics Canada price indexes and some of Bell's publicly available index numbers to derive the 9 price indexes in a similar manner. The lack of disaggregation of material costs prevents B.C. Tel, Teleglobe and Telesat from using the same approach. These companies deflate their total material costs by the GNE Implicit Price Index of Statistics Canada. While we recognize that the use of the GNE deflator by some companies introduces an element of bias and potential incomparability, available records do not permit further data refinement at this time.

For A.G.T. and Bell the material volume index is calculated as the Törnqvist aggregate of the growth rates of constant dollar expenses in the 9 classes of material input. Simple ratios of constant dollar total material costs are computed for the other three participants. These ratios correspond to unweighted material volume indexes, which may be biased either downward or upward.

3.1.3 Capital

The measurement of capital is more complex than the measurement of output or of other inputs. This Report describes the essential features of the methodology. As applied, the processes are very detailed; that fine detail cannot be reported here, but is known, of course, in each company.

Capital input volume is represented by the constant dollar net stock of physical capital.[1] The capital volume measures comprise all capital available to the firm for use. The measures exclude plant under construction and do not reflect variations in the actual rate of utilization. The most important consequence of this capital measurement method is that if changes occur in capacity utilization, they may influence observed movements in productivity and add to the variability of annual productivity gains.

Net capital implies that physical capital depreciates in an economic sense during its life.[2] Economic depreciation is not directly measurable. It is approximated by using accounting rates of depreciation. An exception to this is Telesat, where the economic depreciation of satellites is approximated through a measure of channel loss.[3]

The measurement of the net stock of physical capital is carried out in several steps.[4] First of all, the book value of gross plant in service[5] is broken down into a large number of categories. Secondly, plant in each

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1 There is one exception: B.C. Tel's capital input volume measure is the constant dollar gross stock of capital because net values are not available.

2 The choice of gross capital, on the other hand, seems to imply that no loss of productive capability takes place during the life of physical capital.

3 Telesat has a pronounced investment cycle and a corresponding cycle in capital utilization which are capable of transmitting dramatic fluctuations to Telesat's productivity gains. Productivity gains are low in, and high between, periods of large scale investment. Telesat also has high depreciation rates, reflecting the relatively short lives of satellites and other equipment. Because of high depreciation rates, productivity gains and their fluctuations may be significantly understated or exaggerated if care is not taken to measure depreciation in a manner appropriate to the unique circumstances faced by Telesat.

4 There is some variation among the companies and also between the early and late years of the sample period with respect to the precise manner in which these steps are carried out.

5 The simple arithmetic mean of plant in service at the beginning and at the end of the year is taken to represent average plant in service during the year. In some cases (e.g., Bell Canada) the averaging takes place after re-pricing the plant.

category is further broken down into vintage groups. Thirdly, depreciation reserves are estimated from survival curve analyses for each vintage in each category of plant.[1] These are book value depreciation reserves. Fourthly, net plant is obtained for each vintage of each category as the difference between gross plant and depreciation reserve. Fifthly, Telephone Plant Price Indexes (TPI's) yield plant translators for each vintage in each category and with these translators all three book value items (namely gross plant, depreciation reserve and net plant) can be restated into constant dollars.[2] The sixth step is to add up the category level constant dollar values of net capital within each major class of capital. (Terrestrial carriers distinguish the following six major capital classes: land (whose depreciation is zero, therefore its gross and net values are equal), buildings and leasehold improvements, central office equipment, station equipment, outside plant and general equipment. Telesat has 10 and Teleglobe has 14 classes of depreciable plant.) In the final step of the calculations, the annual rates of change in constant dollar net capital values by major class are aggregated using Törnqvist's formula to obtain the capital input volume index of each participating company. The weights are the shares of each major class in the total annual cost of capital.

For four of the five participating companies, namely A.G.T., Bell, B.C. Tel. and Teleglobe, the capital price which facilitates the calculation of annual capital costs by major class is the so called residual rate of return. Total residual return is the difference between revenue and the sum of labour and material costs. This measure assumes that all revenues are spent on factors of production (cost is equal to

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1 There are several methods to estimate plant survival and depreciation reserve. The theoretical reserve is not necessarily equal to the accounting figure for accumulated depreciation. The differences can be quite large. Theoretical depreciation reserves are reconciled with accumulated depreciation, usually at the account level.

2 However, the participants do not necessarily restate all three items. For example, A.G.T. restates gross plant and depreciation reserve and obtains net plant in constant dollars as the difference. Bell computes book value net plant and restates it into constant dollars. Restatements, on the other hand, may expand beyond the immediate needs of the productivity measure. Gross and net plant are also restated into current and previous year's dollars. Bell restates gross plant as an alternative measure to net plant.

revenue); thus, revenues which are not spent on labour or materials are spent on capital. The rate of return is simply total residual return per constant dollar unit of physical capital. The components of total residual return are depreciation, interest charges, income and capital related other taxes and profits. Teleglobe estimates total return by summing the components directly rather than using the residual method.

Because depreciation rates vary among classes of plant, the rates of return are specific to each class. In order to reflect this fact, a three-stage calculation is used by the four companies. First, total annual depreciation expense is subtracted from the total economic return on capital. This new total, comprising interest, taxes and profit, is then divided by the total volume measure of capital (that is the constant dollar net plant and land), to obtain the common portion of the rate of return to all types of plant. (There is no workable alternative but to assume that profit, taxes and interest per unit of plant are identical for all types of plant). Second, annual depreciation expense for each class of plant is divided by the volume measure of the corresponding class of plant to obtain the class-specific portion of the economic rate of return. The third step is to add together the class-specific rate of return (the depreciation component) and the common rate of return (related to profit, interest, and taxes) to obtain the full rate of economic return for each class of plant (capital). The result is a set of class-specific rates of residual economic return to capital.

Telesat's case is somewhat different from that of the other four carriers. Due to great variation in annual revenues and costs, and also to complicated lagged relationships between costs and revenues, it seems inappropriate to assume that costs are equal to revenues and to use a residual rate of return concept. A direct capital price measure is required. In this direct measure, the capital cost is broken down into a class-specific element of annual depreciation per constant dollar value of net plant (in the same way as for other participants) and a uniform (among classes) element of estimated financial costs per constant dollar net plant.[1]

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1 This kind of measure is referred to in the literature as either the "user cost" or the "rental price" of capital.

As in the case of the other two inputs, the aggregate measure for capital input is the capital volume index. It is an average of growth rates from one year to the next in each of the major classes of plant. The mathematical form is weighted geometric mean for all participants. The weights are the combined percentage shares of each class of capital in the annual total economic return to capital in the base and test years of the comparison. This is the Törnqvist index number formula.

3.1.4 Aggregation of Individual Input Categories

The three major categories of input are aggregated into a volume index of total input using the Törnqvist method. This is true in the cases of all five participating companies.

3.2 Output Data

Telecommunications carriers produce a very large number of services, therefore it is necessary to group these services into major categories. It is also necessary to distinguish between terrestrial carriers (Bell Canada, A.G.T., and B.C. Tel) and non-terrestrial carriers (Teleglobe and Telesat) because the services these two groups of carriers provide differ from each other very substantially.

3.2.1 Terrestrial Carriers

Reflecting traditional industry characteristics, output is broken down into three broad categories: local services, toll services, and miscellaneous services. Actual assembly of the data was carried out at much finer levels of detail. The deflated revenue approach is used to measure the volumes of outputs of terrestrial carriers. Revenues are readily available from the companies' accounting records. Uncollectible revenues are included in the revenue data, on the reasoning that they signify services produced, just as when the bills are collected. The deflated revenue approach constructs service price indexes with which categories of revenues are deflated into constant dollars. The output volume index in each category of services is represented by the year-to-year change in constant dollar revenues. The price indexes for the major categories of services are developed as follows.

Local Services

Bell Canada used fixed base Laspeyres price indexes until 1972 and Paasche price indexes with forecast revenue share weights thereafter. The weights are updated at the time of each rate change. The indexes result from the aggregation of a very large number of service items. A.G.T. uses an identical procedure but with the weights of a typical month, selected at the time of each rate change. For B.C. Tel, Tõrnqvist indexes are calculated for samples of 8 major sub-categories of contract primary local service and various indexes (including some proxies) are used for the remaining 10 sub-categories.

Toll Services

Toll services are disaggregated into Intra-Company, T.C.T.S.[1] and Adjacent Member[2] categories. Until 1980, Bell Canada had a different breakdown. Its services were disaggregated into several sub-categories within message toll (intra, T.C.T.S., adjacent, US and overseas) and non-message toll (WATS, TWX, Private Line and other).

For Intra-Company services, chained Laspeyres price indexes are developed by all terrestrial carriers. All three terrestrial carriers have indexes for message toll only and deflate all Intra-Company toll revenues, including non-message toll revenues, with these indexes.

Fully consistent T.C.T.S. price indexes are available for all terrestrial carriers for the period 1971 to 1981. Total revenues available for T.C.T.S. settlement by class of service are deflated using chained Laspeyres price indexes. The price indexes reflect rate changes for both message and non-message toll services. The resulting constant dollar revenues available for settlement are then distributed to each T.C.T.S. company using the current dollar settlement ratio. Prior to 1976 all inter-company (T.C.T.S.) revenue was aggregated together. From 1976 onward

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1 The TransCanada Telephone System (T.C.T.S.) was re-named Telecom Canada in 1983. Since the sample period of the project ends in 1981, the old name is used in this chapter.

2 Adjacent Member means geographically adjacent company within T.C.T.S.

these revenues are broken down into basic and competitive service revenue sub-categories. For the period 1967 to 1971, both A.G.T. and Bell Canada constructed fixed-base Laspeyres price indexes. The data series of B.C. Tel. do not reach back to the 1960's.

For Adjacent Member services, chained Laspeyres price indexes for the combined two-way message toll traffic were developed and used to deflate revenues available for Adjacent Member settlement. The procedure is similar to the price index calculations for T.C.T.S. services. B.C. Tel and A.G.T. used A.G.T. records to develop their revenues for these categories, since A.G.T.'s records permitted precise estimation of B.C. Tel's settled revenue as the residual of the total two-way originated revenue after deducting the settled revenue of A.G.T. The Adjacent Member price indexes for Bell were calculated by T.C.T.S.

Toll revenues in constant dollars are highly comparable because all of them are calculated using the same method, namely chained Laspeyres indexes. Our examination indicates that the chained Laspeyres price indexes closely approximate Törnqvist indexes, because of the very frequent chaining and because of the very slow shifts in relative proportions within toll categories.

Miscellaneous Services

For terrestrial carriers, miscellaneous service revenue is a residual category comprising all revenues that are not generated by local and toll services. The contents of this residual category vary from company to company. The greatest difference is due to different organizational arrangements for directory advertising. For instance, A.G.T. derives direct revenues from directory advertising which is part of its total revenue (thus, part of the residual over local and toll), while for Bell such revenues are received by a subsidiary (Tele-Direct) since 1971 and therefore are excluded, except for earned commissions from Tele-Direct for sales activity.

All three terrestrial carriers use the implicit price index from combined local and toll services to deflate miscellaneous revenues. The miscellaneous service volume index is the growth rate of constant (1980) dollar miscellaneous revenues in consecutive years.

3.2.2 Non-Terrestrial Carriers

For Teleglobe and Telesat, most outputs are measured in physical units and the deflated revenue approach is used only when direct volume measures are not feasible. The measure of output used by Teleglobe for its Public Telephone and Telex services is minutes of two-way (originated and terminated) traffic in each category of traffic. Telegraph service volume is measured in paid words transmitted, while for leased circuits the volume measure is the number of circuits. Telesat measures the earth segment of its output in constant dollar revenues, while the space segment is measured in channel time (months for RF channels, hours for occasional use). The Company's substantial consulting service output is measured in days. Both non-terrestrial carriers have residual miscellaneous revenue categories. These are deflated by the GNE Implicit Price Index of Statistics Canada.

A single output volume index measure for each of the two non-terrestrial carriers is calculated using the Törnqvist methodology of aggregation. Rates of change in individual outputs are weighted together with their respective revenue shares.

It should be noted that for Teleglobe and Telesat, the definitions of price and quantity differ from those used by the terrestrial companies in that price changes are defined as the residual of revenue growth after volume growth is accounted for. This implies that for Teleglobe, for example, all changes in settlement procedures, retroactive adjustments, and exchange rate fluctuations, as well as explicit price changes are included in price changes. There seems, indeed, to be no other way to handle the problem of deflating Teleglobe's revenues.

3.2.3 Aggregation of Individual Output Categories

For the purposes of this project, major categories of output are aggregated using the Törnqvist method. It has been found that the differences between the indexes obtained by the Laspeyres and Törnqvist methods are insignificant, offering some reassurance that intra-category deviation from the Törnqvist method of aggregation may have inconsequential net impacts on the output indexes.

3.3 Interpretation and Limitations

In this section the interpretation and limitations of output data are discussed around the following issues: the price-quantity relationship in local service, the allocation of toll output between carriers, and the relationship between the composition of output and total factor productivity measure.

3.3.1 Local Service Price-Quantity Relationship

The relationship

Revenue Index = Price Index X Volume Index

allows the calculation of the volume index of output in an indirect way by first calculating revenue indexes and price indexes directly and taking the volume index as their ratio in each revenue category and then aggregating the volume indexes for each class into a single output volume index. The terrestrial carriers use this approach to obtain output volume indexes in an indirect way.

Strictly speaking, the method of computing volume indexes from revenue and price indexes is not valid in the case where there is no one-to-one price-quantity relationship, that is, where revenue is not generated by all output. To some degree, this is the case of local telephone service. Because local calling carries no charge beyond the initial monthly rental, the physical quantity of local calling may fluctuate even when revenue remains unchanged. There is no current presumption that this characteristic of the measure of local output carries any systematic bias to it, but that, of course, may change in the future.

It should be noted that toll service does not have the problem just noted since any change in toll service volume causes a corresponding change in revenue.

It should further be noted that better quality service constitutes more "output", but the present indexes do not reflect that. There is every reason to believe that quality has improved over the study period, hence output measures and, a fortiori, productivity measures are downwardly biased.

3.3.2 Allocation of Toll Output Between Companies

All outputs of terrestrial carriers are measured through constant dollar values of the revenues received by the companies directly from customers. The only exception is inter-company toll where constant dollar settled revenues are used as the measure of output. That is, revenues received are effectively corrected for inter-company transfers of revenue. The reason for these inter-company transfers is for the companies to pay one another for their inputs to inter-company long distance traffic handling. Settled revenues, which are generated as a result of clearing inter-company payments, are based on a very complex set of calculations which recognize in detail the inputs made by each company to the toll network. Having examined this separation procedure, as it is called, we and our staff are satisfied that it is carried out in such a way as to impart no bias to the resultant output and productivity measures, presented here.

3.3.3 Relationship Between Composition of Output and Productivity Measure

It is necessary to analyse the composition of output in order to interpret correctly total factor productivity measures. Since production technologies vary with the type of telecommunications output produced, a change in the composition of output, for example toll service volume relative to local service, may affect the productivity measures of the firm. Consider an example in which it is possible to allocate all inputs to the production of the various types of outputs (non-joint production). In this case, there are different total factor productivity measures corresponding to different types of output. The total factor productivity measure of a multi-output company is a weighted average of the productivity measures of individual outputs and changes in the output mix of a carrier may cause changes in its total factor productivity measure, over and above any changes associated with the various individual service productivities. If at least some inputs are jointly used in the production of two or more outputs then jointness also influences the firm's productivity. At the present time, there is no operationally effective method to identify the impact of output mix changes on the productivity index of the firm.

3.4 Data Compilation: Recapitulation

This chapter has described how input and output data were derived in the present project as well as how adjustments were made to the computations in order to make the best use of the data already available from the participating companies. It also has been noted that the somewhat restrictive Laspeyres index (usually with a frequently moving base) was used at some of the lower levels of aggregation, instead of the less restrictive Törnqvist index. While the use of the latter index would be more desirable from a theoretical viewpoint, the resulting differences between the two indexes are not likely significant enough to warrant the substantial additional costs that would have been incurred had all the price indexes been re-calculated in the Törnqvist form.

Our best judgment is that, subject to the possible problems of quality and local service "quantity", these data permit the computation of reliable productivity indexes. Ad hoc arithmetic experimentation, and analyses by the working group, reveal that biases due to the techniques of compilation are likely to be small.

With all the qualifications thus made regarding the compilation of input and output data used in the project, we now proceed with the presentation of the economic accounts and of the partial and total factor productivity measures computed for each one of the participating carriers, for the two groups of carriers separately, namely terrestrial and spatial carriers, and for all the carriers as a group. These indexes are all Törnqvist indexes, by company and for the aggregates of them.

3.5 Addendum on Data Detail

It will be clear from the above discussion that an enormous number of particular operations are involved in the process of data assembly. Three aspects of this handling require brief mention for the record. These are the use of judgment, revisions, and accounting changes.

Accounting records, faithful as they are to operational and other requirements of a firm, contain many instances where they are incomplete or anomalous for purposes of economic accounting such as that involved in a productivity measure. In all such cases there is nothing to do but apply judgment as to how to reconfigure the accounting data so as to generate economic series which mean what they purport to mean and which do not contain any serious capability to bias or distort the productivity measures. As time goes by, and with the increased application of computerized techniques to data handling, the capacity to refine data will grow. Re-working of data will doubtlessly generate minor changes in individual data series in the future. Because we have been at pains to apply the best industry expertise in data handling for productivity measures and the best industry knowledge that we can find, we believe that such changes will be minimal for reasonable uses of the data. When and if they do materialize they will be normal in the sense that we have had to stop spending at some point and use experience and knowledge to bridge the small remaining gaps which are inevitably encountered. Thus, judgment in handling particular recorded data is always necessary but carries with it the corollary that revisions may be expected in future work. We believe that most revisions will indeed be of minor significance.

Accounting changes occur as time goes by, thus altering the very nature of the data records. Of particular importance here are those changes which shift expenditures from capital accounts to current accounts, and those which re-categorize revenue. Such changes affect the underlying definition of the economic data series used in the productivity measures. Where significant accounting changes have occurred, all carriers have reconfigured the first year's data after the change so as to render the company record as between those two years exactly comparable in accounting terms. Thus the data from accounting records are re-worked to appear as if the test year accounting change had not occurred. The purpose of this is to keep the firm identical between the two years in its economic data, and not, of course, to second guess the accounting change. Once the accounting change is in place for two years, the firm, of course, re-acquires economic compatability between the pairs of years, now based on the new methods of recording data. These re-calculations are necessarily approximations of what would have been, but remove artifactual movements from the data series and the resultant productivity measures. Thus the measures become more accurate estimates of real increases in economic productivity than they would have been otherwise.

We cannot leave the discussions of data assembly without a word about the achievements of A.G.T. All companies put much effort into this aspect of the project. In the case of A.G.T., however, many pre-existing data were quite embryonic for the purposes at hand. During the project, those personnel at A.G.T. who were involved revealed that by their enthusiasm and vigour enormous strides could be and were made in very short order. We note this not only because of A.G.T.'s remarkable achievement but also because we believe that its experience is of value for others who may consider carrying out such studies, starting from the earliest stages of data assembly. The cost burden is not crushing (though it is significant) and we are led to believe that tertiary learning is substantial and worth the effort.

CHAPTER 4

THE NUMERICAL RESULTS

4.0 The Economic Accounts and Productivity Measures

This chapter presents the heart of the project's work. There are essentially two sets of data presented here. The first is the economic accounts; that is, data on revenues, costs, service prices and quantities, input prices and quantities. The second set of data is the productivity indexes. All data are presented first by company then by groupings of terrestrial, non-terrestrial, and all participants together. All tables are grouped together, numbered from 1 to 40, at the end of this chapter. There are no notes to the tables showing the economic accounts because Chapter 3 already contains all relevant note material, and should be read as part of the tables. The source of all of the company tables is the companies themselves; the aggregates and the productivity indexes are obtained from the mechanized calculations carried out within the project.[1]

While the objective of the project is always discussed herein with a focus on productivity indexes, the overwhelming bulk of the work arose out of the need to generate the economic accounts from which the productivity indexes are derived. Moreover, attempts at econometric or other forms of analysis of productivity always require the economic accounting data, although researchers may be required to obtain other data as well, in order to conduct their work. Thus the economic accounts are presented, despite their volume, both to show the results of the work carried out on data and to assist in the interpretation of productivity indexes.

4.1 The Economic Accounts

The economic accounts generated for productivity measurement and economic analysis are conceptually parallel to other forms of accounts kept by firms, in that they record data which constitute a systematic set of measures reflecting certain types of facts and events.

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1 The calculations were designed and carried out by Ferenc Kiss and Bernard Lefebvre

They differ from other accounts with respect to their terms. Economic accounts contain information on the inputs and the outputs of the production process. For both inputs and outputs, the data refer to either volumes or prices separately. This is in contrast to accounting procedures which are aimed at revenues, expenses, etc., thus leaving physical and price changes unseparated.

In order to obtain data on input and output prices and volumes, economic accounting takes the year-to-year changes in revenues, costs, fixed assets, etc. and breaks these changes down into two components. One component is caused by volume changes, the other is caused by price changes. The specific procedures for making these breakdowns have been described in Chapter 3.

Economic accounts also aggregate data into broader categories. Aggregate revenues and costs are simple sums of revenue and cost items. Volumes and prices on the other hand should not be added up for purposes of economic analysis; their aggregates are always shown as index numbers which are computed as averages of rates of change. It was described in Chapter 3 how these index numbers may be arrived at through direct measurement or indirect calculations, using the following relationship

Revenue index	=	Output price index	X	Output volume index	OR	Cost index	=	Input price index	X	Input volume. index

One note of caution in reading the output tables is necessary at this point. In the output and input index calculations reported below, we eliminated the impacts of some revenue and cost shifts.[1] These shifts exist because of organizational changes (e.g., the formation of Tele-Direct altered Bell Canada's revenue data) or accounting refinements. Due to the existence of shifts in actual revenue and cost data, the product of price and volume indexes will not necessarily be equal to indexes of actual unadjusted current dollar revenues and costs.

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1 See above 3.5 for description of the procedure for handling major accounting changes.

4.2 Outputs and Inputs

There are 32 output and input related tables displayed at the end of this chapter. The tables are arranged in sets by company and by aggregate in the following order: A.G.T., Bell Canada, B.C. Tel., Teleglobe, Telesat, terrestrial carriers, non-terrestrial carriers, five-carrier aggregate. For each company and aggregate, four tables are shown.

The first table in each set (tables 1, 5, 9, 13, 17, 21, 25 and 29) contains actual current dollar revenue and cost data. As described in Chapter 3, revenues include uncollectibles, labour costs contain wages, salaries, fringe benefits and labour related taxes, material costs include a large number of non-labour expense items, and capital cost is the difference between revenue and the sum of labour and material costs. The residual method of calculating capital cost makes total cost equal to total revenue.

The second table in each set (tables 2, 6, 10, 14, 18, 22, 26 and 30) displays labour and capital data. The total number of hours worked is shown in the first column. The second column contains total labour costper hour worked. The third and fourth columns show restated plant in dollars of the current year and in constant (1980) dollars, respectively. The rate of return in the last column is the total capital cost, divided by the constant (1980) dollar value of plant.

The third table in each set contains the volume indexes of outputs and inputs. The productivity measures, discussed and shown later, are derived directly from those tables. The indexes are expressed in two different but equivalent forms. Those tables which are marked A contain index number series based on 1980 (1980 = 100), while those marked B show coefficients of growth over the previous years. The output and input volume indexes are found in the third table in each set, that is in tables 3, 7, 11, 15, 19, 23, 27 and 31.

The fourth and last table in each set (tables 4, 8, 12, 16, 20, 24, 28 and 32) provides auxiliary information on price indexes of outputs and inputs. While these index numbers are not required for the calculation of productivity measures, they offer important and interesting information for various analytical purposes. They cannot, as has been noted above, be derived directly from the preceding tables because of the impact on the underlying data of adjustments for consistency.

4.3 The Productivity Indexes

The productivity indexes presented in this section constitute the final step in the project's data handling. They combine output and input data to show the changes in productivity for each of the companies (in alphabetical order), and the aggregates of them. These are tables 33 to 40.

Each company, as well as each aggregate, is displayed on two tables labelled A and B. The A-tables show the productivity indexes. These numbers may be read straightforwardly as showing the index of real productivity, based on 1980 as 100. Productivity gains, expressed as percentage changes are shown in the B-tables. Any particular percentage change may be read as indicating that the physical productivity of the firm on aggregate rose by that percentage for the year, relative to the previous year. For instance, the fact that real physical productivity of A.G.T. rose by 9.8% from 1968 to 1969 is shown in Table 33B under the column TFP, at 1969.

All of the productivity tables contain the partial measures of output per unit of each of the three inputs: labour, material, and capital. Comments herein, while directed primarily toward the TFP measures, can be applied <u>mutatis mutandis</u> to the partial productivity measures. It is, of course, important to keep in mind that the partial measures can have only very specialized applications because each partial measure ignores the contribution of other inputs to increased output, thus measuring all increases in output against a single input.

A number of characteristics of these productivity measures are worth being underlined.

First, productivity improvements have been very high in the Canadian telecommunications industry according to all of the TFP measures shown in the first column of the B-tables. The average annual productivity gain for the five participating companies, which represent over 80% of the industry, was 4.4% during the period 1974 to 1981. During the same period, the productivity of the Canadian economy as a whole declined by an average of .5% per year.

Second, the productivity gains recorded by any of the measures shown in these tables, show very sharp year-to-year volatility. This is true for all companies and, to only a slightly lesser degree, for the totals. The measures are also volatile as between companies. While there are some years when the relative magnitudes of increase are similar between companies, in most cases there are significant differences. The cause of all these variations in the annual productivity gains is, of course, different rates of movement of input and output indexes within and among companies. An understanding of the reasons for these varied movements depends on analyses which are beyond the scope of this study.

Third, there are substantial differences between firms in the overall size of their productivity gains. Among the terrestrial carriers, A.G.T., the smallest company in size and the fastest growing, has the largest productivity gains while Bell, the largest in size and the slowest growing has the smallest productivity gains. These growth patterns occur within a setting where (as can be seen by comparing tables 3B, 7B, 11B, 15B, 19B, 23B, 27B and 31B and the TFP column in the productivity B-tables) increasing growth rates in output are almost always accompanied by increased productivity gains; thus the inter-firm differences in pattern are not intuitively surprising in economic terms. It is beyond this project's scope to assess the exact weights to be given to economies of scale, economies of technological change, network utilization, and other factors, all of which would be of potential significance in any statistical explanation of inter-firm differentials in productivity gain. For the non-terrestrial carriers, Teleglobe and Telesat, high rates of output growth were accompanied by high rates of productivity growth.

Fourth, all of the productivity tables (33 to 40) show a slowdown in productivity growth in 1981, but nothing remotely resembling the productivity losses widely reported in the business press for the rest of the country. For the two companies with longer series, that is, A.G.T. (tables 33A and B) and Bell (tables 34A and B), there is an indication of decline in rates of productivity growth after 1975, paralleling the sharper declines in most industries of most of the North Atlantic nations.

Numerous other particular features of the productivity tables, such as unusually high or low gains in particular years, patterns between the movement of partial and total factor productivity measures, or cyclical movements in the productivity gains, are all of potential interest to particular users of productivity data. Data of this kind thus offer an enormous number of potential insights and lines of inquiry. Coupled with data sets from other sources, these data permit analyses of many kinds to be carried out, all starting from an examination of the many aspects of these productivity data. As they stand, the data show the usual volatility found in productivity measures but very high overall levels for the telecommunications industry.

4.4 Conclusion

One of the functions of productivity measures is to record improvements in the rate of physical conversion of real and measurable inputs into useful final outputs. These data show impressive rates of improvement for a very large part of the Canadian telecommunications industry. Moreover, the measures are reliable in that, as has been explained in Chapter 3, a great deal of time and care has been taken to compile the data carefully and in ways which are similar between firms, thus making them internally consistent when combined into industry averages. Subject to the caveats raised in Chapter 3, we have no hesitation in regarding the economic accounts and the productivity indexes as being data of a generally good grade relative to the state-of-the art in these matters today.

But productivity measures, marking the end of one complex process of measurement as they do, also mark the beginning of another potentially even more complex set of processes. Questions may be asked concerning how high level productivity performance can be sustained, how its causes can be discovered and used to inform management, develop policies and industrial strategies, how further analyses may be carried out, what kind of events weaken productivity performance, and many other matters. While an extensive exploration of these and other related matters is beyond the scope of this project, it is appropriate to assess management applications, policy uses, and regulatory uses of productivity measures. It is to these matters that Chapter 5 now turns, not with a view to being definitive but rather intending to introduce some of the possibilities.

TABLE 1

ALBERTA GOVERNMENT TELEPHONES:

REVENUES AND COSTS IN CURRENT COLLARS (THOUSANDS)

YEAR	REVENUES				COSTS			
	LOCAL	TCLL	MISC.	TOTAL	LAEOUR	MATERIAL	CAPITAL	TOTAL
1968.	28858.	54176.	4243.	87278.	29112.	14009.	44156.	87278.
1969.	32149.	62865.	4419.	99433.	33221.	13967.	52245.	99433.
1970.	35244.	70640.	5093.	110978.	38269.	15043.	57666.	110978.
1971.	38675.	78674.	5470.	122819.	44064.	16108.	62646.	122819.
1972.	43250.	92803.	6103.	142156.	48923.	18288.	74945.	142156.
1973.	47337.	108996.	7053.	163386.	55769.	20044.	87574.	163386.
1974.	54613.	134267.	7933.	196812.	66659.	24988.	105165.	196812.
1975.	64607.	167671.	9428.	241706.	88410.	33336.	119960.	241706.
1976.	90149.	208543.	11661.	310353.	105014.	44595.	160745.	310353.
1977.	113227.	243016.	13989.	370232.	125308.	46639.	198285.	370232.
1978.	137901.	291869.	17085.	446856.	141182.	60869.	244805.	446856.
1979.	160400.	354045.	19449.	533894.	164480.	83496.	285918.	533894.
1980.	190507.	428443.	24246.	643197.	209137.	94036.	340023.	643197.
1981.	223759.	488746.	30525.	743030.	250612.	119471.	372948.	743030.

TABLE 2

ALBERTA GOVERNMENT TELEPHONES:

LABOUR AND CAPITAL DATA

YEAR	HOURS WORKED (THOUSANDS)	AVG. WAGE PER HOUR	NET CAPITAL CUR. DOLLARS (THOUSANDS)	NET CAPITAL 1980 DOLLARS (THOUSANDS)	PRICE OF CAPITAL (PERCENT)
1968.	7915.	3.6782	387006.	912621.	4.8384
1969.	7847.	4.2334	439938.	969101.	5.3911
1970.	8262.	4.6321	492863.	1028606.	5.6062
1971.	8675.	5.0797	563065.	1109463.	5.6465
1972.	8739.	5.5985	648383.	1192176.	6.2864
1973.	8941.	6.2375	729852.	1236901.	7.0801
1974.	9247.	7.2086	823443.	1267323.	8.2982
1975.	11159.	7.9224	997506.	1398281.	8.5791
1976.	11446.	9.1749	1238114.	1600559.	10.0430
1977.	12595.	9.9488	1425647.	1741667.	11.3848
1978.	13181.	10.7108	1577795.	1839040.	13.3115
1979.	13703.	12.0033	1795601.	1935766.	14.7703
1980.	16284.	12.8434	2027305.	2027305.	16.7722
1981.	17461.	14.3524	2257734.	2168144.	17.2012

TABLE 3A

ALBERTA GOVERNMENT TELEPHONES:

OUTPUT AND INPUT VOLUME INDEXES (1980=100)

YEAR	OUTPUTS				INPUTS			
	LOCAL	TOLL	MISC.	TOTAL	LABOUR	MATERIAL	CAPITAL	TOTAL
1968.	22.5039	15.7051	34.9595	18.1319	34.0545	40.1266	41.8533	39.0001
1969.	25.0706	18.2809	33.8617	20.6282	34.8866	38.1879	44.7505	40.3942
1970.	27.4841	20.7597	39.1761	23.1817	39.7727	39.0958	47.5546	43.7365
1971.	30.1595	23.1205	42.0773	25.6553	43.0644	40.1220	50.7860	46.6866
1972.	33.7270	27.2744	43.6227	29.6005	44.1065	43.8995	54.3506	49.3398
1973.	36.9144	31.8361	47.8839	33.8077	49.0942	45.7646	56.8593	52.7027
1974.	42.5879	39.2729	53.9054	40.7646	53.3490	50.9842	58.8770	55.9842
1975.	49.5779	47.4850	53.4506	48.4008	66.3174	61.0115	65.5490	65.4190
1976.	56.9832	51.3863	58.1642	53.2762	68.4781	74.2607	75.4345	73.0399
1977.	63.7852	57.7047	64.4600	59.7402	76.8973	70.0365	82.2292	78.8705
1978.	72.3865	68.6409	74.6828	69.9722	80.8346	86.1176	86.6910	84.7621
1979.	84.1963	82.6614	82.5716	83.1129	83.8678	103.2933	92.8654	91.3692
1980.	100.0000	100.0000	100.0000	100.0000	100.0000	100.0000	100.0000	100.0000
1981.	117.4545	113.2688	119.8741	114.7585	105.8808	113.7381	108.0828	108.1931

TABLE 38

ALBERTA GOVERNMENT TELEPHONES:

OUTPUT AND INPUT VOLUME INDEXES (T-1=100)

YEAR	OUTPUTS				INPUTS			
	LOCAL	TOLL	MISC.	TOTAL	LABOUR	MATERIAL	CAPITAL	TOTAL
1969.	111.4057	116.4008	96.8596	113.7674	102.4436	95.1684	106.9223	103.5746
1970.	109.6265	113.5596	115.6947	112.3791	114.0057	102.3777	106.2661	108.2742
1971.	109.7345	111.3722	107.4055	110.6701	108.2763	102.6247	106.7950	106.7453
1972.	111.8288	117.9664	103.6727	115.3778	102.4198	109.4150	107.0190	105.6830
1973.	109.4508	116.7252	109.7683	114.2134	111.3082	104.2486	104.6156	106.8157
1974.	115.3692	123.3594	112.5752	120.5779	108.6667	111.4053	103.5486	106.2265
1975.	116.4131	120.9105	99.1563	118.7324	124.3087	119.6676	111.3321	116.8527
1976.	114.9367	108.2159	108.8186	110.0730	103.2581	121.7159	115.0812	111.6494
1977.	111.9368	112.2959	110.6241	112.1329	112.2947	94.3116	109.0073	107.9827
1978.	113.4849	118.9520	115.8593	117.1276	105.1203	122.9610	105.4261	107.4701
1979.	116.3149	120.4259	110.5630	118.7797	103.7524	119.9445	107.1223	107.7949
1980.	118.7701	120.9755	121.1070	120.3183	119.2352	96.8117	107.6828	109.4460
1981.	117.4545	113.2688	119.8741	114.7585	105.8808	113.7381	108.0828	108.1931

TABLE 4A

ALBERTA GOVERNMENT TELEPHONES:

OUTPUT AND INPUT PRICE INDEXES (1980=100)

YEAR	OUTPUTS				INPUTS			
	LOCAL	TOLL	MISC.	TOTAL	LABOUR	MATERIAL	CAPITAL	TOTAL
1968.	67.3126	80.5150	50.0615	74.8372	41.8923	40.4154	29.9662	34.8298
1969.	67.3126	80.2638	53.8177	74.9422	46.6649	42.3389	33.1599	38.3111
1970.	67.3126	79.4218	53.6219	74.4299	47.1518	44.5427	34.4423	39.4917
1971.	67.3126	79.4217	53.6150	74.4294	50.1420	46.4763	35.0364	40.9435
1972.	67.3126	79.4170	57.6998	74.6659	54.3559	48.2240	39.1656	44.8414
1973.	67.3126	79.9090	60.7526	75.1374	55.6672	50.7004	43.7461	48.2499
1974.	67.3126	79.7963	60.6948	75.0628	61.2307	56.7355	50.7334	54.7141
1975.	68.4040	82.4152	72.7481	77.6409	65.3293	63.2504	51.9803	57.5037
1976.	83.0434	94.7227	82.6902	90.5690	75.1502	69.5166	60.5249	66.1316
1977.	93.1795	98.2946	89.5051	96.3526	79.6179	76.7416	68.6792	73.0516
1978.	100.0000	99.2457	94.3538	99.2882	85.1318	81.3125	80.5628	82.0413
1979.	100.0000	99.9682	97.1471	99.8718	95.0839	89.4725	88.9817	90.8747
1980.	100.0000	100.0000	100.0000	100.0000	100.0000	100.0000	100.0000	100.0000
1981.	100.0000	100.7116	105.0237	100.6649	112.4672	111.3554	101.9585	106.5064

TABLE 4B

ALBERTA GOVERNMENT TELEPHONES:

OUTPUT AND INPUT PRICE INDEXES (T-1=100)

YEAR	OUTPUTS				INPUTS			
	LOCAL	TOLL	MISC.	TOTAL	LABOUR	MATERIAL	CAPITAL	TOTAL
1969.	100.0000	99.6880	107.5032	100.1403	111.3925	104.7594	110.6579	109.9951
1970.	100.0000	98.9509	99.6361	99.3164	101.0434	105.2050	103.8671	103.0817
1971.	100.0000	100.0000	99.9873	99.9994	106.3417	104.3409	101.7249	103.6762
1972.	100.0000	99.9940	107.6186	100.3177	108.4040	103.7605	111.7856	109.5203
1973.	100.0000	100.6195	105.2908	100.6316	102.4124	105.1352	111.6951	107.6010
1974.	100.0000	99.8589	99.9049	99.9007	109.9941	111.9035	115.9725	113.3975
1975.	101.6214	103.2821	119.8590	103.4346	106.6937	111.4828	102.4576	105.0985
1976.	121.4014	114.9335	113.6664	116.6511	115.0329	109.9070	116.4382	115.0041
1977.	112.2058	103.7709	108.2414	106.3859	105.9450	110.3932	113.4726	110.4640
1978.	107.3198	100.9676	105.4173	103.0468	106.9255	105.9562	117.3032	112.3060
1979.	100.0000	100.7281	102.9604	100.5878	111.6902	110.0353	110.4500	110.7670
1980.	100.0000	100.0318	102.9367	100.1283	105.1703	111.7662	112.3827	110.0417
1981.	100.0000	100.7116	105.0237	100.6649	112.4672	111.3554	101.9585	106.5064

TABLE 5

BELL CANADA:

REVENUES AND COSTS IN CURRENT DOLLARS (THOUSANDS)

YEAR	REVENUES				COSTS			
	LOCAL	TOLL	MISC.	TOTAL	LABOUR	MATERIAL	CAPITAL	TOTAL
1967.	401654.	253680.	35879.	691213.	195877.	99600.	395736.	691213.
1968.	428528.	278840.	38719.	746087.	208457.	107650.	429980.	746087.
1969.	463328.	322595.	43228.	829150.	230404.	133843.	464903.	829150.
1970.	502515.	374834.	47298.	924647.	260108.	138849.	525690.	924647.
1971.	556696.	398489.	47587.	1002772.	276211.	171084.	555477.	1002772.
1972.	614437.	453636.	33933.	1102005.	310818.	180998.	610189.	1102005.
1973.	673835.	532933.	28590.	1235358.	351594.	200837.	682927.	1235358.
1974.	749343.	617006.	33045.	1399394.	418443.	233565.	747386.	1399394.
1975.	850271.	730074.	41130.	1621475.	500927.	255081.	865467.	1621475.
1976.	955882.	838047.	52401.	1846329.	592116.	299313.	954900.	1846329.
1977.	1072205.	939841.	62412.	2074458.	681661.	363457.	1029339.	2074458.
1978.	1225789.	1118929.	90233.	2434950.	771158.	427844.	1235948.	2434950.
1979.	1338953.	1279149.	105462.	2723564.	912926.	467202.	1343436.	2723564.
1980.	1502883.	1471378.	126866.	3101127.	1077504.	559532.	1464091.	3101127.
1981.	1778430.	1794833.	159308.	3732571.	1333245.	650120.	1749206.	3732571.

TABLE 6

BELL CANADA:

LABOUR AND CAPITAL DATA

YEAR	HOURS WORKED (THOUSANDS)	AVG. WAGE PER HOUR	NET CAPITAL CUR. DOLLARS (THOUSANDS)	NET CAPITAL 1980 DOLLARS (THOUSANDS)	PRICE OF CAPITAL (PERCENT)
1967.	56580.	3.4619	2355600.	5787939.	6.8372
1968.	54561.	3.8206	2626315.	6116405.	7.0299
1969.	55535.	4.1488	2899957.	6481249.	7.1731
1970.	56133.	4.6338	3217798.	6802793.	7.7276
1971.	55166.	5.0069	3568506.	7138326.	7.7816
1972.	55125.	5.6384	3947621.	7539881.	8.0928
1973.	57845.	6.0782	4383791.	7907737.	8.6362
1974.	61568.	6.7964	5009213.	8280967.	9.0253
1975.	61346.	8.1656	5868132.	8879031.	9.7473
1976.	64266.	9.2135	6707927.	9470018.	10.0834
1977.	66580.	10.2382	7513938.	9968113.	10.3263
1978.	71192.	10.8321	8403180.	10310127.	11.9877
1979.	72474.	12.5966	9488084.	10536358.	12.7505
1980.	74042.	14.5526	10883135.	10883135.	13.4528
1981.	81074.	16.4448	12418938.	11244448.	15.5562

TABLE 7A

BELL CANADA:

OUTPUT AND INPUT VOLUME INDEXES (1980=100)

YEAR	OUTPUTS				INPUTS			
	LOCAL	TOLL	MISC.	TOTAL	LABOUR	MATERIAL	CAPITAL	TOTAL
1967.	44.1881	25.5171	25.4509	34.1943	76.5718	42.9645	53.4874	57.1844
1968.	47.1591	28.2654	27.1973	37.0024	74.9043	44.9536	56.5014	59.0332
1969.	50.8084	32.4753	29.3820	40.8615	76.1863	53.5584	59.8095	62.9252
1970.	54.3523	35.3677	31.9063	44.0575	77.8287	53.5482	62.7789	65.0553
1971.	57.9648	36.9714	34.2293	46.6246	77.0856	63.5695	65.8814	68.5221
1972.	62.4553	41.7206	37.7531	51.2344	77.1250	65.0706	69.6044	70.9269
1973.	67.3762	48.4779	31.4176	56.6326	80.7852	68.8615	72.9664	74.4508
1974.	73.1757	55.0918	35.5907	62.7974	84.1583	72.5229	76.5828	78.0169
1975.	79.0961	62.7215	42.9766	69.6559	81.9431	70.7163	81.1433	79.5250
1976.	83.9866	68.2867	51.7555	75.0574	85.2826	75.9156	85.4932	83.7160
1977.	88.3750	74.1608	58.6643	80.2931	88.8278	82.9165	90.3553	88.5429
1978.	92.1753	82.9914	78.5740	87.2089	95.6738	90.9360	93.8206	93.9281
1979.	95.1849	90.1494	87.2552	92.4529	98.1732	91.8060	96.3783	96.1624
1980.	100.0000	100.0000	100.0000	100.0000	100.0000	100.0000	100.0000	100.0000
1981.	103.4753	111.2452	112.0401	107.4735	106.3049	102.0410	103.8906	104.3969

TABLE 7B

BELL CANADA:

OUTPUT AND INPUT VOLUME INDEXES (T-1=100)

YEAR	OUTPUTS				INPUTS			
	LOCAL	TOLL	MISC.	TOTAL	LABOUR	MATERIAL	CAPITAL	TOTAL
1968.	106.7235	110.7701	106.8619	108.2123	97.8223	104.6296	105.6349	103.2330
1969.	107.7383	114.8942	108.0327	110.4292	101.7115	119.1415	105.8549	106.5930
1970.	106.9751	108.9065	108.5915	107.8216	102.1558	99.9809	104.9647	103.3852
1971.	106.6464	104.5346	107.2805	105.8267	99.0453	118.7146	104.9421	105.3289
1972.	107.7469	112.8455	110.2948	109.8870	100.0510	102.3613	105.6510	103.5096
1973.	107.8791	116.1965	83.2185	110.5363	104.7458	105.8258	104.8302	104.9683
1974.	108.6075	113.6431	113.2825	110.8857	104.1754	105.3171	104.9562	104.7900
1975.	108.0907	113.8490	120.7526	110.9215	97.3678	97.5089	105.9550	101.9330
1976.	106.1829	108.8729	120.4271	107.7546	104.0754	107.3523	105.3608	105.2700
1977.	105.2252	108.6021	113.3489	106.9756	104.1570	109.2220	105.6871	105.7658
1978.	104.3003	111.9075	133.9382	108.6132	107.7071	109.6717	103.8352	106.0820
1979.	103.2651	108.6249	111.0484	106.0131	102.6124	100.9567	102.7261	102.3787
1980.	105.0586	110.9270	114.6064	108.1632	101.8608	108.9254	103.7578	103.9908
1981.	103.4753	111.2452	112.0401	107.4735	106.3049	102.0410	103.8906	104.3969

TABLE 8A

BELL CANADA:

OUTPUT AND INPUT PRICE INDEXES (1980=100)

YEAR	OUTPUTS				INPUTS			
	LOCAL	TOLL	MISC.	TOTAL	LABOUR	MATERIAL	CAPITAL	TOTAL
1967.	60.4899	67.5759	67.0179	63.8977	25.5834	43.5034	47.5932	39.1516
1968.	60.4714	67.0561	67.6797	63.7362	27.8325	44.9391	48.9531	40.9363
1969.	60.6861	67.5216	69.9418	64.1426	30.2452	46.8967	50.0016	42.6800
1970.	61.5272	72.0394	70.4731	66.3412	33.4239	48.6600	53.8651	46.0372
1971.	63.8920	73.2391	70.8160	68.1943	35.8353	50.5051	54.2369	47.4010
1972.	65.4610	73.8979	70.8464	69.3590	40.3046	52.1992	56.3922	50.3255
1973.	66.5460	74.7144	71.7299	70.3408	43.5264	54.7321	60.2064	53.7451
1974.	68.1379	76.1164	73.1863	71.8586	48.4199	60.2797	63.7520	58.0987
1975.	71.5282	79.1091	75.4370	75.0642	57.8886	66.4876	71.1004	66.0528
1976.	75.7303	83.4080	79.8056	79.3225	65.1363	72.3385	74.9928	71.3755
1977.	80.7278	86.1303	83.8584	83.3119	71.9941	78.4770	77.1427	75.7149
1978.	88.4862	91.6315	90.5192	90.0347	75.6183	84.2326	89.2056	83.8873
1979.	93.5992	96.4348	95.2709	94.9943	87.0018	91.7532	94.3342	91.4924
1980.	100.0000	100.0000	100.0000	100.0000	100.0000	100.0000	100.0000	100.0000
1981.	114.3602	109.6524	112.0779	111.9921	113.5568	110.0688	118.5629	115.4295

TABLE 8B

BELL CANADA:

OUTPUT AND INPUT PRICE INDEXES (T-1=100)

YEAR	OUTPUTS				INPUTS			
	LOCAL	TOLL	MISC.	TOTAL	LABOUR	MATERIAL	CAPITAL	TOTAL
1968.	99.9694	99.2308	100.9874	99.7473	108.7916	103.3000	102.8575	104.5585
1969.	100.3551	100.6942	103.3424	100.6375	108.6684	104.3562	102.1417	104.2594
1970.	101.3860	106.6909	100.7597	103.4278	110.5098	103.7600	107.7268	107.8660
1971.	103.8434	101.6653	100.4866	102.7933	107.2145	103.7917	100.6901	102.9624
1972.	102.4558	100.8996	100.0429	101.7079	112.4718	103.3543	103.9739	106.1697
1973.	101.6574	101.1049	101.2472	101.4155	107.9938	104.8524	106.7637	106.7951
1974.	102.3922	101.8764	102.0304	102.1578	111.2425	110.1360	105.8891	108.1004
1975.	104.9756	103.9317	103.0752	104.4611	119.5555	110.2984	111.5265	113.6906
1976.	105.8748	105.4342	105.7910	105.6728	112.5200	108.8001	105.4745	108.0582
1977.	106.5991	103.2638	105.0784	105.0293	110.5283	108.4858	102.8668	106.0798
1978.	109.6106	106.3871	107.9429	108.0695	105.0341	107.3341	115.6371	110.7937
1979.	105.7782	105.2420	105.2494	105.5086	115.0539	108.9283	105.7492	109.0657
1980.	106.8386	103.6970	104.9638	105.2694	114.9402	108.9881	106.0061	109.2987
1981.	114.3602	109.6524	112.0779	111.9921	113.5568	110.0688	118.5629	115.4295

TABLE 9

BRITISH COLUMBIA TELEPHONE:

REVENUES AND COSTS IN CURRENT DOLLARS (THOUSANDS)

YEAR	REVENUES				COSTS			
	LOCAL	TOLL	MISC.	TOTAL	LABOUR	MATERIAL	CAPITAL	TOTAL
1972.	106289.	114742.	8929.	229960.	80937.	28425.	120598.	229960.
1973.	117469.	132659.	10772.	260900.	92350.	33283.	135267.	260900.
1974.	129197.	163256.	13449.	305902.	114141.	38406.	153355.	305902.
1975.	154956.	194905.	15289.	365150.	129543.	43527.	192080.	365150.
1976.	187693.	235813.	17651.	441157.	158367.	52684.	230106.	441157.
1977.	216097.	270323.	21181.	507601.	162890.	75596.	269115.	507601.
1978.	241369.	318765.	22976.	583110.	185032.	76045.	322033.	583110.
1979.	263076.	371965.	27319.	662360.	221769.	86104.	354487.	662360.
1980.	286478.	442643.	30569.	759690.	248997.	98141.	412552.	759690.
1981.	345637.	521346.	36679.	903662.	298172.	125785.	479705.	903662.

TABLE 10

BRITISH COLUMBIA TELEPHONE:

LABOUR AND CAPITAL DATA

YEAR	HOURS WORKED (THOUSANDS)	AVG. WAGE PER HOUR	CAPITAL CUR. DOLLARS (THOUSANDS)	CAPITAL 1980 DOLLARS (THOUSANDS)	PRICE OF CAPITAL (PERCENT)
1972.	13042.	6.2061	1039752.	1946925.	6.1943
1973.	13863.	6.6617	1198929.	2115639.	6.3937
1974.	14749.	7.7388	1416759.	2330713.	6.5798
1975.	13797.	9.3889	1711780.	2559744.	7.5039
1976.	13077.	12.1108	2036228.	2828223.	8.1361
1977.	13110.	12.4247	2348494.	3099544.	8.6824
1978.	14661.	12.6209	2650259.	3300459.	9.7572
1979.	17270.	12.8414	3041325.	3418340.	10.3702
1980.	17640.	14.1155	3567875.	3567875.	11.5630
1981.	18632.	16.0031	4184175.	3696666.	12.9767

TABLE 11A

BRITISH COLUMBIA TELEPHONE:

OUTPUT AND INPUT VOLUME INDEXES (1980=100)

YEAR	OUTPUTS				INPUTS			
	LOCAL	TOLL	MISC.	TOTAL	LABOUR	MATERIAL	CAPITAL	TOTAL
1972.	55.1626	32.2264	38.5093	40.6823	72.5226	65.6616	53.3438	61.3330
1973.	60.8461	36.8563	46.1641	45.8517	77.3667	70.4431	57.9664	66.1089
1974.	66.9184	45.3571	57.6786	53.7613	82.5172	70.5175	63.8592	71.1104
1975.	72.8602	51.5420	61.1516	59.8178	78.4930	72.1630	70.1344	73.4797
1976.	78.0066	57.2272	63.7764	65.2296	74.7946	78.7590	77.6926	77.0027
1977.	80.1391	62.8017	71.2302	69.6515	77.5923	105.0666	85.1775	85.0589
1978.	84.8191	72.2359	74.7994	77.0795	86.8009	99.0778	90.6988	90.4618
1979.	91.9894	84.0993	89.0352	87.2728	97.4108	101.7234	95.7137	97.0194
1980.	100.0000	100.0000	100.0000	100.0000	100.0000	100.0000	100.0000	100.0000
1981.	110.1409	115.3196	114.7859	113.3032	104.1155	112.9228	106.5687	106.5842

TABLE 11B

BRITISH COLUMBIA TELEPHONE:

OUTPUT AND INPUT VOLUME INDEXES (T-1=100)

YEAR	OUTPUTS				INPUTS			
	LOCAL	TOLL	MISC.	TOTAL	LABOUR	MATERIAL	CAPITAL	TOTAL
1973.	110.3031	114.3667	119.8778	112.7068	106.6795	107.2820	108.6657	107.7868
1974.	109.9797	123.0647	124.9425	117.2503	106.6572	100.1056	110.1659	107.5656
1975.	108.8792	113.6360	106.0213	111.2656	95.1233	102.3336	109.8267	103.3318
1976.	107.0634	111.0302	104.2923	109.0471	95.2881	109.1404	110.7766	104.7945
1977.	102.7338	109.7410	111.6873	106.7789	103.7405	133.4026	109.6341	110.4622
1978.	105.8398	115.0222	105.0109	110.6646	111.8680	94.3000	106.4821	106.3519
1979.	108.4537	116.4232	119.0320	113.2243	112.2232	102.6702	105.5292	107.2491
1980.	108.7081	118.9070	112.3151	114.5833	102.6580	98.3058	104.4782	103.0721
1981.	110.1409	115.3196	114.7859	113.3032	104.1155	112.9228	106.5687	106.5842

TABLE 12A

BRITISH COLUMBIA TELEPHONE:

OUTPUT AND INPUT PRICE INDEXES (1980=100)

YEAR	OUTPUTS				INPUTS			
	LOCAL	TOLL	MISC.	TOTAL	LABOUR	MATERIAL	CAPITAL	TOTAL
1972.	67.2592	80.4373	75.8500	74.4065	46.2171	46.6252	53.5701	49.5724
1973.	67.3906	81.3151	76.3327	74.9000	49.4324	50.8881	55.2944	52.1790
1974.	67.3931	81.3151	76.2771	74.8991	57.2831	58.6590	56.9037	56.8762
1975.	74.2381	85.4294	81.7881	80.3533	68.3458	64.9645	64.8957	65.7029
1976.	83.9896	93.0919	90.5374	89.0250	87.6847	71.2256	70.3631	75.7476
1977.	94.1267	97.2428	97.2750	95.9302	86.9370	76.5098	75.0880	78.8767
1978.	99.3337	99.6928	100.4835	99.5806	88.2777	81.6163	84.3834	85.2241
1979.	99.8279	99.9209	100.3741	99.9031	91.4323	90.0089	89.6843	90.2622
1980.	100.0000	100.0000	100.0000	100.0000	100.0000	100.0000	100.0000	100.0000
1981.	109.5419	102.1339	104.5317	104.9851	110.9656	110.6128	112.2264	111.6037

TABLE 12B

BRITISH COLUMBIA TELEPHONE:

OUTPUT AND INPUT PRICE INDEXES (T-1=100)

YEAR	OUTPUTS				INPUTS			
	LOCAL	TOLL	MISC.	TOTAL	LABOUR	MATERIAL	CAPITAL	TOTAL
1973.	100.1952	101.0913	100.6364	100.6632	106.9569	109.1429	103.2187	105.2581
1974.	100.0038	100.0000	99.9272	99.9988	115.8816	115.2705	102.9106	109.0022
1975.	110.1568	105.0597	107.2250	107.2821	119.3123	110.7494	114.0447	115.5192
1976.	113.1355	108.9694	110.6976	110.7919	128.2957	109.6377	108.4250	115.2879
1977.	112.0694	104.4589	107.4418	107.7565	99.1473	107.4190	106.7149	104.1310
1978.	105.5319	102.5195	103.2984	103.8053	101.5422	106.6744	112.3794	108.0473
1979.	100.4976	100.2288	99.8911	100.3239	103.5735	110.2829	106.2819	105.9116
1980.	100.1724	100.0791	99.6273	100.0970	109.3705	111.1001	111.5023	110.7883
1981.	109.5419	102.1339	104.5317	104.9851	110.9656	110.6128	112.2264	111.6037

TABLE 13

TELEGLOEE:

REVENUES AND COSTS IN CURRENT COLLARS (THOUSANDS)

YEAR	REVENUE TOTAL	COSTS LABOUR	MATERIAL	CAPITAL	TOTAL
1972.	39547.	9084.	8134.	22329.	39547.
1973.	48696.	10103.	10012.	28581.	48696.
1974.	55631.	12014.	13213.	30404.	55631.
1975.	70947.	15397.	21369.	34181.	70947.
1976.	77821.	17537.	21000.	39284.	77821.
1977.	87575.	20344.	24589.	42642.	87575.
1978.	87042.	21478.	25218.	40346.	87042.
1979.	108236.	26285.	30612.	51339.	108236.
1980.	134564.	31969.	29312.	73283.	134564.
1981.	158784.	36538.	37759.	84487.	158784.

TABLE 14

TELEGLOBE:

LABOUR AND CAPITAL DATA

YEAR	HOURS WORKED (THOUSANDS)	AVG. WAGE PER HOUR	NET CAPITAL CUR. DOLLARS (THOUSANDS)	NET CAPITAL 1980 DOLLARS (THOUSANDS)	PRICE OF CAPITAL (PERCENT)
1972.	1206.	7.5337	160570.	284660.	7.8441
1973.	1346.	7.5066	184140.	310530.	9.2039
1974.	1452.	8.2768	280020.	352280.	8.6306
1975.	1630.	9.4454	292590.	390300.	8.7576
1976.	1815.	9.6639	337070.	402140.	9.7687
1977.	1880.	10.8207	358910.	424460.	10.0462
1978.	2101.	10.2237	357650.	440810.	9.1527
1979.	2077.	12.6576	400920.	448590.	11.4445
1980.	2185.	14.6296	461220.	461220.	15.8889
1981.	2232.	16.3699	556060.	486700.	17.3592

TABLE 15A

TELEGLOBE:

OUTPUT AND INPUT VOLUME INDEXES (1980=100)

YEAR	OUTPUT TOTAL	INPUTS LABOUR	MATERIAL	CAPITAL	TOTAL
1972.	22.2110	52.8675	57.8477	62.8363	59.3274
1973.	27.3417	59.6345	67.1612	68.3659	65.9127
1974.	34.3139	64.7034	79.8546	77.5953	74.8768
1975.	45.1570	72.9855	113.3137	85.2773	88.6542
1976.	51.8854	81.5977	100.2826	87.7503	89.0088
1977.	59.3051	84.9433	107.7036	91.6991	93.6373
1978.	69.3869	94.8816	103.1800	94.8168	96.5400
1979.	83.1255	94.7867	114.9425	96.6184	100.4016
1980.	100.0000	100.0000	100.0000	100.0000	100.0000
1981.	111.6000	103.0000	116.1000	106.0000	107.5000

TABLE 15B

TELEGLOBE:

OUTPUT AND INPUT VOLUME INDEXES (T-1=100)

YEAR	OUTPUT TOTAL	INPUTS LABOUR	MATERIAL	CAPITAL	TOTAL
1973.	123.1000	112.8000	116.1000	108.8000	111.1000
1974.	125.5000	108.5000	118.9000	113.5000	113.6000
1975.	131.6000	112.8000	141.9000	109.9000	118.4000
1976.	114.9000	111.8000	88.5000	102.9000	100.4000
1977.	114.3000	104.1000	107.4000	104.5000	105.2000
1978.	117.0000	111.7000	95.8000	103.4000	103.1000
1979.	119.8000	99.9000	111.4000	101.9000	104.0000
1980.	120.3000	105.5000	87.0000	103.5000	99.6000
1981.	111.6000	103.0000	116.1000	106.0000	107.5000

TABLE 16A

TELEGLOEE:

OUTPUT AND INPUT PRICE INDEXES (1980=100)

YEAR	OUTPUT	INPUTS			
	TOTAL	LABOUR	MATERIAL	CAPITAL	TOTAL
1972.	132.3174	53.7477	47.9703	48.4903	49.5370
1973.	132.3545	52.9936	50.8578	57.0472	54.9029
1974.	120.4810	58.0806	56.4490	53.4678	55.2129
1975.	116.7561	65.9889	64.3363	54.6951	59.4711
1976.	111.4609	67.2277	71.4411	61.0891	64.9733
1977.	109.7386	74.9167	77.8871	63.4555	69.5028
1978.	93.2229	70.8081	83.3815	58.0646	67.0028
1979.	96.7628	86.7424	90.8585	72.5078	80.1129
1980.	100.0000	100.0000	100.0000	100.0000	100.0000
1981.	105.7338	110.9631	110.9540	108.7629	109.7664

TABLE 16B

TELEGLOBE:

OUTPUT AND INPUT PRICE INDEXES (T-1=100)

YEAR	OUTPUT TOTAL	INPUTS LABOUR	MATERIAL	CAPITAL	TOTAL
1973.	100.0280	98.5971	106.0192	117.6466	110.8321
1974.	91.0290	109.5992	110.9938	93.7254	100.5646
1975.	96.9084	113.6160	113.9726	102.2955	107.7123
1976.	95.4647	101.8773	111.0432	111.6903	109.2519
1977.	98.4548	111.4372	109.0228	103.8737	106.9714
1978.	84.9499	94.5158	107.0543	91.5045	96.4029
1979.	103.7973	122.5035	108.9672	124.8742	119.5665
1980.	103.3455	115.2839	110.0613	137.9163	124.8239
1981.	105.7338	110.9631	110.9540	108.7629	109.7664

TABLE 17

TELESAT:

REVENUES AND COSTS IN CURRENT COLLARS (THOUSANDS)

YEAR	REVENUE TOTAL	COSTS LABOUR	MATERIAL	CAPITAL	TOTAL
1974.	28049.	3864.	2867.	25552.	32282.
1975.	31129.	4513.	3070.	29315.	36898.
1976.	29580.	4841.	3182.	30631.	38654.
1977.	29911.	5123.	3810.	29586.	38520.
1978.	31381.	5297.	3990.	26943.	36230.
1979.	48776.	6776.	5509.	34334.	46620.
1980.	57044.	8152.	7724.	38209.	54086.
1981.	49298.	10011.	8126.	30102.	48238.

TABLE 18

TELESAT:

LABOUR AND CAPITAL DATA

YEAR	HOURS WORKED (THOUSANDS)	AVG. WAGE PER HOUR	NET CAPITAL CUR. DOLLARS (THOUSANDS)	NET CAPITAL 1980 DOLLARS (THOUSANDS)	PRICE OF CAPITAL (PERCENT)
1974.	407.	9.4828	105535.	177541.	12.0079
1975.	415.	10.8792	130202.	199926.	11.7774
1976.	399.	12.1369	144321.	207131.	10.4071
1977.	405.	12.6548	148261.	195628.	10.7230
1978.	396.	13.3681	146345.	177878.	12.4213
1979.	462.	14.6782	200029.	223695.	16.3123
1980.	518.	15.7353	210377.	210377.	19.5688
1981.	562.	17.8000	162429.	152383.	20.4496

TABLE 19A

TELESAT:

OUTPUT AND INPUT VOLUME INDEXES (1980=100)

YEAR	OUTPUT TOTAL	INPUTS LABOUR	MATERIAL	CAPITAL	TOTAL
1974.	49.1157	78.6426	63.2690	94.7920	87.6799
1975.	55.1928	80.0655	61.1852	102.7161	93.3772
1976.	51.8335	76.9957	57.8445	102.6761	92.4670
1977.	52.2725	78.1440	64.4774	93.1901	86.7444
1978.	52.9975	76.4769	63.2953	84.6953	80.3003
1979.	85.2465	89.1114	79.2471	106.0774	99.5158
1980.	100.0000	100.0000	100.0000	100.0000	100.0000
1981.	103.0263	108.5537	95.1118	74.1065	82.4936

TABLE 19B

TELESAT:

OUTPUT AND INPUT VOLUME INDEXES (T-1=100)

YEAR	OUTPUT	INPUTS			
	TOTAL	LABOUR	MATERIAL	CAPITAL	TOTAL
1975.	112.3730	101.8094	96.7064	108.3595	106.4979
1976.	93.9135	96.1659	94.5402	99.9611	99.0253
1977.	100.8469	101.4913	111.4667	90.7613	93.8111
1978.	101.3870	97.8666	98.1666	90.8844	92.5712
1979.	160.8502	116.5207	125.2022	125.2459	123.9295
1980.	117.3068	112.2191	126.1876	94.2708	100.4866
1981.	103.0263	108.5537	95.1118	74.1065	82.4936

TABLE 20A

TELESAT:

OUTPUT AND INPUT PRICE INDEXES (1980=100)

YEAR	OUTPUT TOTAL	INPUTS LABOUR	MATERIAL	CAPITAL	TOTAL
1974.	100.1119	60.2643	58.6590	70.5484	68.0746
1975.	98.8712	69.1384	64.9645	74.6929	73.0597
1976.	100.0402	77.1314	71.2256	78.0758	77.2912
1977.	100.3095	80.4225	76.5098	83.0902	82.1036
1978.	103.8018	84.9559	81.6163	83.2563	83.4195
1979.	100.3029	93.2818	90.0089	84.7087	86.6156
1980.	100.0000	100.0000	100.0000	100.0000	100.0000
1981.	83.8825	113.1209	110.6128	106.3072	108.1160

TABLE 20B

TELESAT:

OUTPUT AND INPUT PRICE INDEXES (T-1=100)

YEAR	OUTPUT TOTAL	INPUTS LABOUR	MATERIAL	CAPITAL	TOTAL
1975.	98.7607	114.7252	110.7494	105.8747	107.3230
1976.	101.1824	111.5609	109.6377	104.5291	105.7918
1977.	100.2691	104.2670	107.4190	106.4224	106.2263
1978.	103.4815	105.6369	106.6744	100.1999	101.6027
1979.	96.6292	109.8003	110.2829	101.7445	103.8314
1980.	99.6980	107.2021	111.1002	118.0517	115.4527
1981.	83.8825	113.1209	110.6128	106.3072	108.1160

TABLE 21

TERRESTRIAL CARRIERS:

REVENUES AND COSTS IN CURRENT DOLLARS (THOUSANDS)

YEAR	REVENUE TOTAL	COSTS LABOUR	MATERIAL	CAPITAL	TOTAL
1972.	1474121.	440678.	227711.	805732.	1474121.
1973.	1659645.	499713.	254164.	905768.	1659645.
1974.	1902109.	599243.	296959.	1005907.	1902109.
1975.	2228330.	718879.	331944.	1177507.	2228330.
1976.	2597840.	855497.	396592.	1345751.	2597840.
1977.	2952290.	969859.	485692.	1496739.	2952290.
1978.	3464916.	1097371.	564758.	1802786.	3464916.
1979.	3919818.	1299175.	636802.	1983841.	3919818.
1980.	4504013.	1535638.	751709.	2216666.	4504013.
1981.	5379263.	1882029.	895376.	2601859.	5379263.

TABLE 22

TERRESTRIAL CARRIERS:

LABOUR AND CAPITAL DATA

YEAR	HOURS WORKED (THOUSANDS)	AVG. WAGE PER HOUR	CAPITAL CUR. DOLLARS (THOUSANDS)	CAPITAL 1980 DOLLARS (THOUSANDS)	PRICE OF CAPITAL (PERCENT)
1972.	76905.	5.7302	5635755.	10678983.	7.5450
1973.	80649.	6.1962	6312571.	11260277.	8.0439
1974.	85564.	7.0034	7249415.	11879003.	8.4679
1975.	86303.	8.3297	8577417.	12837057.	9.1727
1976.	88788.	9.6352	9982269.	13898800.	9.6825
1977.	92285.	10.5093	11288079.	14809324.	10.1067
1978.	99034.	11.0807	12631234.	15449627.	11.6688
1979.	103447.	12.5589	14325010.	15890464.	12.4845
1980.	107966.	14.2234	16478315.	16478315.	13.4520
1981.	117168.	16.0627	18860847.	17109258.	15.2073

TABLE 23A

TERRESTRIAL CARRIERS:

OUTPUT AND INPUT VOLUME INDEXES (1980=100)

YEAR	OUTPUT TOTAL	INPUTS LABOUR	MATERIAL	CAPITAL	TOTAL
1972.	46.1416	71.4018	62.7118	64.6215	66.3703
1973.	51.3222	75.5522	66.4020	68.0945	70.0765
1974.	57.9041	79.4348	69.7911	71.8936	73.8404
1975.	64.7254	79.2652	69.7995	76.9936	76.5352
1976.	70.0533	81.0939	76.1075	82.6025	81.0504
1977.	75.3495	85.2079	84.2746	88.2042	85.5814
1978.	82.8922	92.0735	91.4806	92.1890	92.0392
1979.	90.2070	96.0438	94.4504	95.7243	95.6218
1980.	100.0000	100.0000	100.0000	100.0000	100.0000
1981.	109.4369	105.8954	104.9351	104.9902	105.2892

TABLE 23B

TERRESTRIAL CARRIERS:

OUTPUT AND INPUT VOLUME INDEXES (T-1=100)

YEAR	OUTPUT	INPUTS			
	TOTAL	LABOUR	MATERIAL	CAPITAL	TOTAL
1973.	111.2275	105.8127	105.8843	105.3744	105.5841
1974.	112.8246	105.1389	105.1039	105.5791	105.3712
1975.	111.7805	99.7865	100.0120	107.0939	103.6496
1976.	108.2314	102.3071	109.0373	107.2849	105.8994
1977.	107.5602	105.0731	110.7310	106.7814	106.8242
1978.	110.0104	108.0575	109.5506	104.5178	106.3036
1979.	108.8245	104.3121	103.2464	103.8349	103.8925
1980.	110.8561	104.1191	105.8757	104.4667	104.5787
1981.	109.4369	105.8954	104.9351	104.9902	105.2892

TABLE 24A

TERRESTRIAL CARRIERS:

OUTPUT AND INPUT PRICE INDEXES (1980=100)

YEAR	OUTPUT TOTAL	INPUTS LABOUR	MATERIAL	CAPITAL	TOTAL
1972.	70.9317	42.6985	50.9904	53.5437	49.5086
1973.	71.7976	45.7587	53.7511	57.1214	52.7915
1974.	72.9334	51.2335	59.6290	60.7773	57.4199
1975.	76.4372	60.4211	65.8706	67.4273	64.9067
1976.	82.3350	69.8559	71.8335	72.1662	71.4031
1977.	86.9920	75.2881	77.9520	75.5763	75.8814
1978.	92.8067	78.8101	83.4675	87.1053	83.8579
1979.	96.4775	88.7329	91.2466	92.7089	91.1960
1980.	100.0000	100.0000	100.0000	100.0000	100.0000
1981.	109.1338	112.9601	110.2552	114.8351	113.4854

TABLE 24B

TERRESTRIAL CARRIERS:

OUTPUT AND INPUT PRICE INDEXES (T-1=100)

YEAR	OUTPUT TOTAL	INPUTS LABOUR	MATERIAL	CAPITAL	TOTAL
1973.	101.2208	107.1671	105.4140	106.6819	106.6310
1974.	101.5819	111.9644	110.9355	106.4002	108.7673
1975.	104.8041	117.9329	110.4674	110.9417	113.0386
1976.	107.7158	115.6151	109.0525	107.0281	110.0089
1977.	105.6562	107.7763	108.5176	104.7254	106.2717
1978.	106.6842	104.6780	107.0755	115.2547	110.5118
1979.	103.9553	112.5907	109.3280	105.4331	108.7507
1980.	103.6511	112.6978	109.5931	107.8646	109.6539
1981.	109.1338	112.9601	110.2552	114.8351	113.4854

TABLE 25

NON - TERRESTRIAL CARRIERS:

REVENUES AND COSTS IN CURRENT DOLLARS (THOUSANDS)

YEAR	REVENUE TOTAL	COSTS LABOUR	MATERIAL	CAPITAL	TOTAL
1974.	83680.	15878.	16080.	55956.	87913.
1975.	102076.	19910.	24439.	63496.	107845.
1976.	107401.	22378.	24182.	69915.	116475.
1977.	117486.	25467.	28399.	72228.	126095.
1978.	118423.	26775.	29208.	67289.	123272.
1979.	157012.	33061.	36121.	85673.	154856.
1980.	191608.	40121.	37036.	111492.	188650.
1981.	208082.	46549.	45885.	114589.	207022.

TABLE 26

NON - TERRESTRIAL CARRIERS:

LABOUR AND CAPITAL DATA

YEAR	HOURS WORKED (THOUSANDS)	AVG. WAGE PER HOUR	NET CAPITAL CUR. DOLLARS (THOUSANDS)	NET CAPITAL 1980 DOLLARS (THOUSANDS)	PRICE OF CAPITAL (PERCENT)
1974.	1859.	8.5411	385555.	529821.	9.7623
1975.	2045.	9.7362	422792.	590226.	9.7805
1976.	2214.	10.1095	481391.	609271.	9.9858
1977.	2285.	11.1457	507171.	620088.	10.2597
1978.	2497.	10.7227	503995.	618688.	10.0924
1979.	2538.	13.0251	600949.	672285.	13.0642
1980.	2703.	14.8415	671597.	671597.	17.0417
1981.	2794.	16.6577	718489.	639083.	18.0960

TABLE 27A

NON - TERRESTRIAL CARRIERS:

OUTPUT AND INPUT VOLUME INDEXES (1980=100)

YEAR	OUTPUT TOTAL	INPUTS LABOUR	MATERIAL	CAPITAL	TOTAL
1974.	38.0113	67.7179	76.5326	84.3614	79.2423
1975.	47.5568	74.5676	102.4531	92.1142	90.3704
1976.	51.5365	80.6308	91.4442	93.5579	90.3066
1977.	56.9835	83.4931	98.6973	92.0978	91.5927
1978.	64.2355	90.8341	94.8649	90.3808	91.4076
1979.	83.7651	93.5999	107.4791	100.0318	100.1723
1980.	100.0000	100.0000	100.0000	100.0000	100.0000
1981.	109.2406	104.1374	111.7208	95.1155	100.3151

TABLE 27B

NON - TERRESTRIAL CARRIERS:

OUTPUT AND INPUT VOLUME INDEXES (T-1=100)

YEAR	OUTPUT TOTAL	INPUTS LABOUR	MATERIAL	CAPITAL	TOTAL
1975.	125.1125	110.1150	133.8686	109.1899	114.0431
1976.	108.3682	108.1312	89.2547	101.5672	99.9294
1977.	110.5693	103.5499	107.9317	98.4394	101.4241
1978.	112.7265	108.7923	96.1170	98.1357	99.7980
1979.	130.4031	103.0448	113.2971	110.6782	109.5885
1980.	119.3815	106.8377	93.0413	99.9682	99.8280
1981.	109.2406	104.1374	111.7208	95.1155	100.3151

TABLE 28A

NON - TERRESTRIAL CARRIERS:

OUTPUT AND INPUT PRICE INDEXES (1980=100)

YEAR	OUTPUT TOTAL	INPUTS LABOUR	MATERIAL	CAPITAL	TOTAL
1974.	114.8935	58.4397	56.7290	59.4921	58.8088
1975.	112.0202	66.5490	64.4077	61.8264	63.2582
1976.	108.7625	69.1759	71.4032	67.0259	68.3690
1977.	107.6023	76.0253	77.6926	70.3417	72.9762
1978.	96.2162	73.4683	83.1333	66.7764	71.4867
1979.	97.8261	88.0386	90.7439	76.8173	81.9452
1980.	100.0000	100.0000	100.0000	100.0000	100.0000
1981.	99.4115	111.4106	110.8954	108.0550	109.3943

TABLE 28B

NON - TERRESTRIAL CARRIERS:

OUTPUT AND INPUT PRICE INDEXES (T-1=100)

YEAR	OUTPUT	INPUTS			
	TOTAL	LABOUR	MATERIAL	CAPITAL	TOTAL
1975.	97.4991	113.8764	113.5358	103.9236	107.5660
1976.	97.0918	103.9472	110.8613	108.4099	108.0791
1977.	98.9333	109.9014	108.8083	104.9470	106.7387
1978.	89.4183	96.6368	107.0028	94.9315	97.9590
1979.	101.6732	119.8321	109.1547	115.0367	114.6300
1980.	102.2223	113.5865	110.2002	130.1790	122.0327
1981.	99.4115	111.4106	110.8954	108.0550	109.3943

TABLE 29

FIVE CARRIERS:

REVENUES AND COSTS IN CURRENT DOLLARS (THOUSANDS)

YEAR	REVENUE TOTAL	COSTS LABOUR	MATERIAL	CAPITAL	TOTAL
1974.	1985789.	615121.	313038.	1061863.	1990022.
1975.	2330406.	738789.	356383.	1241003.	2336175.
1976.	2705241.	877875.	420774.	1415666.	2714315.
1977.	3069776.	995327.	514091.	1568967.	3078385.
1978.	3583339.	1124146.	593966.	1870075.	3588188.
1979.	4076830.	1332236.	672924.	2069514.	4074674.
1980.	4695622.	1575759.	788745.	2328158.	4692663.
1981.	5587346.	1928577.	941261.	2716447.	5586285.

TABLE 30

FIVE CARRIERS:

LABOUR AND CAPITAL DATA

YEAR	HOURS WORKED (THOUSANDS)	AVG. WAGE PER HOUR	CAPITAL CUR. DOLLARS (THOUSANDS)	CAPITAL 1980 DOLLARS (THOUSANDS)	PRICE OF CAPITAL (PERCENT)
1974.	87423.	7.0361	7634970.	12408824.	8.5232
1975.	88348.	8.3623	9000209.	13427283.	9.1994
1976.	91002.	9.6468	10463660.	14508071.	9.6952
1977.	94570.	10.5247	11795250.	15429413.	10.1129
1978.	101531.	11.0719	13135229.	16068314.	11.6081
1979.	105985.	12.5700	14925959.	16562750.	12.5080
1980.	110669.	14.2385	17149912.	17149912.	13.5926
1981.	119962.	16.0766	19579335.	17748341.	15.3113

TABLE 31A

FIVE CARRIERS:

OUTPUT AND INPUT VOLUME INDEXES (1980=100)

YEAR	OUTPUT TOTAL	INPUTS LABOUR	MATERIAL	CAPITAL	TOTAL
1974.	56.9699	79.0999	70.1111	72.4485	74.0397
1975.	63.9904	79.1383	71.3695	77.6655	77.0749
1976.	69.2609	81.0820	76.8418	83.0949	81.4110
1977.	74.5774	85.1636	84.9642	88.3870	86.7776
1978.	82.1144	92.0411	91.6458	92.1415	92.0282
1979.	89.9424	95.9814	95.0739	95.9108	95.7953
1980.	100.0000	100.0000	100.0000	100.0000	100.0000
1981.	109.4288	105.8510	105.2550	104.5245	105.0905

TABLE 31B

FIVE CARRIERS:

OUTPUT AND INPUT VOLUME INDEXES (T-1=100)

YEAR	OUTPUT TOTAL	INPUTS LABOUR	MATERIAL	CAPITAL	TOTAL
1975.	112.3232	100.0486	101.7948	107.2010	104.0994
1976.	108.2365	102.4561	107.6677	106.9907	105.6258
1977.	107.6759	105.0339	110.5702	106.3687	106.5920
1978.	110.1063	108.0756	107.8640	104.2478	106.0506
1979.	109.5330	104.2810	103.7406	104.0909	104.0934
1980.	111.1823	104.1868	105.1814	104.2635	104.3893
1981.	109.4288	105.8510	105.2550	104.5245	105.0905

TABLE 32A

FIVE CARRIERS:

OUTPUT AND INPUT PRICE INDEXES (1980=100)

YEAR	OUTPUT TOTAL	INPUTS LABOUR	MATERIAL	CAPITAL	TOTAL
1974.	74.2326	51.4120	59.4838	60.7212	57.4943
1975.	77.5575	60.5771	65.8077	67.1403	64.8444
1976.	83.1811	69.8371	71.8305	71.9089	71.2786
1977.	87.6610	75.3058	77.9586	75.3229	75.7629
1978.	92.9342	78.6668	83.4523	86.1610	83.3488
1979.	96.5306	88.7113	91.2383	91.9615	90.8154
1980.	100.0000	100.0000	100.0000	100.0000	100.0000
1981.	108.7379	112.9157	110.3051	114.5691	113.3257

TABLE 32B

FIVE CARRIERS:

OUTPUT AND INPUT PRICE INDEXES (T-1=100)

YEAR	OUTPUT TOTAL	INPUTS LABOUR	MATERIAL	CAPITAL	TOTAL
1975.	104.4790	117.8266	110.6312	110.5713	112.7839
1976.	107.2508	115.2864	109.1521	107.1024	109.9226
1977.	105.3858	107.8307	108.5314	104.7477	106.2911
1978.	106.0154	104.4632	107.0469	114.3889	110.0127
1979.	103.8699	112.7684	109.3299	106.7321	108.9582
1980.	103.5940	112.7252	109.6031	108.7412	110.1135
1981.	108.7379	112.9157	110.3051	114.5691	113.3257

TABLE 33A

ALBERTA GOVERNMENT TELEPHONES:

PRODUCTIVITY INDEXES (1980=100)

YEAR	TFP	LABOUR	MATERIAL	CAPITAL
1968.	46.4919	53.2437	45.1866	43.3224
1969.	51.0672	59.1292	54.0176	46.0959
1970.	53.0032	58.2855	59.2946	48.7476
1971.	54.9520	59.5741	63.9431	50.5164
1972.	59.9931	67.1114	67.4279	54.4621
1973.	64.1480	68.8630	73.8731	59.4586
1974.	72.8145	76.4112	79.9555	69.2370
1975.	73.9859	72.9836	79.3307	73.8392
1976.	72.9412	77.8004	71.7422	70.6258
1977.	75.7447	77.6883	85.2987	72.6508
1978.	82.5513	86.5622	81.2520	80.7146
1979.	90.9637	99.0998	80.4630	89.4982
1980.	100.0000	100.0000	100.0000	100.0000
1981.	106.0683	108.3847	100.8972	106.1764

TABLE 33B

ALBERTA GOVERNMENT TELEPHONES:

ANNUAL PRODUCTIVITY GAINS (PERCENT)

YEAR	TFP	LABOUR	MATERIAL	CAPITAL
1969.	9.8410	11.0537	19.5433	6.4020
1970.	3.7912	-1.4268	9.7691	5.7525
1971.	3.6768	2.2108	7.8397	3.6285
1972.	9.1735	12.6519	5.4498	7.8106
1973.	6.9257	2.6101	9.5587	9.1744
1974.	13.5102	10.9612	8.2335	16.4457
1975.	1.6087	-4.4858	-0.7814	6.6470
1976.	-1.4119	6.5999	-9.5656	-4.3519
1977.	3.8434	-0.1441	18.8961	2.8673
1978.	8.9863	11.4224	-4.7441	11.0993
1979.	10.1905	14.4839	-0.9711	10.8824
1980.	9.9339	0.9084	24.2808	11.7340
1981.	6.0683	8.3847	0.8972	6.1764

TABLE 34A

BELL CANADA:

PRODUCTIVITY INDEXES (1980=100)

YEAR	TFP	LABOUR	MATERIAL	CAPITAL
1967.	59.7965	44.6565	79.5872	63.9296
1968.	62.6808	49.3996	82.3125	65.4895
1969.	64.9366	53.6337	76.2933	68.3194
1970.	67.7231	56.6083	82.2764	70.1789
1971.	68.0432	60.4842	73.3443	70.7705
1972.	72.2355	66.4303	78.7366	73.6080
1973.	76.0672	70.1027	82.2413	77.6146
1974.	80.4921	74.6183	86.5898	81.9994
1975.	87.5899	85.0052	98.5004	85.8431
1976.	89.6572	88.0102	98.8696	87.7934
1977.	90.6827	90.3919	96.8361	88.8638
1978.	92.8464	91.1523	95.9014	92.9528
1979.	96.1424	94.1732	100.7046	95.9271
1980.	100.0000	100.0000	100.0000	100.0000
1981.	102.9470	101.0993	105.3238	103.4487

TABLE 34B

BELL CANADA:

ANNUAL PRODUCTIVITY GAINS (PERCENT)

YEAR	TFP	LABOUR	MATERIAL	CAPITAL
1968.	4.8234	10.6214	3.4243	2.4399
1969.	3.5990	8.5710	-7.3126	4.3213
1970.	4.2911	5.5462	7.8421	2.7217
1971.	0.4726	6.8468	-10.8562	0.8430
1972.	6.1612	9.8310	7.3521	4.0095
1973.	5.3045	5.5282	4.4512	5.4432
1974.	5.8171	6.4413	5.2875	5.6495
1975.	8.8181	13.9201	13.7553	4.6874
1976.	2.3602	3.5351	0.3747	2.2720
1977.	1.1438	2.7061	-2.0567	1.2191
1978.	2.3860	0.8413	-0.9652	4.6015
1979.	3.5499	3.3141	5.0085	3.1998
1980.	4.0123	6.1873	-0.6997	4.2459
1981.	2.9470	1.0993	5.3238	3.4487

TABLE 35A

BRITISH COLUMBIA TELEPHONE:

PRODUCTIVITY INDEXES (1980=100)

YEAR	TFP	LABOUR	MATERIAL	CAPITAL
1972.	66.3302	56.0960	61.9575	76.2643
1973.	69.3579	59.2655	65.0905	79.1005
1974.	75.6025	65.1516	76.2382	84.1872
1975.	81.4072	76.2078	82.8926	85.2902
1976.	84.7108	87.2117	82.8218	83.9586
1977.	81.8861	89.7660	66.2927	81.7721
1978.	85.2068	88.8003	77.7970	84.9841
1979.	89.9539	89.5925	85.7942	91.1811
1980.	100.0000	100.0000	100.0000	100.0000
1981.	106.3039	108.8246	100.3369	106.3193

TABLE 35B

BRITISH COLUMBIA TELEPHONE:

ANNUAL PRODUCTIVITY GAINS (PERCENT)

YEAR	TFP	LABOUR	MATERIAL	CAPITAL
1973.	4.5646	5.6500	5.0567	3.7189
1974.	9.0035	9.9318	17.1266	6.4306
1975.	7.6780	16.9699	8.7284	1.3102
1976.	4.0581	14.4394	-0.0854	-1.5612
1977.	-3.3345	2.9288	-19.9574	-2.6043
1978.	4.0552	-1.0757	17.3538	3.9279
1979.	5.5713	0.8921	10.2796	7.2919
1980.	11.1680	11.6165	16.5580	9.6719
1981.	6.3039	8.8246	0.3369	6.3193

TABLE 36B

TELEGLOBE:

ANNUAL PRODUCTIVITY GAINS (PERCENT)

YEAR	TFP	LABOUR	MATERIAL	CAPITAL
1973.	10.8011	9.1312	6.0293	13.1434
1974.	10.4754	15.6682	5.5509	10.5727
1975.	11.1486	16.6667	-7.2586	19.7452
1976.	14.4422	2.7728	29.8305	11.6618
1977.	8.6502	9.7983	6.4246	9.3780
1978.	13.4821	4.7449	22.1294	13.1528
1979.	15.1923	19.9199	7.5404	17.5662
1980.	20.7831	14.0284	38.2759	16.2319
1981.	3.8140	8.3495	-3.8760	5.2830

TABLE 36A

TELEGLOBE:

PRODUCTIVITY INDEXES (1980=100)

YEAR	TFP	LABOUR	MATERIAL	CAPITAL
1972.	37.4380	42.0126	38.3956	35.3474
1973.	41.4817	45.8488	40.7106	39.9932
1974.	45.8271	53.0325	42.9704	44.2216
1975.	50.9362	61.8713	39.8513	52.9532
1976.	58.2925	63.5869	51.7392	59.1285
1977.	63.3349	69.8173	55.0632	64.6736
1978.	71.8737	73.1300	67.2484	73.1799
1979.	82.7930	87.6974	72.3192	86.0349
1980.	100.0000	100.0000	100.0000	100.0000
1981.	103.8140	108.3495	96.1240	105.2830

TABLE 37A

TELESAT:

PRODUCTIVITY INDEXES (1980=100)

YEAR	TFP	LABOUR	MATERIAL	CAPITAL
1974.	56.0171	62.4543	77.6299	51.8142
1975.	59.1073	68.9345	90.2062	53.7334
1976.	56.0562	67.3199	89.6082	50.4825
1977.	60.2683	66.8925	81.0710	56.0923
1978.	65.9991	69.2987	83.7305	62.5743
1979.	85.6614	95.6629	107.5706	80.3626
1980.	100.0000	100.0000	100.0000	100.0000
1981.	124.8900	94.9082	108.3213	139.0247

TABLE 37B

TELESAT:

ANNUAL PRODUCTIVITY GAINS (PERCENT)

YEAR	TFP	LABOUR	MATERIAL	CAPITAL
1975.	5.5167	10.3759	16.2002	3.7040
1976.	-5.1621	-2.3422	-0.6628	-6.0499
1977.	7.4999	-0.6350	-9.5273	11.1123
1978.	9.5233	3.5971	3.2805	11.5560
1979.	29.7917	38.0444	28.4723	28.4275
1980.	16.7387	4.5337	-7.0378	24.4360
1981.	24.8900	-5.0918	8.3213	39.0247

TABLE 38A

TERRESTRIAL CARRIERS:

PRODUCTIVITY INDEXES (1980=100)

YEAR	TFP	LABOUR	MATERIAL	CAPITAL
1972.	69.5215	64.6225	73.5772	71.4029
1973.	73.2374	67.9295	77.2902	75.3691
1974.	78.4179	72.8951	82.9677	80.5414
1975.	84.5695	81.6568	92.7306	84.0660
1976.	86.4318	86.3854	92.0452	84.8076
1977.	87.0273	88.4302	89.4095	85.4262
1978.	90.0619	90.0283	90.6118	89.9155
1979.	94.3373	93.9228	95.5073	94.2363
1980.	100.0000	100.0000	100.0000	100.0000
1981.	103.9394	103.3443	104.2901	104.2354

TABLE 38B

TERRESTRIAL CARRIERS:

ANNUAL PRODUCTIVITY GAINS (PERCENT)

YEAR	TFP	LABOUR	MATERIAL	CAPITAL
1973.	5.3450	5.1174	5.0463	5.5546
1974.	7.0735	7.3100	7.3457	6.8626
1975.	7.8446	12.0196	11.7671	4.3762
1976.	2.2021	5.7908	-0.7391	0.8822
1977.	0.6891	2.3671	-2.8635	0.7294
1978.	3.4869	1.8072	1.3448	5.2552
1979.	4.7472	4.3258	5.4027	4.8053
1980.	6.0026	6.4705	4.7040	6.1163
1981.	3.9394	3.3443	4.2901	4.2354

TABLE 39A

NON - TERRESTRIAL CARRIERS:

PRODUCTIVITY INDEXES (1980=100)

YEAR	TFP	LABOUR	MATERIAL	CAPITAL
1974.	47.9684	56.1318	49.6668	45.0576
1975.	52.6243	63.7768	46.4181	51.6281
1976.	57.0684	63.9166	56.3584	55.0851
1977.	62.2141	68.2493	57.7356	61.8728
1978.	70.2736	70.7173	67.7126	71.0720
1979.	83.6210	89.4927	77.9361	83.7384
1980.	100.0000	100.0000	100.0000	100.0000
1981.	108.8974	104.9004	97.7800	114.8505

TABLE 39B

NON - TERRESTRIAL CARRIERS:

ANNUAL PRODUCTIVITY GAINS (PERCENT)

YEAR	TFP	LABOUR	MATERIAL	CAPITAL
1975.	9.7063	13.6198	-6.5408	14.5824
1976.	8.4448	0.2192	21.4146	6.6960
1977.	9.0167	6.7787	2.4437	12.3222
1978.	12.9546	3.6162	17.2804	14.8679
1979.	18.9934	26.5499	15.0984	17.8219
1980.	19.5872	11.7410	28.3102	19.4195
1981.	8.8974	4.9004	-2.2200	14.8505

TABLE 40A

FIVE CARRIERS:

PRODUCTIVITY INDEXES (1980=100)

YEAR	TFP	LABOUR	MATERIAL	CAPITAL
1974.	76.9450	72.0227	81.2566	78.6349
1975.	83.0236	80.8589	89.6607	82.3922
1976.	85.0757	85.4208	90.1344	83.3516
1977.	85.9408	87.5695	87.7751	84.3760
1978.	89.2275	89.2149	89.5997	89.1177
1979.	93.8902	93.7081	94.6026	93.7771
1980.	100.0000	100.0000	100.0000	100.0000
1981.	104.1282	103.3800	103.9654	104.6920

TABLE 40B

FIVE CARRIERS:

ANNUAL PRODUCTIVITY GAINS (PERCENT)

YEAR	TFP	LABOUR	MATERIAL	CAPITAL
1975.	7.9000	12.2687	10.3427	4.7781
1976.	2.4717	5.6419	0.5283	1.1644
1977.	1.0169	2.5154	-2.6176	1.2290
1978.	3.8243	1.8790	2.0788	5.6198
1979.	5.2257	5.0364	5.5836	5.2283
1980.	6.5074	6.7144	5.7053	6.6359
1981.	4.1282	3.3800	3.9654	4.6920

CHAPTER 5

APPLICATIONS

5.0 Applications of Productivity Analysis: An Overview

The concept of productivity often appears to be very much removed from day-to-day economic activities. It would probably be easier to discuss the merits and implications of productivity through the profitability of the firm. Both of these notions are related to the well-being of the firm, one dealing with the financial side, the other with the operational or real physical side. A firm may achieve a high level of profitability not only on account of high productivity, but also due to reasons having very little to do with its productivity such as, for instance, a temporary monopoly position for a particular line of products. However, if productivity gains are low relative to competitors and to the firm's own capabilities, given current circumstances, problems will emerge. Competitors with greater productivity improvements will eventually make increasing inroad into the firm's markets. Regulators will ask increasingly sharply pointed questions. Government policy makers will take increasing direct interest in the firm's performance and in its structure. In any case, a profitable firm generates a large net income for its owner or shareholders but it may not contribute much to increasing social welfare in general if its productivity gains are inadequate. High productivity on the other hand contributes to the firm's objective of efficient utilization of resources while the productivity improvements also bring a net gain to society by obtaining more output from the same resources. A firm with high productivity gains evokes either less critical or more supportive public attitudes toward it, depending on current circumstances and the way the potential economic rent generated by productivity gains is distributed between shareholders, workers and consumers.

The concept of productivity, with its inherent capability to orient thinking toward real efficiency with all of its benefits, has a proper place alongside the financial efficiency involved in profitability. It has therefore found applications, and there is much further potential use for it in industry management, policy development, and regulation.

5.1 Applications in Management

Productivity analysis has become the subject of wider and wider interest in the industry. In the following we shall discuss some of the most significant potential applications in the management area.

5.1.1 Budget-Implicit Productivity Gains

A firm's budget is prepared largely in terms of revenues and costs. Inherent in these are forecast changes in prices, input unit costs, output volumes and input volumes. These volume implications in a preliminary budget could be used to calculate the productivity gain which is being implied by the budget. Once these gains were expressed, they could be compared to the firm's historical achievements under parallel conditions of output growth, technological change and other relevant factors which determine productivity gains. Should the number implied by the preliminary budget be either too high or too low, senior management may be alerted to the need to identify why that is so, and to take corrective action if adequate explanations for the deviations are not found. The measure of total factor productivity thus would become a potentially useful additional tool for sizing the budget at the policy making level of the firm. While productivity targets are unwise to adopt directly, deviations from the historically possible trend may evoke some of the most searching questions that senior management could ask, and provoke new search procedures for means of increasing efficiency. This technique has been explored by Bell Canada,[1] Telesat, and other companies to see if it would enable management to use productivity growth of the company in the budget planning process.

5.1.2 Forecasting Cost-Minimizing Productivity Gains

With the values for the level of output, wage rate, capital price and material price available from the corporate budget and with the index of technological improvements estimated from management decisions such as the

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1 Bell Canada's senior managers expect that the greatest potential for the use of TFP measures will be in the medium term planning process as opposed to the annual budgetary process.

introduction of new technologies, and the implementation of particular construction program strategies, it appears that it may be possible to forecast with an acceptable degree of accuracy the expected volumes of labour, capital, and materials; these forecasts would rely on the prior establishment of how output volumes, input prices and improvements in technology determine the total costs of production. The ratio of the budgeted output growth and the analytically derived input growth yields a forecast of cost-minimizing productivity gain.

The cost-minimizing productivity gain can be broken down into a scale effect and a technological effect. The former is generated by and is proportional to the predicted output growth rate when economies of scale are present in the production process. The latter is generated by the planned technological improvements. This procedure provides a method to estimate the proximate causes of productivity gains and establishes how much productivity improvement can be expected when the output growth rate, input prices and technological improvements are as foreseen.

The above procedures, that is the computation of productivity gains from the corporate budget and the forecasting of potentially realizable productivity gains from a model of total production cost based on the assumed cost-minimizing behaviour of the firm can be used together in an interactive way to assess whether values of productivity gains which are implicit in the corporate budget are also compatible with the assumed cost-minimization of the firm. Most importantly, this analysis provokes a search for explanations which might otherwise not have been seen to be required, making use of formal analytical techniques available from productivity analysis.

5.1.3 Management Uses: Summary

This section has presented some potential applications of total factor productivity analysis to budgetary analysis. It is to be stressed that such analysis is aggregative and thus would serve as a general sizing criterion for budget analyses. It would not answer detailed questions; rather it would provoke the questions which may lead subsequently to the more detailed answers required for management action in various areas of the operations of the firm. Once the answers required by this analysis were found, there are plenty of detailed partial productivity measures already in use in telecommunications to permit management to implement and monitor specific policies.

It should be noted here that there are numerous other potential opportunities of applications to use the underlying data base. These include labour force analysis, construction program analysis, assessment of financial requirements, analysis of market strategy, and so forth. As yet these types of application have been sporadic but we understand that they may hold considerable promise. Because TFP measures real changes in inputs and outputs separately from price changes, the data base can also be potentially useful for purposes of inflation accounting and adjustment.

5.2 Applications in Policy Development

There are a number of cases in which the public sector has undertaken productivity analysis in support of policy development and also in search of appropriate policies to increase productivity in both the private and public sectors. These cases are becoming more frequent, and public policy interest is becoming more intense with the prolonged productivity slowdown of recent years.

In the U.S., the Department of Commerce has set up a group within the Office of Industrial Economics to monitor productivity trends and advise the government of appropriate actions to take. The American Productivity Center in Houston, Texas was set up with support from business, labour, and government for the purpose of contributing to the awareness and education on productivity and quality of work life in the U.S. In particular, the Center concerns itself with the following five areas of study: Productivity and Quality of Work Life Management; Productivity Measurement, Labour-Management Cooperation and Employee Involvement, National Policy, and White Collar Productivity. These initiatives all reflect an early broad interest in increased productivity, dating mostly from the mid and late 1970's.

In Canada, the Economic Council of Canada has conducted several studies on productivity. The federal Department of Industry, Trade, and

Commerce and Regional Expansion recently set up a Technology, Productivity, and Innovation Directorate with a focus on developing policies to ensure that innovation and the adoption of efficient production processes play a key role in promoting Canadian industrial and regional development. In the Province of Quebec, a productivity study centre called "l'Institut national de productivité" was established in 1978 in order to provide a provincial focal point for productivity studies.

In addition to the above initiatives, a large number of non-governmental organizations have been set up for productivity studies in North America and elsewhere in the world. All of these organizations seek to discover how to specify public policies that will increase productivity, and how to determine where and how such policies might be most appropriately applied.

Many public policies have a direct and indirect impact on productivity. In this regard, mention may be made of research and development support, employment and training, fiscal, and trade policies. In the formulation of industry support policies it should be recognized that it would be futile to continue to support firms in a competitive market which are unable to increase their productivity, since sooner or later these firms would be driven out of the market by their productivity-conscious competitors. Indeed, from a purely economic perspective the general policy orientation should be to withdraw privileges and support from firms or industries with expected low productivity contributions relative to their potentials, and give support to those with high performance.

In summary, productivity analysis plays a crucial role, in a competitive world, not only in the development of corporate strategies but also in the development of public policies. Well taken public policies should go with productivity winners. Productivity analysis is required to assess the impact of policies on industry productivity. It is also required to determine whether particular policies are appropriate in ensuring that public funds are used in the most effective and efficient way.

5.3 Applications in Regulation

Total factor productivity analysis has been used by several telecommunications carriers in rate hearings conducted by regulatory agencies. In some cases, the regulators requested it in order to evaluate the firm's performance; in other cases, the firms used it to support their requests for rate increases. Before discussing the role of total factor productivity analysis in rate determination process it would be worthwhile to look into this process itself.

5.3.1 Rate Determination Process

The rates that telecommunications carriers charge for their services are determined by the particular regulatory agencies, either at the provincial or federal level. In general, the regulator determines the total amount of revenues that a carrier is allowed to collect from users for a given level of service, according to some criteria, including the rate-of-return on investment. Usually this amount of revenues is determined in such a way that it allows the regulated firm not only to cover all operating expenses including depreciation and taxes but also to provide investors (both debt and equity) with returns on their investment which are comparable to those prevailing in similar industries, or from investments of similar risk. Underlying the regulator's analysis of the firm's needs is some examination of whether it has done all that is reasonable to do in avoiding cost increases. Productivity measures are powerful indicators of the degree to which the firm has increased its overall economic efficiency, thereby avoiding cost increases. They do not, of course, provide any assessment of the quality of management decisions, or of the reasons for observed gains in productivity.

5.3.2 Issues Associated with the Rate Determination Process

In the present regulatory structure governing the Canadian and U.S. telecommunications carriers, the rate determination process raises a number of contentious issues such as rate of return, regulatory lag, and regulatory costs. Productivity relates to all of these. Realistic productivity estimates can assist in allowing prices to be set which will in fact yield target rates of return. The explicit use of productivity in rate setting processes can help abbreviate the hearing processes and thereby reduce both regulatory costs and regulatory lags.

a) Rate of Return

The question of what rate of return a utility may be allowed to earn has been a major topic of debate involving the courts, regulatory agencies, the industry, and the public for many decades.

Usually regulatory agencies set a maximum or a range of rates of return that telecommunications carriers are allowed to earn. If this rate is considered as a target, it has rarely been attained. For example, the Canadian Radio-Television and Telecommunications Commission, in various decisions regarding Bell Canada's requests for rate increases in 1977, 1978, and 1979, stated that a 12% rate of return on the company's common equity was acceptable.[1] It was found that Bell Canada's actual rate of return in 1979 was 11.6%. In a case involving Michigan Bell Telephone in the U.S., the Company was allowed by the Michigan Public Service Commission in 1979 to earn up to 12.96% return on common equity but it was never able to realize a rate of return over 10% in the last four years, given the tariffs which the Commission allowed.

The above examples show that despite the rate increases that telecommunication carriers are allowed to charge their customers, there are other factors outside the rate-making process which may prevent them from earning as much as they are allowed to do.

b) Regulatory Lag

It usually takes a significant amount of time for regulatory agencies to decide on requests for rate increases. For example, the average time lapse between filing a rate application and the regulatory agency's

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1 Canadian Radio-Television and Telecommunications Commission, Telecom Decision CRTC 77-7 (June 1, 1977) and Telecom Decision CRTC 78-7 (August 10, 1978), Ottawa.

decision in the U.S. was nine to ten months.[1] In Canada, the regulatory lag involving the decisions of the Canadian Radio-Television and Telecommunications Commission in the years 1968 to 1981 ranged from 5 to 12 months. It thus appears that any device, such as a rate adjustment formula, which provides for automatic increases in tariffs on the basis of appropriate criteria agreed upon in advance, could contribute to a reduction in these lags and thereby to an increase in the efficiency of both regulation and operation.

c) Regulatory Costs

The process of rate making is not only time-consuming but it is also expensive. It has been estimated that a typical rate case for a medium to large utility firm in the U.S. costs about $300,000 to $500,000 in out-of-pocket expenses. This amount is probably doubled when company fixed expenses such as staff salaries are included.[2] Bell Canada stated in 1975 that the average cost to the Company of a rate hearing amounted to $500,000.[3] When the resources spent by the regulatory agency and the intervenors are included, the total costs of rate hearings can amount to $1 million to $2 million per hearing, depending on the scope of activities and the size of the carrier involved. Assuming that each company requires one hearing per year, a country with 10 telecommunications carriers to regulate could easily spend several times this one or two million dollars each year on rate hearings. Although these costs may appear to be rather small in comparison to the overall increase in revenue typically requested by the carriers, they are still substantial in absolute terms and any method devised to simplify the regulatory process and to reduce the regulatory costs is highly desirable.

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1 See M. Schmidt, Automatic Adjustment Clauses: Theory and Application, MSU Public Utilities Studies, (East Lansing: Michigan State University, 1980).

2 Schmidt, op. cit.

3 Department of Communications, Rate Adjustment Formula: An Overview and Assessment, Economic Policy Division, (Ottawa: D.O.C., June 1975).

d) Rate Adjustment Formula: An Application of Total Factor Productivity

In an effort to reduce both the regulatory lag and the costs of regulation the Michigan Public Service Commission approved in April 1980 a Consumer Price Index (CPI) adjustment formula for use by the Michigan Bell Telephone Company. This formula, applicable to monthly intra-state rates, non-recurring charges and message charges, contains the following elements:

- the year-to-year change in CPI, used as a proxy for changes in costs due to inflation;

- a productivity growth target;

- an offset for the resulting reduction in regulatory lag.

The formula was used to compute allowable adjustments in rates between formal hearings. These adjustments were approved by the Michigan Public Service Commission to take effect in October 1980, October 1981, and October 1982. To illustrate, the percentage rate increase for the October 1980 adjustment was computed as follows:

Change in CPI (Dec. '78 to Dec. '79)	13.30%
minus Productivity Gain	-4.00
	9.30
90% of this figure (substract 10% to offset benefits from the expected reduction in regulatory lag)	x 0.90
	8.37

Three annual rate adjustments have been allowed by the Michigan Public Service Commission in October 1980, 1981, and 1982. According to the Michigan Public Service Commission the reaction from business, labour, and the public has been very positive. On the Michigan Bell Telephone's side, it was found that the application of the adjustment formula not only enabled the Company to save a substantial amount of resources normally required to prepare for rate hearings but it also resulted in some stability in the company's planning process. On the Commission's side, this plan enabled it to save on the average 2 person-years and $100,000 to $200,000 a year required to prepare and carry out the rate hearings.

With regard to the technical aspects of the plan, the Commission was aware that while changes in the consumer price index do not represent accurately those of wages, salaries and the costs of capital and materials which telecommunications carriers have to consider in the formulation of rates, they usually move in the same direction. It turned out that due to its simplicity, the use of the consumer price index has been identified as one of the factors responsible for the success of the plan. The productivity factor was originally incorporated into the formula as a rate of productivity growth forecast for the year in which the formula was first applied. The same figure (4%) was, however, used for the other years as a target figure. The actual rate of productivity growth of Michigan Bell Telephone Company in 1982 and 1983 was about 1%. Despite its enthusiastic support of this rate adjustment plan, Michigan Bell had to discontinue its use due to the re-structuring of the Company following the divestiture of AT&T.

The use of the total factor productivity measure in a rate adjustment plan in the above example is a specific application of total factor productivity analysis in the regulation area. It should be added that regulatory agencies in carrying out their mandate "to ensure that regulated telecommunications carriers are made publicly accountable in the determination of just and reasonable rates",[1] have from time to time requested the carriers to testify on the status of their productivity improvement. Examples of these applications of total factor productivity analysis include the submissions by Bell Canada to the Canadian Transport Commission[2] and the recent submission by the Alberta Government Telephones (A.G.T.) to the Alberta Public Utilities Board.[3] These instances of the use of

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1 Michigan Public Service Commission, Opinion and Order (Case No. U-6002), April 1, 1980.

2 Canadian Transport Commission, Railway Transport Committee, Bell Canada Application, (File C995.178), 1968-69).

3 Alberta Government Telephones, Evidence-in-Chief re Economic Conditions and Productivity, January 15, 1982.

productivity measures in regulatory proceedings illustrate the application of such measures primarily as tests of overall reasonability. They have been used as indicators of overall increases in economic efficiency rather than as indicators of specific areas to explore.

5.3.3 Regulatory Applications: Conclusion

Productivity measures, used directly as in the Michigan case, or in conjunction with other indicators can help regulators make more informed decisions and contribute to reduce regulatory lags and costs without causing the regulator to abdicate its responsibilities. In any case, productivity measures can function as tests of reasonability of a firm's performance in the regulatory process; they are an important element of accountability. Their potential to focus discussion in rate hearings appears to be great but has so far only been explored to a limited extent.

5.4 Applications: Conclusion

It has been shown in this chapter that total factor productivity analysis may have great potential and has actually been explored in management, policy development, and regulation. In view of the ever-increasing competition that Canadian firms have to face not only domestically but also abroad, there is some urgency to explore the applicability of this kind of analysis in management and policy development. With regard to the regulatory area, the Michigan rate adjustment plan has shown that it is possible to streamline the regulatory process, to reduce regulatory lags and costs without compromising the regulatory agencies' role as guardians of the public interest. In management, the measure may add a powerful new method of carrying out policy analysis with respect to budgetary and other matters. These are all promising avenues for further exploration with a view to the development of applications.

CHAPTER 6

CONCLUSIONS

6.0 Introduction

Before this project began it was known that productivity measures could be developed on a case-by-case basis for individual carriers in telecommunications. The objectives of this project were to see whether a uniform method of measurement could be developed and applied, and to examine whether the concept of productivity is a viable and significant concept, warranting the effort to measure it. Subsidiary, but important, was the objective of testing a common system of measurement, and examining the appropriate comparisons which can be made with productivity data. Finally, having carried out this project, a further objective was to determine what directions might be taken in the future, both in measurement and in application.

6.1 Data Assembly

> **A consistent method for assembling data was found and applied.**

As noted above in Chapter 2, the data available are never exactly right for measuring productivity, and any specific measurement therefore embodies a number of particular decisions about how to overcome data deficiencies for the purpose. There are a large number of ways in which data problems may be solved, often but by no means always, with little to choose between them. Yet different solutions will generate slightly different measures. This project's threshold task in data assembly was to determine whether a methodology could be developed which would be for all practical purposes identical in application between companies, but which could be implemented between companies on a decentralized basis. Such a method has been found and implemented. The method is described in Chapter 3, and the implementation is reflected in the data presented in Chapter 4.

Consistency of method is important. Using the methods developed for this project it was discovered that total factor productivity indexes developed here showed sometimes significant variation from those previously developed by the participants acting independently. These differences are not large in absolute magnitude, but could be consequential for analytic applications of the data; they resulted from improvements in measurement methods and aggregation procedures. Four of the five participants now use identical data for their own internal productivity study and for their measure in this Report, while B.C. Tel. is currently planning a major rearrangement of its internal productivity study to better serve its new corporate organization.

The project's productivity measurement was straightforward and could be readily understood by all participants. There is no doubt that the measures could be kept up to date relatively economically. Further, it appears to be the case that new companies could join the project without a great deal of difficulty because the methodology is quite generally applicable within the telecommunications industry. New companies would have to commit themselves to developing the raw data, which requires a significant initial commitment of effort and professional knowledge, but is also a process wherein experienced assistance could now be available from the participating companies.

6.2 Productivity Comparisons

The project assessed four main types of productivity comparisons. These were inter-temporal for the same firm, inter-temporal for different firms and industries, inter-temporal comparisons for the industry, and inter-firm level comparisons. They are discussed in most detail, and technically, in Appendix C to this Report. The conclusions of that assessment are presented here.

6.2.1 Inter-Temporal Comparisons: Same Firm

> **Productivity gains over time for the same firm can be compared and analysed in meaningful ways.**

Inter-temporal comparisons for the same firm are the most reliable comparisons which can be made. Year-to-year changes in productivity occur within an operating environment, technology context, demand structure, and procedural structure which is relatively slowly changing and is, in any case, very similar from year to year in its broad characteristics. Thus any given percentage increase in productivity can be safely regarded as comparable to others for the same firm in different years. As a result, acceleration or deceleration in the rate of increase in aggregate economic effectiveness for the firm can safely be inferred from the measures. Furthermore, econometric and other analytical techniques can be applied to try to decompose productivity gains into their various component parts, including technological change, scale effects, output mix effects, and others.

The productivity gains so measured have potential uses for management purposes, as will be discussed below, such as budget analysis, labour force projections, and construction program analysis. Again this is because, within the same firm, underlying production similarities dominate other effects from year to year, permitting them to be isolated and analyzed for further managerial investigations. Similarly, regulatory applications can make use of underlying continuities, to permit forecasting of required rate changes, for example, or to permit assessments of the various main elements of a rate application. In all these cases, year-to-year comparisons are with respect to the same firm, in the same environment, subject to the same or very similar operating conventions and rules, from one year to the next. Thus the data can be safely presumed to reflect aggregate changes in economic productivity, and treated or used accordingly. Where any discontinuity occurs it will be clear to the analysts and can be integrated into any analysis to permit appropriate compensation for it. For example, when a firm divests itself of a subsidiary, creating a major change in output or input composition, that change is clear and can be reflected in the data handling; similarly, changes in accounting conventions can be noticed readily and then reflected in data handling so as to remove any aberrational impact. In short, there are methods of minimizing to generally acceptable levels the effects that data problems might have on inter-temporal comparisons for the same firm.

6.2.2 Inter-Temporal Comparisons: Different Firms or Industries

Productivity gains over time for different firms or industries can be compared for sizes of the respective rates of change, but differences in those sizes have only very limited direct meaning. They serve more to invite further questions than to answer questions directly.

When one has time series for several firms, productivity estimates for each firm taken separately are subject to the observations above. However, comparing the rates of change between firms raises much more complex questions.

As between any two firms, it is meaningful to say, assuming that measurement techniques are comparable, that one has shown more or less rapid productivity gain than the other. The precise meaning of that statement is only that each firm, faced with its own particular circumstances and environment in many relevant regards, has improved its measured rate of improvement in economic efficiency at a different rate. Nothing else can be inferred from the observation of different rates of productivity growth. For example, it cannot be inferred that one firm is "catching up" on or "outdistancing" the other in any relevant regard. Were the two firms producing one output only (or exactly identical levels and mixes of outputs), and using identical inputs in both quality and proportions, and were all input and output prices identical, the "catching up" phenomenon could be inferred in a limited sense. However when differences exist in any of these regards, then relatively more rapid productivity gain in one firm compared to another can mean all sorts of things other than "catching up", and it is likely in multi-output, multi-input firms in different locations in the country that these other things are of great consequence for the measure. Moreover, especially in telecommunications, different firms face different regulatory requirements imposing varying restraints on the pursuit of increased productivity; for example some activities with negative impacts on productivity may be required. Only over extremely long periods of time would it be reasonable to infer that a systematic divergence in the measure implied a parallel systematic convergence or divergence, (and one never knows a priori which), in truly comparable economic effectiveness.

That being said, it may be asked whether there is any value in comparing data for different firms or industries on their rates of productivity gain. There is, but not primarily for the information yielded directly by the comparison. Each firm's productivity measure indicates the rate of increase in outputs derived from given changes in the quantities of all inputs. Differences indicate that firms have done more or less well as indicated by the measure, but not whether they have done more or less well than might have been expected. That latter determination depends on knowing the firm's productivity history and interpreting further information about the circumstances faced by each firm, and the responses made by each firm to those circumstances. Thus, for example, the fact that telecommunications productivity gains are typically large by any comparison tells one that the socially desirable objective of economizing on resources is proceeding very rapidly, but not whether there is necessarily any remediable defect in those industries showing lower productivity gains nor whether, on the other hand, productivity improvement could not have been larger in telecommunications than those actually experienced. Such inferences could only be made on the basis of further detailed analysis of the operating characteristics of the firms involved.

What inter-firm or inter-industry comparisons of productivity gains do, then, is to provide two important pieces of information. First, they indicate which firms or industries, facing their own individual circumstances and constraints are making the most rapid gains in reducing resource input per unit of output. Second, they indicate what kind of questions may be asked of the firms or industries with high or low productivity gains. Of those with high gains, one can ask how it is achieved, and how to obtain more; of those with low gains, one can ask whether the performance is explicable (which it usually is), but more importantly what changes in circumstances are feasible and workable to improve the performance. These are, of course, analytically complex questions which are very expensive to address in detail. Improvement in the ability to direct these questions perceptively is the most important contribution made by inter-firm, inter-temporal comparisons of productivity.

6.2.3 Inter-Temporal Industry Comparisons

Measures of productivity gain for an industry over time reflect broad industry characteristics but may mask in the average some important firm specific productivity movements. Thus their use is more macro-economic than that of firm measures of TFP.

When the data from many firms are combined to create industry-wide productivity series, the resultant measure constitutes a weighted average of the effects of all conditions and operating approaches, and is thus in some sense a weighted average productivity performance. Can such measures, popular as they are in some quarters, have much meaning, given the considerations discussed in the previous two sections?

As a general matter, industry-wide productivity measures must be approached with caution. Many divergent particulars are, or may be, suppressed into the average represented by such a measure. Nevertheless it is useful as a starting point for both business and government policy purposes. It makes sense to speak of the industry as a whole, in some cases, because there are commonalities which spread across the industry. Thus, in the case of productivity measures, there are common technological, scale, demand, input and operational conditions which make it meaningful to refer to the whole industry. Firms are different but they are also all part of a single matrix of economic and operational conditions in at least some important senses. These are generally different enough from other industries so that it makes sense to contrast one industry with another. Thus one might wish to analyze conditions leading to demand growth, technological change or other matters for the telecommunications industry, and explore their industry wide impacts on productivity. Both business and government policy attitudes are validly influenced by these comparisons.

6.2.4 Inter-Firm Level Comparisons

Comparisons of productivity levels between firms cannot be made on any meaningful basis with existing data and techniques.

It is always tempting to try to compare levels because they seem to be so much more substantial than movements. Unfortunately such comparisons are so extremely difficult as to defeat completely any attempt to do so at this time. The considerations raised above will already have foreshadowed the difficulties.

Productivity measures are, as has been noted above in Chapters 2 and 3, very sensitive to the data used. They are also sensitive to the properties of the production processes from which the data are derived. Thus one may expect any firm's productivity measure to differ substantially from that of other firms because of firm-specific particularities in inputs, outputs, technologies, operating conditions, price levels and structures, cost levels and structures, and accounting and other conventions. When one seeks to compare levels of productivity it is necessary to take all of these matters into specific and very detailed account. As shown in Appendix C to this Report, relatively small differences between firms, of no material consequence to inter-temporal comparisons, may be of enormous consequence to inter-firm level comparisons.

It is the conclusion of this Report that given the state of the art, inter-firm level comparisons are not meaningful in any known sense. Data problems are serious, but so are conceptual problems. For multi-product enterprises the idea of level depends on there being a meaningful concept of input and output which can be made operationally comparable between firms. Such a concept does not exist at any but the most ethereal level of conceptualization. Nothing remotely approaching an operationally meaningful concept is available for purposes of level comparisons. In the abstract, one can often meet this kind of problem, in most cases, by refining large masses of data and re-configuring the raw data until remaining conceptual ambiguities cannot have much empirical consequence, as far as professional judgment can discern. For cases such as telecommunications the data requirements would be enormous, involving at the very least exactly comparable measures of all input and output prices and quantities, technology characteristics, environmental and operating characteristics, accounting practices in exact detail, and external constraints such as regulatory rules, legal requirements and so on. Since these data do not exist in any manageable compilation for any firm, there is no chance that inter-firm level comparisons can be meaningful at this time. Analysts and others have to be satisfied with elements of operating characteristics being compared, such as the number of employees per 10,000 telephones, or selected prices, and bear in mind that such comparisons can tell only the tiniest (and possibly misleading) fragments of the tale of how one firm compares to another.

6.2.5 Carrying Out Comparisons

> **Thus, various kinds of comparisons can be meaningful, but they must be kept in their proper contexts. Some comparisons, notably those involving level, are not currently possible.**

The conclusion of this Report then is that comparisons can be carried out and can be meaningful, but that they are both limited in extent and specifically very restricted by the underlying data. That being said, inter-temporal (that is, time series based) comparisons are meaningful and useful for firms or industries. Inter-firm or inter-industry comparisons of productivity movements are also meaningful for many purposes, but must not be viewed in simplistic terms which imply that the idea of "catching up" or "losing ground" can have any proper application. These comparisons indicate how the different firms or industries did in their own circumstances but no more, and especially do not bear interpretations which require convergence or strict similarity. Inter-firm or inter-industry level comparisons are not possible in most cases, and can only be done on the basis of fragmentary operating characteristics as things now stand.

6.3 Management Uses of Productivity

> **While management uses of productivity are still largely in an exploratory state, there appears to be enough potential to warrant further analysis in areas of budget planning and strategic analyses.**

During the course of this project's work it has become clear not only that there are numerous potential management uses of productivity but also that a number of specific applications have actually been explored. Because productivity measures quantify parts of the aggregate underlying regularities in the production processes for a firm, they also provide data which can be useful for management control. In preparing this Report, numerous potential applications of productivity data have been found in budget sizing, construction program analysis, labour force analysis, and so on. There have also been many applications of the concept in the presentation of management's case during rate hearings, public inquiries, and as part of the accounting of management stewardship to shareholders.

These are all important potential uses of productivity. By making use of productivity measures as tests of reasonability, firms may increase their ability to discern where and how to develop and apply strategic managerial initiatives. For example, budgets which appear to imply one level of productivity gains when other conditions would suggest that higher levels might be expected, invite further management review of the budget to determine why, or if, such an economically anomalous result should be accepted. In more detail, the historical insight into quantities of labour and plant associated with various levels of output, could permit fairly precise aggregate estimation of the cost minimizing construction program or labour force requirement. Specific differences from these estimates, arising from proposed budgets, may be reasonable but are brought squarely to the foreground by productivity analysis, for managerial examination.

The conclusion is very clear that productivity measures may have great potential both to strategic thinking and to developing an orientation toward aggregate physical efficiency of operation.[1] It is, however, important to recognize that total factor productivity measures are only useful at these broad levels, and even here further analysis is required to determine the operational efficiency of using such measures. Proposals are sometimes found to use total factor productivity measures for very detailed purposes. Such proposals are usually not well thought out. At the detailed operational level, very fine partial measures relating some dimension of an activity, or some discrete activity, to one of the inputs are necessary and important. These measures abound in telecommunication already, and cannot be usefully supplemented by the broader measures which are the subject of this report. Strategic analysis would probably benefit from the application of strategic measures such as total factor

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1 See for example R.C. Scrivener, "Productivity in a Modern Economy", The Canadian Business Review, Volume 1, No. 1, Winter 1974.

productivity; operational analysis requires much more detailed measures of strictly limited scope. It is in enhancing strategic managerial thinking and control that productivity measures may be so important.[1]

6.4 Regulatory Uses of Productivity

> **Regulators have used productivity measures as general indicators of the performance of firms. Further uses of the measures in streamlining the regulatory processes, and reducing the costs of regulation warrant additional exploration.**

Productivity measures have been used by regulators as tests of reasonability of the performance of telecommunications firms. The data that have been used bear on the firm itself, and on other industries, both measured over time. Thus, regulators have done inter-temporal comparisons for the firm, and between the firms of the same industry. These comparisons are useful, providing the regulator a sense of the overall productivity performance of the firm. Such comparisons could probably be extended, and the discussion around them deepened, if both the regulator and the firm could bring sufficient expertise to bear on that process.

At the same time, it must be borne in mind that productivity comparisons by regulators are subject to the limitations described above in 6.2.2. In particular, productivity comparisons in the absence of detailed analyses of the operating characteristics of the firms involved may be harmful if inappropriate inferences are allowed to influence regulatory decisions.

Beyond such general uses of total factor productivity, there have been several specific uses of it to permit the rate making process to be expedited. This project's examination of those processes, reported in Chapter 5, leads to the conclusion that productivity data can be properly applied for such undertakings. There are two ways in which it can be done. One is to use productivity data to calculate what are effectively interim rate increases to respond to inflation, that is, to develop a formula approach,

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1 R.E. Olley, "Productivity Analyses as Tools for Management" in Daly, D.J. (ed.) Research on Productivity of Relevance to Canada, Ottawa: Social Science Federation of Canada, 1983, pp. 123-127.

reserving the full review of the firm, that is the formal hearing, as a process for once every three or four years, or when deemed to be needed. When firms are turning in reasonable productivity gains under the prevailing circumstances, no one's interest is served by having the regulator and the applicant prepare for and plough through repetitive hearings into detail. Productivity-based formulae or rules of acceptability for forecasted components of costs can improve the efficiency of regulation.

6.5 Policy Uses of Productivity Measures

The potential uses of productivity analysis in policy development by government are less clear than in other areas, but productivity measures can serve to condition the direction and type of public policy.

Probably the most important operational use of productivity measures in public policy development is to provide a focal point around which discussions can take place between government officials and industry representatives. During the project it became very clear that a fairly large number of discussions were both clarified and brought into perspective by having reference to productivity as a kind of conceptual touchstone. For policy making, productivity has to be one of the most important objectives for an industry. Other important policy objectives also exist, of course. Analysis of the impact on productivity of any important policy change constitutes a valuable common ground of government-industry communications, and a critical internal requirement of government which should always be met. Just as productivity measures bring considerations of economic efficiency to the fore in managerial contexts, so would productivity thinking help sharpen and focus government policy thinking in the same way, in relevant cases.

6.6 The Importance of Productivity: General Conclusions

Productivity is, of course, important. Explicit measurement of it appears to offer more than enough potential payoff to warrant continued attention to possibilities for measurement and analysis.

Productivity increases are at the heart of increased real standards of living for a nation. Key industries, when recording large productivity gains make an important contribution to national productivity both directly and indirectly through the spillover benefits from greater efficiency, emulation, and so on. Thus productivity in any major industry, such as telecommunications, is an important subject of analysis in the public interest.

The productivity measures obtained during the course of the project show that the participating companies, making up a large part of the whole industry, have recorded very impressive individual productivity gains, each in their own circumstances. The companies grouped together as an industry have done similarly. These measures record that performance, and lay down methods of measurement which can be consistently applied. Investigations carried out in the project reveal that there are numerous important and practical purposes to which productivity based analyses may be applied. There are of course numerous mis-applications also possible, and some of these have been identified, or cautioned against above. Furthermore, appropriate applications may contribute not only to increasing our understanding of the sources of productivity gains in telecommunications, but also to increasing further both the productivity of the industry and the productivity of regulatory and policy making processes. These are important matters.

Finally, the project concludes that it is more than worthwhile to continue to measure productivity, and to explore means to increase the utilization of the resultant measures in several ways. These aspects of the project's conclusions are embodied in the recommendations which follow in the next, and last, chapter. Entailed in those recommendations is the conclusion that productivity measures are promising enough to be well worth the effort to explore their development and to analyse how they may be further utilized.

CHAPTER 7

RECOMMENDATIONS

7.0 Introduction

For all of the reasons discussed in Chapter 6, this project concludes that productivity measures are important in telecommunications. Those measures should be compiled on similar bases to enhance their comparability between firms, and to facilitate their aggregation into industry measures. Furthermore, these measures of total factor productivity are or can be useful for managerial, regulatory, and policy making purposes.

Accordingly, it is the conclusion of the co-chairpersons that the following recommendations are appropriate to make to the project's sponsors, the telecommunications industry and the Department of Communications. We make these recommendations fully cognizant that each entails administrative and other costs which would have to be set against the expected benefits. Thus the recommendations which follow represent our best judgment of what kinds of initiatives would likely, upon further analysis of costs, turn out to be attractive undertakings.

7.1 Recommendations to Industry

a) A small permanent working group or committee might usefully be formed to complete the standardization and mechanization of the data bases required for total factor productivity measurement. The most important functions of this working group would likely be to assist new participants if any wish to join the project, and existing ones to refine their data when appropriate.

b) A method should be developed to permit the regular updating of the productivity measures, on an annual basis. This might be in a form similar to the publications of the Canadian Pulp and Paper Association, but could take on any desired format, for example an annual bulletin, a news release, or a letter from the working group proposed above to the participating members. The permanent working group could perform the data assembly for purposes of publication, and might do so under the aegis of a Telecom Canada committee. It would not be required that the Telecom Canada coordinator have any particular expertise in productivity, since the provision of that would occur through the membership.

c) Meetings should be organized at least annually for people working in, or otherwise interested in telecommunications productivity measurement. The purpose of the meetings would be to exchange views on productivity measurement, and on ways to use it for managerial or other purposes. These meetings could be convened by one of the participating carriers, by a carrier just becoming a participant, by the Telecom Canada supervisory committee, if one is given that role, or by an independent authority such as DOC or Statistics Canada or some private agency.

7.2 Recommendations to the Department of Communications

d) An extensive exploration of how to use productivity measures as the bases for rate adjustment formulae, or as the means to otherwise expedite the handling of repetitive matters in rate hearings, should be undertaken. DOC should suggest that the CRTC take a lead role in this exploration and in the implementation of time saving techniques, and should offer its own assistance in carrying out the research. Care should be taken to recognize the needs of regulators at all levels of government, as each seeks more efficient administrative techniques to be used in rate determinations proceedings, bearing in mind the full range of responsibilities of the regulators.

e) Productivity gains for industry should be considered explicitly as part of government's objectives for industry. To enable that to occur, analyses of the productivity implications of policy proposals should be integrated to the extent possible into policy formulation.

7.3 Recommendations to Industry and Government

f) Regular meetings between industry and DOC officials interested in productivity measurement and analysis should be organized to assure a maximum of mutual assistance and interchange of ideas, and to seek ways to support both DOC and industry members in exploiting productivity measures more fully.

g) A committee should be formed, including both DOC and industry members, perhaps including some from beyond the carriers themselves, whose purpose would be to explore ways and means to identify and pursue joint initiatives which would enhance industry productivity. This committee would function as if it were a productivity council for telecommunications, and might work with the proposed Federal Government productivity council. Among other things, it would make productivity enhancement one of the focal points around which to organize discussions of potential policies, at whatever level of formality is deemed appropriate for the committee.

We recognize that the industry already pursues available avenues for productivity gain, as is shown by its outstanding measured performance (as compared to most other industries) recorded in Chapter 4. The intent of the above recommendation is to suggest a forum wherein the opening up of new avenues may be explored.

Less specifically, we the co-chairpersons of this project, after all this time working in a mixed industry and government group, strongly recommend that mechanisms for exchange of views in a working context be found, and that high priority be given to that task. We found that the working context gave people a framework within which to fit and understand different perspectives, to face and solve problems as they arose, often before they become too serious. The ability to root multi-lateral discussions in a firm conceptual framework is not often found in the way that it is in this case, and should be fully exploited.

APPENDIX A

MEMORANDUM OF UNDERSTANDING

BETWEEN

THE DEPARTMENT OF COMMUNICATIONS,
GOVERNMENT OF CANADA

AND

THE CANADIAN TELECOMMUNICATIONS CARRIERS ASSOCIATION

CONCERNING JOINT STUDIES OF THE

TOTAL FACTOR PRODUCTIVITY OF CANADIAN

TELECOMMUNICATIONS COMMON CARRIERS

PURPOSE OF MEMORANDUM OF UNDERSTANDING

The purpose of this Memorandum of Understanding (MOU) between the Canadian Telecommunications Carriers Association (CTCA) on the one hand and the Department of Communications (DOC), Government of Canada on the other hand is to define the objectives of the two parties in jointly undertaking studies of the total factor productivity of Canada's telecommunications common carriers, as well as to specify the conditions under which both parties agree to participate in the project, including the obligations which each has accepted to assume.

This project is conceived as long term and currently involves a plan of several phases which embraces the total project.

The project will commence with the signing of this Memorandum, and is expected to terminate in July 1983.

The Objectives of the project, the Project Description, the Working Arrangements and the Plan of Action, as outlined in this Memorandum of Understanding, pertain to the project as a whole. Within the Plan of Action, the Memorandum of Understanding outlines specific commitments of both parties to Phase 1 of the project.

This Memorandum of Understanding may be reviewed and amended at any time by mutual agreement of the two contracting parties.

The CTCA and the DOC affirm their intention to use their best efforts to discharge their responsibilities under this MOU.

OBJECTIVES

There are objectives which are common to both parties and objectives which are specific to each party.

A. The common objectives of the DOC and the CTCA in these studies of telecommunications common carriers productivity are:

1. to improve the conclusions which can be drawn from the analysis of productivity data by creating measures of productivity which:
   i) are in accord with existing theories and practices;
   ii) can be readily calculated and maintained, and
   iii) are consistent across the industry;
2. to work towards the economical production of data which are well defined and have clearly understood uses by both industry and government.

A set of sub-objectives has been defined as being necessary for the fulfilment of the above objectives.
The sub-objectives are:

1. to develop methodologies, with the particular objectives of:
   i) minimizing the costs to the CTCA member companies of collecting, recording, maintaining and analysing data, and
   ii) avoiding duplicated or wasted effort;
2. to develop a flexible data base which can be used to support the construction of a variety of productivity measures;
3. to contribute to clarity and precision in the reports to be published and the measures of productivity to be developed;

4. to assure the validity of comparisons of data and measures of productivity between telecommunications carriers, and

5. to ensure that the data are properly used, and that the limitations on the uses which may be made of the data are clearly enunciated in all publications.

B. The objectives specific to CTCA are, inter alia:

1. to assure the maintenance of the confidential nature of data classed by the CTCA member companies as proprietary, and

2. to safeguard the specific and general interests of the CTCA member companies.

C. The objectives specific to DOC are, inter alia:

1. to improve the DOC ability to develop policies that foster the orderly development of the telecommunications industry in the public interest and promote continuing efficiency among the telecommunications common carriers.

PROJECT DESCRIPTION

The execution of the project as currently planned foresees, as a minimum, that the following broadly defined tasks will be carried out:

1. an economic analysis of productivity in a regulated environment, including the formulation of appropriate measures of productivity;
2. an exploratory analysis of the possible use of such measures in promoting continuing economic efficiency in a regulated service-providing environment;
3. development of a flexible data base and productivity measures consistent across the industry which can be readily calculated and maintained;
4. where valid and feasible, careful comparative analysis of productivity among Canadian telecommunications carriers
   - in the context of the industry,
   - in the context of the Canadian economy,

   and recognizing inherent inter-firm differences.

WORKING ARRANGEMENTS

This project has the potential to develop into a long term cooperative effort between the DOC, the CTCA and the participating telecommunications carriers and to enhance the understanding of the industry by agencies of government, as well as others.

To protect the interests of participants in the eventuality of differences of opinion in the analysis and interpretation of results, each party will have an opportunity to present dissenting views with respect to technical working papers and reports developed as part of the joint project and non-proprietary to both parties. These views will become an integral part of the relevant non-proprietary published reports which will represent the official views of both parties. This necessitates that no technical working paper or report, produced as part of the joint project, may be published without dissenting views, where applicable.

The word "developed" refers to those documents which are part of the background material to reports which are themselves eventually to be published as part of the joint project. The word "published" refers to any document prepared for distribution beyond DOC and its contractors, CTCA headquarters staff and CTCA member companies.

This arrangement does not apply to any subsequent use of the results by either party except insofar as such applicability may be later agreed upon.

An organization chart outlining a proposed organization of the managerial and professional team responsible for this joint project is attached to this section. The final organization is the responsibility of the project's co-Chairpersons, subject to the following conditions.

The co-Chairpersons of the project team will be appointed by the signatories of this MOU, that is, one by CTCA and one by DOC.

The co-Chairpersons may each appoint a maximum of two members to the Board of Control. The Board of Control will be responsible to the co-Chairpersons.

The Board of Control may appoint a Project Manager. The Project Manager will be responsible to the Board of Control.

In consultation with the Board of Control, the parties to this MOU will appoint Scientific Authorities for the DOC and Economic Counsel for the CTCA. These appointees will report to the Project Manager for that part of their work related to this project.

The Project Manager, the Scientific Authorities and the Economic Counsel will constitute a Research Team.

The Board of Control may appoint a Project Advisory Committee whose membership will be drawn from the DOC and from CTCA headquarters or CTCA member companies or both. This Project Advisory Committee will be responsible to the Board of Control.

The Board of Control may appoint such other advisory committees as it considers necessary.

Each party may subcontract as it deems appropriate. The contracts let will be the responsibility of the contracting party.

Any of the responsibilities or lines of authority listed below may be cancelled, added to, or otherwise amended, on the recommendation of the Board of Control to the co-Chairpersons for their approval.

Under the direction of the CTCA Executive Committee and DOC senior management, the responsibilities of the co-Chairpersons will be:

1. to convene, direct and and provide guidance to the Board of Control as required;
2. to assure a continued and smooth working relationship between DOC and CTCA;
3. to carry out such other liaison as may be necessary with their respective agencies, other government bodies, the telecommunications carriers, or such other persons or bodies as may be appropriate;
4. to make such reports as may be necessary and desirable to the CTCA Executive Committee and the DOC senior management;
5. to maintain due regard for and care in advancing the joint and separate interests of the DOC and the CTCA, as these are involved in the project, touched upon or evoked by the project, and
6. to reconcile differences of opinion which cannot be resolved at the level of the Board of Control.

Under the guidance of the co-Chairpersons, the responsibilities of the Board of Control will be:

1. to implement the joint DOC/CTCA mandate for the project;

2. to establish broad policy direction;
3. to provide direction to the Project Manager, the Project Advisory Committee and such other committees as the Board of Control may appoint;
4. to approve all particular works and projects being undertaken as part of the project;
5. to coordinate the interaction between CTCA and DOC;
6. to ensure that the methodology does not impose unreasonable burden or cost on the participating telecommunications companies;
7. to approve all requests, related to the joint project, to be made to CTCA or DOC, especially for data, whether these are to be channelled to participating carriers or directed elsewhere; and
8. to reconcile differences of opinion which may transcend the responsibility of the Project Manager.

Under the guidance of the Board of Control, the responsibilities of the Project Manager will be:

1. to manage the day-to-day affairs of this program;
2. to carry out the directions of the Board of Control;
3. to maintain due care and vigilance over the progress of the project and report to the Board of Control any matters arising or imminent which may materially affect the project;
4. to receive and distribute to appropriate parties, for comment, non-proprietary technical working papers and reports prepared as part of the joint project, and
5. to exercise management responsibility for the proper functioning of the Research Team.

The responsibilities of Scientific Authorities and Economic Counsel will be:

1. to recommend and assist in the preparation of project definitions, which will be submitted through the Project Manager, for the consideration of the Board of Control;
2. to monitor the technical execution of the project and report to the Project Manager from time to time; and
3. to certify the technical quality of the work.

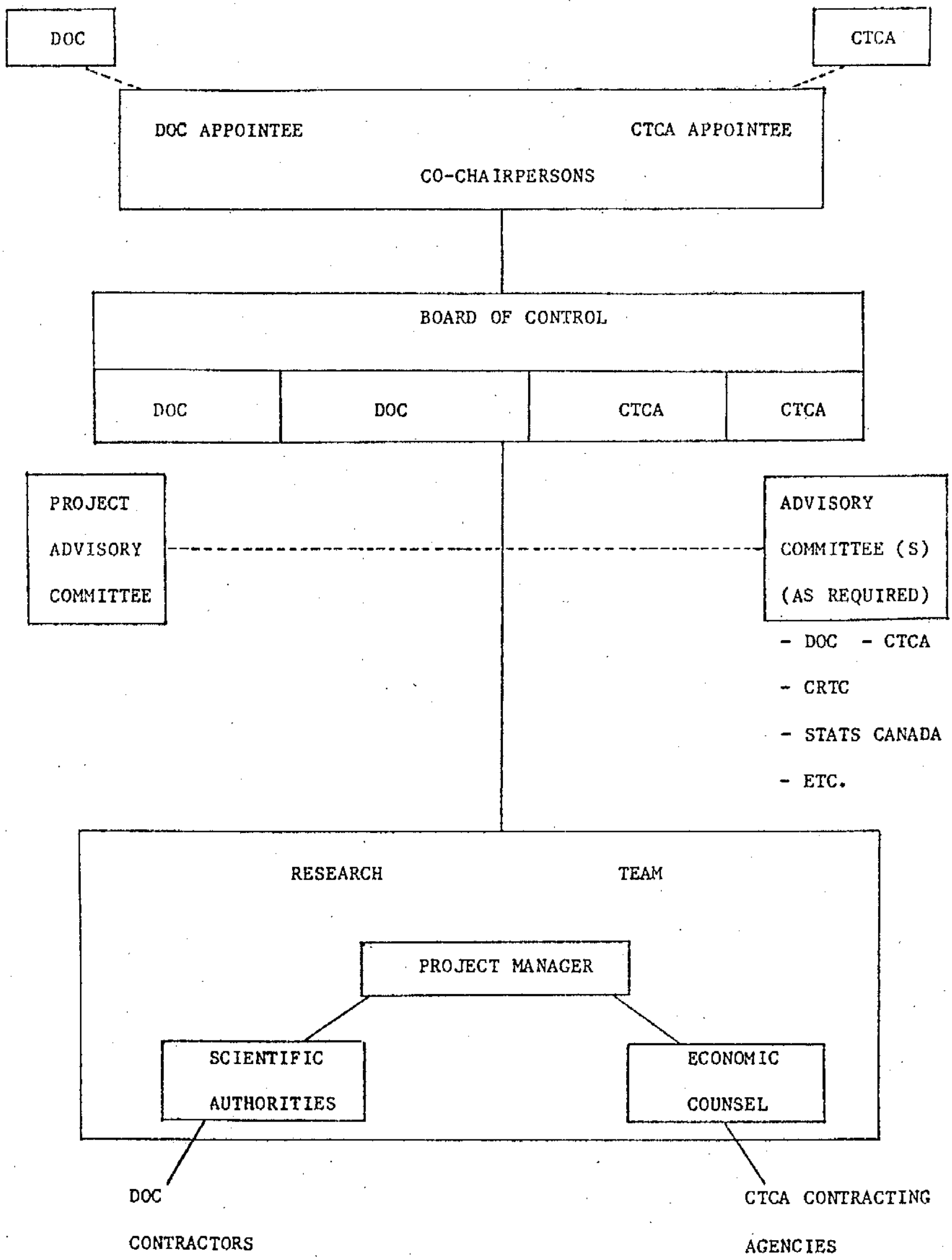
The Research Team will be responsible for the preparation of appropriate documents for the consideration of the Board of Control.

The responsibilities of the Project Advisory Committee will be:

1. to provide a forum for critical discussion of the concepts and measures being investigated; and
2. to provide advice and technical support to the Project Manager and the Research Team in areas such as, inter alia;
   i) data availability,
   ii) cost and burden considerations associated with specific data requirements,
   iii) management and policy requirements for measures of productivity,
   iv) the formulation of measures which can be operationally developed and implemented, and
   v) the likely uses and misuses of the data being generated.

The responsibilities and authorities of other advisory committees will be determined by the Board of Control as it sees fit.

ORGANIZATION CHART



PLAN OF ACTION AND COMMITMENTS

1. PLAN OF ACTION

On October 19, 1979, the Executive Committee of the CTCA accepted the recommendation that this program be initiated in a form that provided manageable sections or phases with milestone decision points, at which commitments could be made for further work, or the participation of CTCA members could be terminated.

This development by stages is important because it is difficult, with this type of work, to identify the total cost and benefit implications at the outset. The first phase of the project will include a detailed project definition and will attempt to provide more precise information regarding the expected costs and benefits. The results of this phase are expected prior to the second milestone decision point in May 1980, and will represent a major influence over the decisions of both parties for continuation of the project.

The telecommunications carriers have expressed the view that their continuation beyond May 1980 may be dependent upon financial assistance from the federal government.

DOC, for its part, has expressed the view that the decision by either party to proceed with the project and commit funds beyond May 1980 must be based on a critical assessment of the expected costs and benefits to each party. However, any decision with respect to the division of the relative financial burden between the two parties must await the results obtained in the project definition phase.

The proposed phases of the project are:

PHASE	MILESTONE DATES	EVENT
	October 1979	CTCA initial commitment to the project.
1	January 1980	Memorandum of Understanding signed.
	May 1980	Completion of the project definition phase.
2	September 1982	Completion of historical data reduction exercise.
3	July 1983	Completion of the final report of the Research Team.

The CTCA's Executive Committee committed the Association to the first phase of the program, that is until May 1980, reserving further commitment until that second milestone is reached. The DOC has committed itself independently to certain studies which will be absorbed into Phase 1 of this project.

2. COMMITMENTS TO PHASE 1

A. The CTCA commitments to Phase 1 are:

1. appointment and funding of one of the co-Chairpersons;
2. within the parameters established under the section above entitled Working Arrangments, such other appointments and the funding thereof, as are deemed appropriate;
3. coordination of two part-time researchers and the requisite associated activity by member companies to carry out research into:
   - i) members' data collection systems and methods of data assembly,
   - ii) the development of alternative data sources,
   - iii) the costs to members of executing a long-term program, in particular those costs associated with the data collection exercise, and
   - iv) means by which relevant costs to the CTCA members can be minimized;
4. liaison with DOC researchers with respect to their activities;
5. the preparation of a full report of the CTCA activities and findings under Phase 1; and
6. the preparation of recommendations for the guidance of the CTCA Executive Committee, concerning the Association's continuation with or withdrawal from the program.

At the end of these activities, the CTCA will have produced no data but will know the availability, costs, needed administrative arrangements, and other requirements for data generation.

B. The DOC commitments to Phase 1 are:

1. appointment and funding of one of the co-Chairpersons;

2. within the parameters established under the section above entitled Working Arrangements, such other appointments and the funding thereof, as are deemed appropriate;

3. liaison with the CTCA working researchers; and

4. preparation of a report on the DOC findings.

C. Both the DOC and the CTCA are committed jointly to have the Research Team prepare a report by April 30, 1980 which synthesizes its findings. This report, together with such recommendations as the Board of Control deems appropriate, will be prepared for submission to the CTCA Executive Committee and the DOC senior management prior to the second milestone date in May 1980.

EFFECTIVE DATE, APPLICATION AND TERMINATION

This Memorandum of Understanding enters into force upon signature by the authorized representatives of both parties.

This MOU is valid until a decision to continue or terminate the CTCA participation is taken by the Executive Committee of the CTCA, or until a decision to continue or terminate the DOC participation is taken by senior management of the DOC.

In the event of a decision to terminate this MOU, written notice of that decision will be given in writing at least thirty (30) days in advance of the termination date. This written notice will be from the co-Chairperson of the terminating party to the co-Chairperson of the other party.

Any such notice to DOC will be addressed to its offices at 300 Slater Street, Ottawa, Ontario, K1A 0C8. Any such notice to the CTCA will be addressed to its offices at Suite 700, 1 Nicholas Street, Ottawa, Ontario, K1N 7B7.

In the event of termination, each party will be responsible for its own contractual obligations and any expenses which it has incurred.

If this MOU is terminated, the parties will prepare a joint report, containing non-proprietary information, of their activites, findings and recommendatfons to that date, relative to the project, for submission to the senior management of DOC and the Executive Committee of the CTCA.

The laws of the Province of Ontario will apply to this MOU.

SIGNATURES

This Memorandum of Understanding consists of sixteen pages in the English version and seventeen pages in the French version. It has been made in four copies, two in French and two in English, all copies being equally authentic.

Accepted for the Department of Communications, Government of Canada by:

Title Deputy Minister

At Ottawa

Date February 1, 1980

Accepted for the Canadian Telecommunications Carriers Association by:

Title President

At Ottawa

Date 7 February 1980

APPENDIX B

TOTAL FACTOR PRODUCTIVITY MEASUREMENT: AN ILLUSTRATION

In the following example,[1] a hypothetical telecommunications carrier is assumed to use labour, capital, and material inputs to produce local and toll telephone services in two consecutive years, 1980 and 1981. The purpose is to show how the rate of productivity growth of this firm from 1980 to 1981 can be obtained, and in fact is obtained in Törnqvist calculations.

The raw data of the hypothetical firm are assumed to be as follows:

Output Volume[2]	Year 1980	Year 1981	Coefficient of Change
Local	25	45	45/25 = 1.8
Toll	25	60	60/25 = 2.4
Output Prices[3]			
Local	1.0	1.4	
Toll	1.0	1.8	
Revenue (= Output volume X Price)			
Local	25	63	
Toll	25	108	
Total	50	171	

1 This Appendix makes use of numbers which are already shown in Appendix C, in order to present the essential characteristics of the process of indexing used in this Report and described more generally in Chapter 3.

2 Deflated constant (1980) dollar revenues, representing physical units.

3 Price indexes (on 1980 base year).

	Year 1980	1981	Coefficient of Change
Input Volume[1]			
Labour	3	4	4/3 = 1.33
Capital	200	500	500/200 = 2.50
Material	5	10	10/5 = 2.00
Input Price[2]			
Labour	7.7	12.75	
Capital	0.11	0.20	
Material	1.0	2.0	
Cost (= Input volume X Price)			
Labour	23	51	
Capital[3]	22	100	
Material	5	20	
Total	50	171	

From the above data the values of revenue and cost shares can be derived. This is necessary in order to attach weights to the various output and input growth coefficients, reflecting the relative importance of each element in total output and total input.

1 Labour is measured in expensed hours worked, that is, it excludes own account construction. Capital volume is the constant (1980) dollar value of telephone plant in service. Material volume is the deflated constant (1980) dollar value of material and various miscellaneous expenses.

2 Labour price is the hourly wage rate in dollars; capital price is the residual rate of return to capital; material price is a price index based on the 1980 base year.

3 Capital cost is equal to total revenue, less labour and material cost.

The calculation of revenue and cost shares is as follows:

	Year 1980	Year 1981	Average (1980 + 1981)
Revenue Share			
Local	25/50 = 0.50	63/171 = 0.368	0.434
Toll	25/50 = 0.50	108/171 = 0.632	0.566
Cost Share			
Labour	23/50 = 0.46	51/171 = 0.298	0.379
Capital	22/50 = 0.44	100/171 = 0.585	0.512
Material	5/50 = 0.10	20/171 = 0.117	0.109

The weighted averages of individual coefficients of output and input volume changes from 1980 to 1981, called the output and input volume indexes respectively, are computed as follows

$$\underline{\text{Output Index}} = (\text{Local Output Volume Change})^{(\text{Average Local Revenue Share})}$$

$$\times\ (\text{Toll Output Volume Change})^{(\text{Average Toll Revenue Share})}$$

$$= 1.8^{0.434}\ 2.4^{0.566}$$

$$= 2.1182.$$

This index is a Törnqvist volume index of output. It indicates that 2.12 times as much output was produced by the firm in 1981 as in 1980.

$$\underline{\text{Input Index}} = (\text{Labour Volume Change})^{(\text{Average Labour Cost Share})}$$

$$\times\ (\text{Capital Volume Change})^{(\text{Average Capital Cost Share})}$$

$$\times\ (\text{Material Volume Change})^{(\text{Average Material Cost Share})}$$

$$= 1.33^{0.379}\ 2.50^{0.512}\ 2.00^{0.109}$$

$$= 1.9229.$$

This index is a Törnqvist index of input. It implies that the firm used 1.92 times as much inputs in 1981 as in 1980.

We see from the values of the output and input indexes computed above that total output increased faster than total input between 1980 and 1981; that is, there was a productivity improvement. The productivity index, called in this case the Total Factor Productivity (TFP) Index, is obtained from the ratio of output and input indexes as follows:

$$\underline{\text{TFP Index}} = \frac{\text{Output Index}}{\text{Input Index}} = \frac{2.1182}{1.9229} = 1.1016.$$

This indicates that there was a 10.16% improvement in the firm's total factor productivity between 1980 and 1981. When this calculation is to span a number of years, it is repeated sequentially pairing each year with the following year, exactly as illustrated above.

APPENDIX C

ON INTER-FIRM PRODUCTIVITY COMPARISONS

FERENC KISS

Department of Communications
Government of Canada
1983

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FOREWORD

In September 1982, I was asked by the Department of Communications to prepare an essay on the topic of inter-firm productivity comparisons for the DOC/CTCA joint project to measure productivity in the Canadian telecommunications industry. The essay is intended to be read by non-specialists in government and industry. Its main objectives are (1) to summarize and explain the underlying issues and methodology of inter-firm productivity comparisons in plain and non-technical English and (2) to evaluate the existing methods of comparison, as they apply to the Canadian telecommunications industry, from the point of view of validity, accuracy and analytical value.

The structure of the essay is as follows. The discussion begins with a simple definition of productivity and an overview of the various kinds of productivity comparisons in Section 1. The overview reveals where inter-firm comparisons stand in the general scheme of productivity comparisons. Section 2 contains a brief description of comparison methodology. The major concepts (inputs, outputs, index numbers) are introduced and it is shown how they can be put to work in productivity comparisons. The reader will be able to catch a glimpse of the productivity measurement methodology we use in the Canadian telecommunications industry. The evaluation of productivity comparisons begins in Section 3. First, we attempt to find out why productivity comparisons are made. Our findings reveal some of the uses of comparisons of productivity and lead the reader to the central question: How can we explain the observed differences? Section 4 advocates the construction of decomposition models for intra-firm productivity gains and inter-firm productivity gain differences. Due to the general nature of discussion, only an outline of these models is given. The same section contains references to decomposition models of inter-firm differences in productivity levels and states that such models cannot be successfully built in the Canadian telecommunications industry at the present time. Section 5 further elaborates on this theme by comparing the practical problems of intra-firm and inter-firm comparisons of productivity. Section 6 describes an index problem and its practical consequences. Section 7 is a summary.

The essay is a distillation, formalization and extension of experience acquired over the life of the DOC/CTCA joint project. In the process of assembling the material, I relied extensively on the advice of representatives of the Department of Communications, Canadian Telecommunications Carriers' Association (CTCA), Alberta Government Telephones, Bell Canada, British Columbia Telephone and Teleglobe. I found a series of discussions on the subject with Dr. R.E. Olley especially beneficial. Every effort has been made to find and express a concensus on the issues of inter-firm productivity comparison. However, some differences of opinion, some errors and misconceptions may have remained undiscovered, unexplained and unresolved. These are the author's sole responsibility.

1. WHAT KIND OF PRODUCTIVITY COMPARISONS CAN BE MADE?

Let us begin our discussion of inter-firm productivity comparisons with a brief answer to this question. The answer will help determine the position of inter-firm comparisons among all other kinds of productivity comparisons.

Throughout the essay, we shall refer to productivity as the output/input ratio.[1] Thus, if there is only one input (X) and one output (Q) or, alternatively, there is a way to generate a single input aggregate and a single output aggregate, the level of productivity is simply Q/X.[2] When we compare productivity, we compare output/input ratios.

One's ability to make use of comparisons of output/input ratios depends on many circumstances; for instance, whether the necessary information is available and accurate, or whether the comparison itself is meaningful and capable of facilitating an analysis and understanding of productivity. Disregarding the specific circumstances for the moment, we can make the general statement that productivities (input/output ratios) can be compared in two fundamentally different ways. First, the productivity of a country, industry, firm, department, etc. can be compared to itself through time. The resulting measure is usually referred to as a productivity gain (or loss). It is an intertemporal measure of productivity levels. It tells us that, for example, the productivity level of firm A was 10% higher in 1981 than in 1980. Secondly, we could set out to compare the productivities of different countries, industries, firms, departments, etc., at the same point in time. The result of such comparisons is an interspatial measure of productivity levels. This tells us that, for example, firm A was 14% less productive than firm B in 1981. Furthermore, temporal changes can be compared through space and spatial differences can be compared through time.[3] E.g., we may find that the productivity gain of firm B was 7% higher than that of firm A in 1981 or that the relative productivity level of firm A (relative to that of firm B) declined by 12% in 1981 from its 1980 relative level.

2. HOW DO WE MAKE PRODUCTIVITY COMPARISONS?

Historically, productivity measurement evolved in the form of temporal comparisons of productivity levels. As of the end of 1982, five companies have intertemporal measures of productivity in the Canadian telecommunications industry. The measures are index numbers, showing year-to-year changes in the companies' output/input ratios. Their methodology can be best demonstrated through a numerical example.

Table 1 depicts a hypothetical telephone company (firm A) which uses labour, capital and material inputs to produce local and toll telephone services in two consecutive years (1980 and 1981).[4] Output volumes are represented by constant (1980) dollar revenues. Labour input is measured by the number of hours worked during the year by the employees of the firm on the production of telephone services. The volume of capital is represented by the constant (1980) dollar value of telephone plant in service and material input is the constant (1980) dollar value of the non-labour component of operating expenses (excluding depreciation and non-income taxes). All measures may be understood as millions.

TABLE 1: Temporal Comparison of Productivity
(Firm A, 1981/1980)

Output, input	1981	1980	1981/1980	Average	Productivity Index
Local output	45	25	1.8	2.1182 (outputs)	
Toll output	60	25	2.4		
				2.1182 / 1.9229	= 1.1016
Labour input	4	3	1.33	1.9229 (inputs)	
Capital input	500	200	2.5		
Material input	10	5	2.0		

NOTE: The more involved reader will find an expanded version of Table 1 (and of Tables 2, 3 and 4 to follow), together with further explanatory notes, in the Addendum.

The intertemporal productivity index of firm A is obtained in three steps. The index of total output is determined first as the average of the 1981/1980 growth coefficients of the individual outputs. The local growth coefficient is 45/25 = 1.8 and the toll growth coefficient is 60/25 = 2.4. The (geometric) average of these two numbers is shown to be 2.1182, indicating that in 1981 firm A produced 2.12 times as much output as in 1980. This average is somewhat higher than the mid-point between 1.8 and 2.4 (which is 2.1), in order to express the fact that during the two years more of the faster growing toll service was produced than the slower growing local service. 56.6% of the two years' combined revenue originated from toll services and the remaining 43.4% was produced by local services. When the average is taken, 1.8 is weighted by 43.4% and 2.4 is weighted by 56.6%. This weighted geometric mean is referred to as the Törnqvist volume index of output.[5]

The second step is the calculation of the index of total input. The three input growth coefficients are: 1.33 for labour, 2.5 for capital and 2 for material. Their weighted geometric mean is taken. The weights are the respective percentage shares in the two years' combined total input cost. The Törnqvist volume index of input is 1.92, indicating that in 1981 firm A used 92% more resources than in 1980.

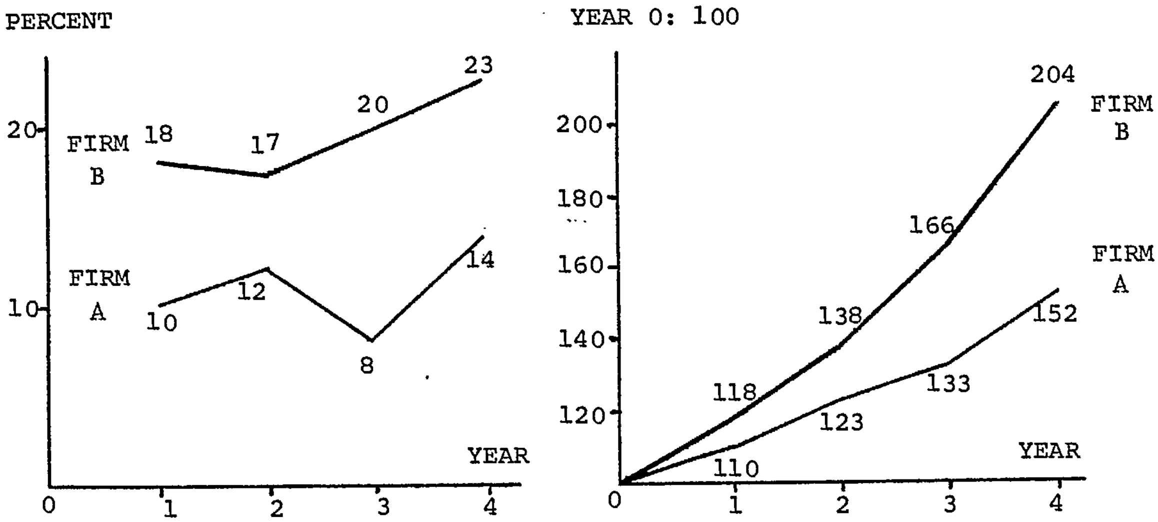
The third and final step is the calculation of the productivity index as the ratio of the output index and the input index. Output grew faster than input; thus, firm A had a 10.16% productivity gain, because 2.1182/1.9229 = 1.1016. The ratio of the output index to the input index is an equivalent expression of the year-to-year change in the firm's output/input ratio.[6]

The same intertemporal productivity level comparison is repeated in Table 2 for another hypothetical telephone company, firm B. We see that its average output growth was 88.45%, while its inputs grew only by 59.72% on the average; thus, the productivity of firm B improved by 17.99% from 1980 to 1981, because 1.8845/1.5972 = 1.1799.

TABLE 2: Temporal Comparison of Productivity
(Firm B, 1981/1980)

Output, input	1981	1980	1981/ 1980	Average	Productivity Index
Local output	8	5	1.6		
Toll output	20	10	2.0		
				$\frac{1.8845}{1.5972}$	= 1.1799
Labour input	1	.8	1.25		
Capital input	158.8	100	1.59		
Material input	5	2	2.5		

The most obvious inter-firm productivity comparison would have us say that the 17.99% improvement for firm B is greater than the 10.16% improvement for firm A. This would be an inter-firm comparison of productivity gains. Annual productivity improvements can be calculated and compared for many years. Figure 1 shows such a comparison.



1(a): Productivity gain 1(b): Productivity index

Figure 1: Temporal productivity comparisons for two firms

The result of temporal productivity comparisons can be expressed either by an index number (which is 1.0 or 100% in some selected base year) or by a productivity gain (which expresses the productivity improvement as a percentage over a base year). It is customary to measure productivity gains over the previous year and to relate the productivity index to a fixed base year as shown in Figure 1.

In Figure 1, we see that firm B had consistently higher productivity gains than firm A. However, we do not know whether B was more or less productive; i.e., whether it had a higher or lower productivity level (output/input ratio), than firm A. Only an interspatial measure; i.e., an inter-firm productivity level comparison, could provide this knowledge.

Table 3 contains a comparison between firms A and B for 1980. The data that were used earlier to calculate productivity gains for the two firms are taken from Tables 1 and 2.[7] The calculations proceed very much the same way as in Tables 1 and 2. First, we establish that the much larger firm A produced 5 times as much local service and 2.5 times as much toll service as firm B in 1980. The weighted average of these two numbers indicates that firm A's combined output was 3.34 times as much as B's. 3.34 is an interspatial Törnqvist volume index of output, because the average is a geometric mean and the weights are the combined revenues shares. Secondly, we calculate input ratios. Firm A used 3.75 times as much labour, twice as much capital and 2.5 times as much material as B to produce its output. On the average, A's input was 2.58 times greater than B's. 2.58 is an interspatial Törnqvist volume index of input. Thirdly, we obtain the inter-firm productivity index, which is 1.294, signifying that in 1980 the productivity level of firm A was 29.4% higher than that of firm B. In an identical fashion, Table 4 establishes that the productivity level of firm A was 13.7% higher than that of firm B a year later in 1981.[8]

The structural similarity between Tables 1 and 2 on the one hand and Tables 3 and 4 on the other hand demonstrates that there are no basic conceptual differences between methods of temporal and spatial comparisons of productivity. Both comparisons use index numbers and the index numbers may be of the same formula. In our Tables 1 to 4, we used Törnqvist intertemporal and interspatial volume indexes for outputs and inputs.

TABLE 3: Inter-Firm Comparison of Productivity Levels (1980,A/B)

Output, input	Firm A	Firm B	A/B	Average	Productivity Index
Local output	25	5	5.0		
Toll output	25	10	2.5	3.3371 / 2.5794	= 1.2937
Labour input	3	.8	3.75		
Capital input	200	100	2.0		
Material input	5	2	2.5		

TABLE 4: Inter-Firm Comparison of Productivity Levels (1981, A/B)

Output, input	Firm A	Firm B	A/B	Average	Productivity Index
Local output	45	8	5.63		
Toll output	60	20	3.0	3.5868 / 3.1541	= 1.1372
Labour input	4	1	4.0		
Capital input	500	158.8	3.15		
Material input	10	5	2.0		

We learn from Tables 3 and 4 that firm A had higher productivity levels than firm B both in 1980 and in 1981, but the gap was closing as the difference shrank from 29.4% in 1980 to 13.7% in 1981. The second finding corresponds to and is explained by the fact that B's 1981 productivity gain was higher than A's.[9] The numerical relationship between productivity gains and changes over time in the productivity level of firm A relative to firm B is shown and further analysed in Section 6. Figure 2(a) combines the numerical results in Tables 3 and 4.

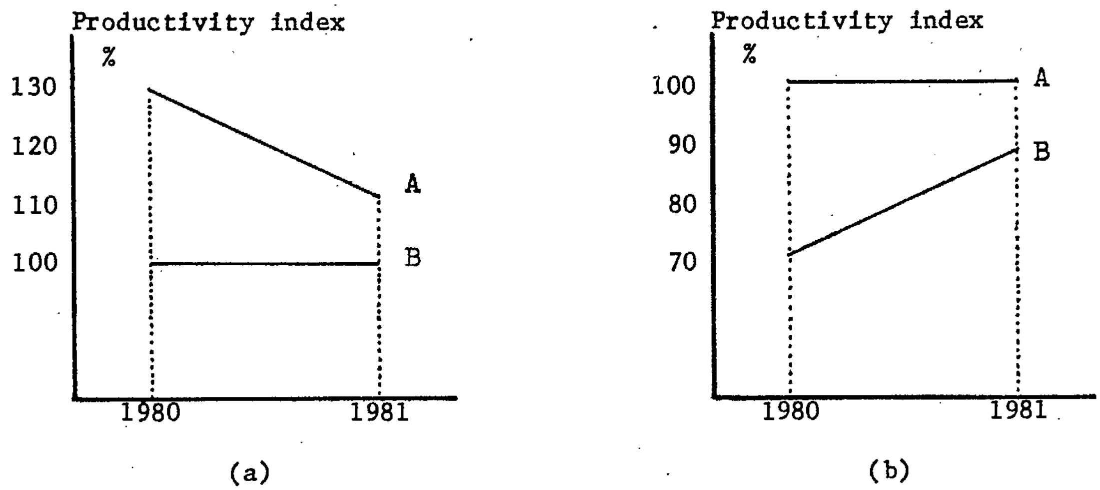


Figure 2: Inter-firm productivity level comparison between firms A and B

The productivity levels of both firms undergo continuous changes. In Figure 2(a), firm A is related to a changing firm B, but the productivity movements of B are not shown, because B serves merely as the base of comparison. Of course, we can make A the base of comparison, as in Figure 2(b), but that would prevent us from showing the temporal productivity change within firm A. It is possible to express the temporal productivity movement in both firms simultaneously with their inter-firm relationship at different points in time if we use a single fixed point as the base of comparison, as shown in the combination of temporal and spatial comparisons in Figure 3.

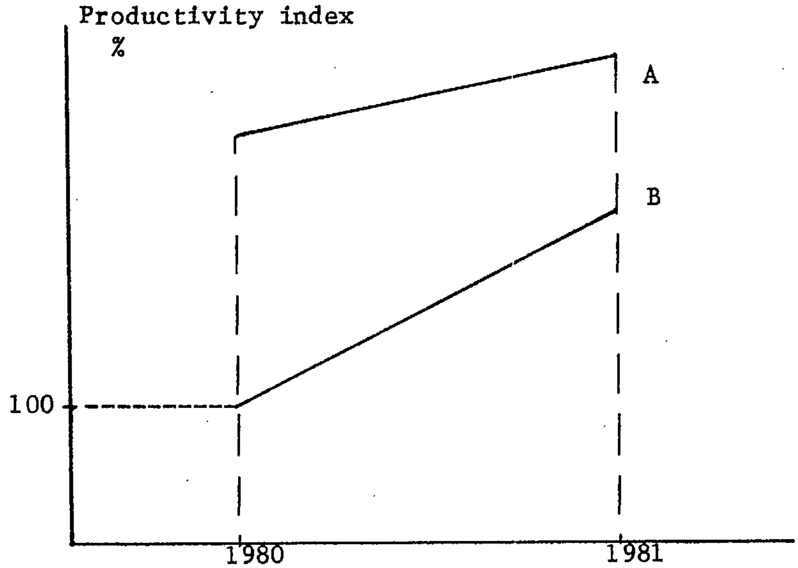


Figure 3: Combined inter-firm productivity gain and level comparison for firms A and B

Although the productivity level of firm B in 1980 is chosen as the base of comparison in Figure 3, any of the four known points would fulfill this role with equal ease. The choice of base depends on the purpose of the comparison.

Figure 3 concludes the descriptive part of this essay. It contains a full and complete productivity comparison between two firms in two years. If we could make a combined comparison such as the one shown in Figure 3 we would know how each firm's productivity changed over time and what the relationship was between the productivity levels of the firms at each point in time.

Sections 1 and 2 fulfill one of our two main objectives by providing a summary and explanation of the methodology of inter-firm productivity comparisons. In order to achieve maximum clarity in our explanation, we simply assumed that the required information is always available and that any kind of productivity comparison can be made with a sufficient degree of accuracy. We did not burden the description with analyses of the meaning and usefulness of productivity comparisons. The next section turns to the practical uses of productivity comparisons, emphasizing the areas wherein they may add to managerial and policy insight.

3. WHY DO WE MAKE PRODUCTIVITY COMPARISONS?

There are two reasons for making productivity comparisons. First, we want to understand and explain things that are affected by productivity; second, we want to understand and explain productivity itself.

We seldom compare productivity just to learn, without any particular reason, what spatial and temporal differences exist. We usually need a measure of productivity differences because productivity is one of the factors that determine the behaviour of output prices (telephone rates), revenues, production costs and profits. Suppose the inflationary increase in total cost (appropriately calculated to reflect inflation not only in current operating expenses but also in interest charges and other embedded costs, etc.) is a uniform 10% for all telephone companies; then telco X with a 10% productivity gain needs no rate increases, while telco Y with a 4% productivity gain does, but not as much as telco Z whose productivity gain is 1%. The regulatory aspect of productivity gains is obvious. Any regulatory agency which is engaged in setting telephone rates must learn about temporal changes in productivity in order to be able to decide that, for example, telco Y should be given an approximately 6% rate increase, while telco Z needs an approximately 9% rate increase in order to maintain profits at sufficiently high levels to attract investment. Regardless of the causes of productivity gains or whether they are satisfactory or not, differences will be generated in the price increases, revenues, costs and profits of the three telcos. Such differences may give rise to inter-regional price differences or may result in X or Y taking over the market of Z and Z going out of business if the three firms are competitors. The inter-regional price difference or Z's bankruptcy cannot be fully understood and explained without accurately comparing the productivity gains and levels. However, while this is undoubtedly true, it is also true that the productivity comparison does not reach very far. There are further questions. What generated the productivity gains of X, Y and Z? Are they as high as they should be? How high should they be? How can the productivity gains be improved? Only when we have answers to these questions can we say that we have understood and explained the situation of inter-regional price differences or Z's bankruptcy. We have to understand and explain productivity itself. Similarly, the regulatory agency would have to understand productivity in order to establish what degree of rate increase is justified and beyond what degree would the rate increase serve to encourage inefficiency. In our example, a uniform 6% rate increase would be justified for telco Y, while it would create grave financial difficulties for Z and would encourage X to relax its cost control.

As an overall measure, productivity involves all outputs and inputs of the production process. Thus, the productivity of a firm is influenced by almost everything that influences the firm. Productivity changes are generated by a great number of causes. Understanding productivity changes involves (1) the identification of causes and (2) the quantification of their effect on productivity. Comparisons help with respect to both items. When productivities are compared through time or space, differences in various circumstances may be observed and measured as well. Coincidences between differences in productivity and in some of these circumstances may be suggestive of causal relationships. E.g., one may observe in the telecommunications industry that the higher the growth rate of output the greater the productivity gain or that the greater the size of the firm the higher the level of productivity. A strong relationship between productivity gains and growth rates suggests economies of scale in some years and a strong relationship between productivity levels and firm size suggests economies of scale within a certain range of output volumes.[10] It is also possible to observe some relationship between productivity and product mix; e.g., the local/toll ratio. The local/toll ratio affects productivity if the degree of economies of scale and the rate of technological improvements are not the same for local and toll services. Such suggestions are interesting and useful. However, it must be emphasized that relationships suggested by casual comparisons have only a limited analytical value in themselves if they cannot be verified (e.g., by engineering knowledge or statistical tests) and especially if they cannot be quantified.

How does one go about verification and quantification? There are two circumstances that make these tasks difficult: first, the very large number of causes; second, the complexity of relationships. The former makes the individual treatment of causes impossible and forces the analyst to deal with broad classes of causes, and the latter calls for complex quantitative models.

4. DECOMPOSITION MODELS

With respect to intertemporal measures of productivity, there are economic models in existence which have been designed to tell us how much of the productivity gain of a firm is generated by technological changes (depending on the rate of introduction of improvements and on the degree of cost savings achieved by them), by economies of scale (depending on their degree and also on the growth rate of the size of the firm) and by other factors (e.g., cross-subsidization, rate of return regulation).[11]

As an illustration, we show the decomposition of the annual productivity gains of a fictitious firm with economies of scale in Table 5.

TABLE 5: Productivity Gain Decomposition

	1971	1972	...	1980	1981
Productivity gain	3.2%	5.4%		3.1%	1.6%
Technology effect	1.1	1.3		1.2	.8
Scale effect	2.5	3.1		1.4	1.0
Other effects	-.4	1.0		.5	-.2

Productivity gain decomposition models have not been exploited to any significant extent yet (only Bell Canada has long enough time series to construct them), but the knowhow certainly exists and shows promise. The information these models are capable of providing is important even if (or, as one might say, precisely because) it remains highly aggregate in nature. E.g., it is important to know whether a one percent increase in constant dollar revenues generates a productivity gain of .4 percent or only .1 percent or none at all. These percentages are not very accurate for all real life situations because it matters in general where the revenue increases come from. Nevertheless, they enable a firm to size up the impact of economic up- and downturns or that of the capture or loss of a market.[12]

It has been suggested that the method of decomposing intra-firm productivity gains can also be used to explain inter-firm differences in productivity gains.[13] The underlying idea is that if in a given year the productivity gains of firms A and B are due to the above mentioned three factors then the same three factors are responsible for the differences in the productivity gains of A and B. Even in relatively simple models, inter-firm productivity gain differentials can be decomposed into effects of inter-firm differences with respect to (1) the rates of introduction of new technologies, (2) the cost saving capabilities of new technologies, (3) output growth rates, (4) the degree of economies of scale and (5) an inter-firm difference in that portion of productivity gains which is not explained by the first four effects. Table 6 summarizes the results of the decomposition of the difference between the productivity gains of two fictitious firms, U and V.

TABLE 6: Decomposition of Inter-Firm Productivity Gain Difference in a Given Year

	Firm U	Firm V	U-V	Percentage distribution
Productivity gain	8%	5%	3%	100%
Technology effect	2%	1%	1%	33.33%
- rate of improvement	-	-	.6	20.00
- cost saving ability	-	-	.4	13.33
Scale effect	5%	3%	2%	66.67%
- growth rate	-	-	1.2	40.00
- economies of scale	-	-	.8	26.67
Other effect	1%	1%	0%	0%

It is not only possible but also highly desirable to construct decomposition models of inter-firm productivity gain differences in the Canadian telecommunications industry. Such models would be capable of providing considerable insight into cyclical as well as regional movements in productivity by linking productivity gains to the state of the economy and to regional economic conditions through their impact on telephone demand and on inflationary cost increases. This insight would readily translate into an ability to forecast cyclical and regional productivity movements. Decomposition models would also make it possible to establish a crude measure of the cost saving impact of new technologies (1) on a nation-wide basis and (2) within a wide range of rates of introduction as observed in different firms. Furthermore, decomposition models would shed new light on inter-firm differences in productivity gains by explaining them in part through the different capabilities of different firms to improve their productivity. Apart from its regulatory significance, the insight that decomposition models can provide might prove to be valuable through focussing the attention of policy makers on the best ways of promoting productivity and through providing an assessment of the approximate impact of productivity promoting policy decisions.

Another major advantage of inter-firm productivity gain decomposition models is related to the fact that short time series of available output and input data (10 to 15 years at most) prevent almost all firms in the Canadian telecommunications industry from estimating the cost characteristics that would enable them to decompose, analyse and forecast their own productivity gains. For these firms, inter-firm productivity gain decomposition models represent the only opportunity, not only at present but also for some time to come, for intra-firm productivity gain decomposition, analysis and forecasting.

There is a certain conceptual analogy between decomposing intra-firm productivity gains and doing the same for inter-firm productivity level differences. For instance, just as temporal changes in a firm's productivity are related to changes over time in its technology and in the growth rate of its size, inter-firm productivity level differences can be associated with inter-firm differences in technology and firm size. Even though we advocate the building of models to decompose intra-firm productivity gains and inter-firm productivity gain differences, we believe that several important obstacles prevent the successful decomposition of inter-firm productivity level differences at the present time and in the foreseeable future.

In the absence of decomposition models, inter-firm productivity level comparisons are restricted, ab ovo, to simply showing differences among firms with respect to their output/input ratios. The observed differences cannot be analysed in any systematic and quantitative manner in order to learn what factors generate them and to what extent. Without decomposition models, inter-firm productivity level comparisons lack analytical value.

The reason for not being able to construct decomposition models in the Canadian telecommunications industry is to be found not so much in the theoretical as in the practical difficulties of inter-firm productivity comparisons. They are the subject of the next section.

5. A COMPARISON OF INTRA-FIRM AND INTER-FIRM COMPARISONS OF PRODUCTIVITY

Let us begin our elaboration with the causes of temporal changes in overall firm productivity. Capacity utilization changes affect productivity gains, because the stock of physical capital is measured to represent the productive services of the capital stock. Technological changes are one of the main factors of productivity improvement, because they often achieve substantial input savings. (Of course not all technological changes are aimed at improving productivity. E.g., some R&D efforts may introduce new products and the resulting market advantage may improve profits through price increases without increasing productivity.) The degree of economies of scale is important, because the higher the degree the greater the productivity increasing effect of a given demand/output growth rate. The growth rate of the firm is important in many ways. Higher growth rates generate higher productivity gains if economies of scale exists. The growth rate also influences the rate of introduction of new technologies. Product quality improvements also influence productivity. They may result in input savings as well as in additional input requirements. The Canadian telecommunications industry has a peculiar measurement problem with respect to product quality. Some qualitative changes, such as rural service improvements, enhanced service in the North, etc., are seldom measured as output increases but they require additional inputs, measured productivity tends to change in inverse direction with product quality. The danger in this situation is that it is possible to show short term productivity improvement by lowering product quality. Product mix changes are also a major factor as the productivity improvement potential usually differs from product to product. In the telecommunications industry, increases in the toll/local ratio are generally regarded as a productivity enhancing factor. Product prices play a role, partly because price changes alter the product mix, and partly due to the measurement methodology. Since the prices of local services tend to be lower than their marginal costs and the prices of toll services are normally higher than their marginal costs, the output and productivity indexes are usually upward biased in the telecommunications industry. The reason is that the revenue share weight of the slower growing local services becomes too low and the revenue share of the faster growing toll services becomes too high. If the revenue share of local output were 52% instead of 43.4% in Table 1 and if the toll revenue share were reduced to 48% from 56.6% the output index would be 2.07 instead of 2.12. Regulation influences firm-level productivity by demanding large amounts of costly information and also by making and influencing input and output related decisions (e.g., regulating product prices, scrutinizing construction programs, employment policies). Managerial decision making may also figure in temporal productivity changes. Major reorganizations may result in significant gains from one year to the next, while major errors may have a noticeable negative impact. Individual events that influence the volume of of outputs (e.g., postal strikes, EXPO, Olympic or Commonwealth Games) or inputs (e.g., strikes, natural disasters) also impact on productivity.

Despite this long list of factors, which must be borne in mind in any productivity gain analysis, there are two circumstances, viz. the availability of information and the relatively small magnitude of changes in the influencing circumstances and in productivity from one year to the next, that encourage us to believe that the task of measuring and analysing productivity gains can be accomplished. However, it is important to note that significant aspects of any particular productivity change will remain unexplained in any given model of inter-temporal productivity comparison.

There is usually adequate availability of information because intra-firm temporal changes are managed, i.e., they are planned, budgeted, supervised, verified, measured, analysed and evaluated. Accounting records and managerial studies collect the information which is thereby readily available for the purposes of productivity measurement and analysis. As for the small magnitude of temporal changes, even in the telecommunications industry, where productivity gains tend to be very high in comparison to other segments of the economy, annual gains seldom exceed 5 or 10%. Revenue and cost shares and the above listed causal factors change slowly and gradually. Except under very unusual circumstances, a firm remains highly comparable to itself for several adjacent years.

The same is not true for inter-firm comparisons. It is fair to say that productivity gain comparisons are more difficult to make than intra-firm temporal comparisons, but they are not as difficult as inter-firm productivity level comparisons. To a great extent, gain comparisons involve the same difficulties as the gains that are being compared because the factors that explain productivity gains also explain their inter-firm differences. However, gain comparisons give rise to additional complications, mainly because certain temporal changes depend on inter-firm differences. E.g., the degree of economies of scale may depend on the size of the firm if the technologies are more or less the same and differences in the product mix may also play an important role. As a result, one has to explore various inter-firm differences in order to facilitate an explanation as to why the causal factors of differences in productivity gains have different intensities and numerical values. Moreover, when evaluating the role of inter-firm differences, one must remember that a lack of knowledge in this respect eliminates some elements of the explanation and analysis but in no way does it prevent the comparison itself and the decomposition of productivity gain differences.

Differences in characteristics become crucial in inter-firm productivity level comparisons. Spatial differences between firms are usually much greater than annual differences within any given firm in utilization, size, product mix, quality, technology, management, regulatory procedures, etc. A given firm is normally more comparable to itself in two consecutive years than two different firms are in the same year. E.g., no Canadian telecommunications company could double or treble its output in one year, but the output volume of the largest of them is many times greater than that of even the medium sized telcos; the toll/local ratio changes by a few percentage points at most from one year to the next, but some Canadian telephone companies produce no or little local service, while others produce no or little toll. The products of Teleglobe and Telesat are different from the products of regional telephone carriers and so are their technologies. To a less obvious but nevertheless important degree, the regional telephone carriers produce different products from one another as well.

If we group the numerous causes of inter-firm differences in productive characteristics we can arrive at four major classes of environmental factors:

1. climate,
2. topography,
3. demography,
4. economy.

It is not the task of this essay to describe them exhaustively. Climate and topography require no further elaboration. Demography refers to phenomena such as population growth, density and mobility, degree of urbanization. The impact of economic differences is probably the most complicated. As an illustration, we mention infrastructure, industry mix (e.g., agricultural, mining, manufacturing, fishing regions) and the large to small business ratio. The impact of the above phenomena is direct and great with respect to inter-firm differences in productivity, while it is usually small and indirect in intertemporal differences within a given firm.

A similar situation exists with respect to management. Temporal differences in the impact on productivity of management are usually relatively small. This is to say that the management of a given firm very seldom improves or deteriorates in a substantial way from one year to the next. On the contrary, significant changes in personnel, in management philosophy, style and in the quality of decisions require longer periods of time to take place. In contrast, given that the management of different firms involves different sets of managers whose philosophy, style, competence, etc. may be significantly different, it is reasonable to conclude that differences in management may cause significant differences in productivity levels.

The fact that differences in the environment, production characteristics (technology) and management of firms are normally, and in the majority of cases we face in our practical productivity analysis, greater than temporal differences (if the latter do not span long periods of time) raises the issue of the degree of comparability. Inter-firm level comparisons tend to be less meaningful than temporal comparisons on account of incomparability. Level comparisons also tend to be less accurate and subject to greater error than temporal comparisons.

Let us turn now to the availability and accuracy of information. The most striking point is that inter-firm differences are rather spontaneous and are not managed. Nobody plans, budgets, supervises, verifies, measures, analyses and evaluates them, except for some idiosyncratic instances of casual comparison for parts of operations. As a result, much less information is collected and can be made available for inter-firm productivity analysis than for intra-firm analysis of productivity. Such information as is available is the product of each firms' own accounting activity. The accounting procedures, however, can be and usually are different to various degrees between firms, resulting in discrepancies in the contents and in the measurement methods of variables. It is interesting to note that relatively minor changes in some of Bell Canada's accounting procedures caused a downward bias of up to 1.5 percentage points in the uncorrected measures of annual productivity gains.[14] The effect of inter-firm differences in accounting procedures may be considerably greater. The unavailability and inconsistency of information creates two problems in inter-firm comparisons of productivity levels. First, it reduces the accuracy of the comparison by biasing one firm's output and input measures relative to the other. Secondly, even if total outputs and inputs were comparable, little analysis would be permitted because of different output and input classifications, different definitions and assumptions concerning individual prices and volumes that emerge, often in an untraceable manner, from different accounting procedures.

The problems caused by data unavailability are worth a little more attention. The DOC/CTCA joint project used available firm-level information provided by Canadian telecommunications firms, and could not engage on its own in a detailed inter-firm comparison of all the variables involved in productivity measurement and analysis. Some measures, normally the disaggregated ones that are expressed in their natural and specific physical units (e.g., the number of employees) are readily comparable. Aggregate measures are not so easy to compare. Unfortunately, productivity studies, because of their aggregate nature, have to rely on index numbers which are aggregate measures. Let us examine the situation with respect to these aggregate variables. The output and input prices of Canadian telecommunications companies are being measured by price indexes for groups of services and resources. Price indexes show temporal changes relative to some selected base year but they do not show inter-firm differences in prices. Therefore, the constant dollar revenues and costs that are designed to represent volumes of outputs and inputs also show temporal changes but are not capable of showing inter-firm differences in volumes. E.g., if we observe, as in Table 1, that the 1980-dollar toll revenue of firm A was $25 million in 1980 and $60 million in 1981 then we can conclude that the volume of toll services of the firm increased 60/25 = 2.4 times from 1980 to 1981. In contrast, if we observe, as in Table 4, that the 1980-dollar toll revenue of firm A was $60 million, while that of firm B was $20 million in 1981, then we cannot draw the conclusion that the toll service volume of firm A was 60/20 = 3 times as much as that of firm B. The reason is that the 1980 toll rates might have been different for the two firms; thus, equal amounts of 1980 dollars may represent different service volumes. In order to make the comparison meaningful, we should express the two firms' revenues in truly common dollars; e.g., the dollars of firm B in 1980. This can be done only if inter-firm price indexes are constructed on the basis of a detailed inter-firm price comparison. Inter-firm price indexes require special studies. Such studies are very difficult and costly to make. Sometimes they are quite inconceivable, because different firms will not reveal detailed price and cost information to one another. Studies of inter-firm price level comparison do not exist in the Canadian telecommunications industry and the more competition is introduced the more remote becomes the chance of conducting such studies.

To illustrate the possible numerical consequences of not having inter-firm price indexes, we took Table 3 and corrected its data by assuming that in 1980 the local service prices of firm A were 10% higher, than B's, its toll prices were 20% higher, its material purchase prices were 10% lower and its equipment purchase prices were also lower. This is the kind of information inter-firm price indexes would give us. We corrected the productivity calculations of Table 3 in Table 7 for the year 1980 and also re-calculated the inter-firm productivity comparison of Table 4 in Table 8 for the year 1981. The Addendum contains Tables 7 and 8, together with the necessary explanatory notes. We found that instead of being 29.37% more productive than firm B, firm A had roughly the same productivity level as firm B in 1980. A year later, in 1981, firm A was in reality 13.69% less productive than firm B, instead of being 13.72% more productive as originally shown in Table 4.

We should emphasize at this point, that assuming 10 or 20% higher or lower output and input prices for one firm than for another is by no means an exaggeration. Price levels may be different to an even greater extent, especially if we consider that our firms are telephone companies serving different geographical areas under rather different conditions. Another point to be made is that the bias in the productivity index that is due to the lack of inter-firm price indices may be either upward or downward. The relative productivity level of a firm is distorted upward if the measure of its output prices is distorted downward and/or its input price measure is distorted upward. This is what happened with firm A in Tables 3 and 4. Conversely, the relative productivity level is downward biased if the output price measure is upward and/or the input price measure is downward biased. Of course, the magnitude of the actual distortion depends on whether distortions in individual prices strengthen (as in the example) or weaken each other.

6. A TECHNICAL PROBLEM IN PRODUCTIVITY COMPARISONS

We referred to the problem in a footnote to Section 1: It makes a difference in combined comparisons whether the temporal or spatial comparison is made first. For example, let us try to find out how much higher the productivity of firm A is in 1981 than that of firm B in 1980 according to our numerical example. As shown below, different paths lead from B,1980 to A,1981.

Two paths of productivity from B,1980 to A,1981

First path	Second path
from B,1980 to B,1981	from B,1980 to A,1980
+ 17.99% (Table 2)	+ 29.37% (Table 3)
from B,1981 to A,1981	from A,1980 to A,1981
+ 13.72% (Table 4)	+ 10.16% (Table 1)
Together:	**Together:**
1.1799 X 1.1372 = 1.3418	1.2937 X 1.1016 = 1.4251
+ 34.18%	+ 42.51%

+ 34.18% ←—— (?) ——→ + 42.51%

Indeed, it makes a difference whether we compare through time first and through space second or through space first and through time second. The inequality of the two solutions means that after doing the combined comparison in two different ways, we are not sure how much higher firm A's 1981 productivity level really is than firm B's productivity level in 1980.

With respect to output, input and productivity, the problem can be expressed in the following simple format:

$$\left[\frac{B,\ 1980}{B,\ 1981}\right] \cdot \left[\frac{B,\ 1981}{A,\ 1981}\right] \neq \left[\frac{B,\ 1980}{A,\ 1980}\right] \cdot \left[\frac{A,\ 1980}{A,\ 1981}\right].$$

We can conclude from the formula that the discrepancy is an aggregation problem. If all numerators and denominators in the formula above were simple numbers the equality would certainly hold. The reason why it does not hold is that all fractions are <u>index numbers</u>. This problem has been well known for a long time and is often referred to as <u>non-transitivity</u> of index numbers.

The problem of non-transitivity is not unique to combined temporal-spatial comparisons. It also exists both in temporal and in spatial comparisons and can be shown with ease whenever more than two points in time or space are compared. We can write

$$\left[\frac{1980}{1981}\right] \cdot \left[\frac{1981}{1982}\right] \neq \left[\frac{1980}{1982}\right]$$

signifying that the change (index) of output or input volumes from 1980 to 1981, times the change (index) from 1981 to 1982, is not equal to the directly measured change (index) from 1980 to 1982. Similarly, if we consider firms A, B and C we can write

$$\left[\frac{A}{B}\right] \cdot \left[\frac{B}{C}\right] \neq \left[\frac{A}{C}\right]$$

which illustrates that the change (index) of output or input volumes from firm A to firm B, times the change (index) from B to C, is not equal to the directly measured change (index) from A to C.

The significance of the non-transitivity problem goes beyond creating simple discrepancies between direct and indirect indexes of outputs and inputs. The main difficulty lies in the fact that we cannot say that the discrepancy is due to either A/B or B/C or A/C, to take the spatial comparison as an example. Thus, we must conclude that the problem is caused by their (common) structure, the mathematical formula. Hence, they are all suspect.

What causes non-transitivity in the Törnqvist volume indexes of outputs and inputs we use to compare productivity?[15] The answer is simple. It is the revenue and cost shares that are used to weight together the growth rates of individual outputs and inputs into geometric means. The problem is that these revenue and cost shares are different for each year and for each firm. It can be shown in any numerical example, if one is willing to do the necessary calculations, that the Törnqvist index is transitive and the above described problems do not exist if the points of comparison (years, firms) have identical revenue and cost shares.[16]

On the other hand, the greater the differences between revenue and cost shares the greater the error due to non-transitivity. This ties the non-transitivity problem to one of our findings in Section 5. We established in that section that inter-firm differences with respect to revenue and cost shares tend to be much greater than temporal differences, especially if one compares consecutive years only. It follows that the error in comparison caused by the non-transitivity of the index number is greater in inter-firm comparisons of productivity than in intra-firm temporal comparisons. There are three consequences of this.

- First, inter-firm comparisons of productivity levels are more error-prone than intra-firm productivity gain measures.

- Secondly, the main source of error is the inter-firm comparison in combined comparisons.

- Thirdly, great errors may combine in multilateral spatial productivity level comparisons, possibly rendering the results useless.

7. SUMMARY

Higher productivity signifies a more efficient use of our scarce resources and tends to result in greater welfare for our society. Our ability to increase productivity depends, among many other things, on how well we measure it, understand its causes, predict it and evaluate its impact on revenues, costs and profits. All these tasks involve comparisons of productivity.

At present, five Canadian telecommunications firms have intra-firm temporal productivity comparisons, resulting in measures of annual productivity gains. The existing productivity measures are capable of providing the basis for extensive analysis, forecasting and impact evaluation. Analysis and forecasting are facilitated by decomposition models of intra-firm productivity gains and of inter-firm productivity gain differences. The construction of gain decomposition models appears to be the next major task of productivity research in the Canadian telecommunications industry. Gain decomposition models necessitate further improvements in measurement methods and some minor extensions of the existing data bases.

Inter-firm productivity level comparisons could be useful for the industry in two ways. First, they would complete the analytical picture of productivity by showing what relative productivity levels result from the already observed and analysed temporal changes in productivity. Secondly, inter-firm productivity level comparisons would enhance our understanding of productivity if they enabled us to analyse the effect of a greater number of causes in a greater range of productivity variation than productivity gains and gain comparisons can offer.

However, inter-firm productivity level comparisons have severe practical limitations. Perhaps the most obvious limitation is the lack of comparability of outputs and inputs. Also, differences with respect to environment, technology and management, tend to be greater between two firms at a given point in time than within a given firm in two consecutive years. A firm is normally more comparable to itself over time than different firms are at the same point in time. Lower degrees of comparability create added difficulties in modeling inter-firm productivity level differences relative to inter-firm productivity gain differences, and especially relative to intra-firm temporal changes in productivity. E.g., the degree of accuracy is normally much lower in inter-firm productivity level comparisons than in gain comparisons or in temporal comparisons within the firm. Accuracy is also reduced by great output and input volume differences, unavailability of information, variation in accounting procedures, and some technical problems associated with index numbers (non-transitivity). The unavailability of information is a particularly important obstacle in inter-firm productivity level comparisons. These comparisons would require a substantial extension of the existing industrial data bases on productivity. The data bases would have to include information on a wide range of environmental, technological and managerial differences among Canadian telecommunications companies, and would have to incorporate special studies aimed at constructing inter-firm indexes of output and input prices and volumes. The required extension of data bases would be costly, difficult and in many instances the effort to obtain new data would be stymied by the unavailability and confidentiality of information. (There is a relationship between the degree of competition in the industry and the availability of information, since competing firms will not reveal detailed price and cost information to one another.)

Theoretical decomposition models of inter-firm productivity level differences can be built. However, the above mentioned difficulties are expected to prevent the successful application of theoretical models in the Canadian telecommunications industry at the present time and in the foreseeable future. Without decomposition models, inter-firm productivity level differences cannot be satisfactorily analysed and understood.

Considering the practical difficulties of inter-firm productivity level comparisons, it appears that the interest of the industry would be best served if further research efforts in the near future were to focus on improving the existing measures of intra-firm productivity gains and on constructing decomposition models of gains and inter-firm differences in gains. These models would permit a systematic analysis of productivity. They would serve and satisfy the existing managerial, regulatory and policy making objectives with respect to predicting productivity improvements and evaluating their impact on Canadian telecommunications companies as well as on the industry as a whole.

ADDENDUM:

EXPANDED COMPARISON TABLES

NOTE: There are no Tables 5 and 6 in the Addendum in order to avoid confusion with Tables 5 and 6 of the main text.

TABLE 1: Temporal Comparison of Productivity: Firm A
(1981/1980)

VARIABLES		YEAR 1981	YEAR 1980	1981/1980	
Local output volume	Q_{LO}	45	25	1.8	Average
Toll output volume	Q_T	60	25	2.4	2.1182
Local output price	P_{LO}	1.4	1.0		
Toll output price	P_T	1.8	1.0		
Local revenue	R_{LO}	63	25		
Toll revenue	R_T	108	25		
Total revenue	R	171	50		
Local revenue share	r_{LO}	36.8%	50%		
Toll revenue share	r_T	63.2	50%	1981/1980	
Labour volume	L	4	3	1.33	Average
Capital volume	K	500	200	2.50	1.9229
Material volume	M	10	5	2.00	
Labour price	P_L	12.75	7.7		
Capital price	P_K	.20	.11		
Material price	P_M	2.0	1.0		
Labour cost	C_L	51	23		
Capital cost	C_K	100	22		
Material cost	C_M	20	5		
Total cost	C	171	50		
Labour cost share	S_L	29.8%	46%		
Capital cost share	S_K	58.5%	44%		
Material cost share	S_M	11.7%	10%		
		(a)	(b)		

Productivity Index: 1.1016

TABLE 2: Temporal Comparison of Productivity: Firm B.
(1981/1980)

VARIABLES		YEAR 1981	YEAR 1980
Local output volume	Q_{LO}	8	5
Toll output volume	Q_T	20	10
Local output price	P_{LO}	1.25	1.0
Toll output price	P_T	2.0	1.0
Local revenue	R_{LO}	10	5
Toll revenue	R_T	40	10
Total revenue	R	50	15
Local revenue share	r_{LO}	20%	33.3%
Toll revenue share	r_T	80	66.7%
Labour volume	L	1	.8
Capital volume	K	158.8	100
Material volume	M	5	2
Labour price	P_L	14	5
Capital price	P_K	.17	.09
Material price	P_M	1.8	1.0
Labour cost	C_L	14	4
Capital cost	C_K	27	9
Material cost	C_M	9	2
Total cost	C	50	15
Labour cost share	S_L	28%	26.7%
Capital cost share	S_K	54%	60.0%
Material cost share	S_M	18%	13.3%
		(a)	(b)

	1981/1980	Average
Q_{LO}	1.6	
Q_T	2.0	1.8845

	1981/1980	Average
L	1.25	
K	1.5882	1.5972
M	2.50	

Productivity Index: 1.1799

TABLE 3: Inter-Firm Comparison of Productivity Levels: 1980

(A/B)

VARIABLES		FIRM A*	FIRM B**	A/B	Average
Local output volume	Q_{LO}	25	5	5.0	
Toll output volume	Q_T	25	10	2.5	3.3371
Local output price	P_{LO}	1.0	1.0		
Toll output price	P_T	1.0	1.0		
Local revenue	R_{LO}	25	5		
Toll revenue	R_T	25	10		
Total revenue	R	50	15		
Local revenue share	r_{LO}	50%	33.3%		
Toll revenue share	r_T	50%	66.7%		
				A/B	
Labour volume	L	3	.8	3.75	Average
Capital volume	K	200	100	2.00	2.5794
Material volume	M	5	2	2.50	
Labour price	P_L	7.7	5		
Capital price	P_K	.11	.09		
Material price	P_M	1.0	1.0		
Labour cost	C_L	23	4		
Capital cost	C_K	22	9		
Material cost	C_M	5	2		
Total cost	C	50	15		
Labour cost share	S_L	46%	26.7%		
Capital cost share	S_K	44%	60.0%		
Material cost share	S_M	10%	13.3%		
		(a)	(b)		

Productivity Index: 1.2937

* Same as (b) in Table 1.
** Same as (b) in Table 2.

TABLE 4: Inter-Firm Comparison of Productivity Levels: 1981 (A/B)

VARIABLES		FIRM A*	FIRM B**	A/B	Average
Local output volume	Q_{LO}	45	8	5.625	
Toll output volume	Q_T	60	20	3.0	3.5868
Local output price	P_{LO}	1.4	1.25		
Toll output price	P_T	1.8	2.0		
Local revenue	R_{LO}	63	10		
Toll revenue	R_T	108	40		
Total revenue	R	171	50		
Local revenue share	r_{LO}	36.8%	20%		
Toll revenue share	r_T	63.2%	80%		
Labour volume	L	4	1	4.0	
Capital volume	K	500	158.8	3.1481	3.1541
Material volume	M	10	5	2.0	
Labour price	P_L	12.75	14		
Capital price	P_K	.20	.17		
Material price	P_M	2.0	1.8		
Labour cost	C_L	51	14		
Capital cost	C_K	100	27		
Material cost	C_M	20	9		
Total cost	C	171	50		
Labour cost share	S_L	29.8%	28%		
Capital cost share	S_K	58.5%	54%		
Material cost share	S_M	11.7%	18%		
		(a)	(b)		

Productivity Index: 1.1372

* Same as (a) in Table 1.
** Same as (a) in Table 2.

TABLE 7: Inter-Firm Comparison of Productivity Levels: 1980
(Corrected)

VARIABLES		FIRM A*	FIRM B**	A/B	Average
Local output volume	Q_{LO}	22.73	5	4.5455	
Toll output volume	Q_T	20.83	10	2.0833	2.8836
Local output price	P_{LO}	1.1	1.0		
Toll output price	P_T	1.2	1.0		
Local revenue	R_{LO}	25	5		
Toll revenue	R_T	25	10		
Total revenue	R	50	15		
Local revenue share	r_{LO}	50%	33.3%		
Toll revenue share	r_T	50%	66.7%		
Labour volume	L	3	.8	3.75	
Capital volume	K	240	100	2.40	2.8710
Material volume	M	5.56	2	2.78	
Labour price	P_L	5	5		
Capital price	P_K	.0917	.09		
Material price	P_M	.9	1.0		
Labour cost	C_L	23	4		
Capital cost	C_K	22	9		
Material cost	C_M	5	2		
Total cost	C	50	15		
Labour cost share	S_L	46%	26.7%		
Capital cost share	S_K	44%	60.0%		
Material cost share	S_M	10%	13.3%		
		(a)	(b)		

Productivity Index: 1.0044

* Same as (b) in Table 1 and (a) in Table 3, with the exception of corrected local and toll output prices (thus volumes), capital volume (thus price) and material price (thus volume).
** Same as (b) in Tables 2 and 3.

TABLE 8: Inter-Firm Comparison of Productivity Levels: 1981 (Corrected)

VARIABLES		FIRM A*	FIRM B**	A/B	Average
Local output volume	Q_{LO}	40.91	8	5.1136	
Toll output volume	Q_T	50	20	2.5	3.0639
Local output price	P_{LO}	1.54	1.25		
Toll output price	P_T	2.16	2.0		
Local revenue	R_{LO}	63	10		
Toll revenue	R_T	108	40		
Total revenue	R	171	50		
Local revenue share	r_{LO}	36.8%	20%		
Toll revenue share	r_T	63.2%	80%		
				A/B	Average
Labour volume	L	4	1	4.0	
Capital volume	K	600	158.8	3.7778	3.5497
Material volume	M	11.1	5	2.22	
Labour price	P_L	12.75	14		
Capital price	P_K	.167	.17		
Material price	P_M	1.8	1.8		
Labour cost	C_L	51	14		
Capital cost	C_K	100	27		
Material cost	C_M	20	9		
Total cost	C	171	50		
Labour cost share	S_L	29.8%	28%		
Capital cost share	S_K	58.5%	54%		
Material cost share	S_M	11.7%	18%		
		(a)	(b)		

Productivity Index: .8631

* Same as (a) in Tables 1 and 4, with the exception of corrected local and toll output prices (thus volumes), capital volume (thus price) and material price (thus volume)

** Same as (b) in Tables 2 and 4.

Explanatory notes to Table 1

Table 1 depicts a hypothetical telephone company (firm A) which uses labour, capital and material inputs to produce local and toll telephone services in two consecutive years (1980 and 1981). In order to correspond to the measurement methodology of the DOC/CTCA joint project, the local and toll output volumes are deflated constant (1980) dollar revenues and the output prices are represented by price indices. We see that both local and toll price indices are equal to 1.0 in 1980, which is the base year of the intertemporal productivity level comparison (thus, in 1980, current and constant dollar revenues are identical). Labour is measured in expensed hours worked. We assume, for simplicity, that only one kind of labour is used. Labour price is the hourly rate of total labour expense in dollars. Capital volume is the restated constant (1980) dollar value of telephone plant in service. Capital price is the so called residual economic rate of return to capital. The residual rate of return is the difference between revenue and the combined labour and material cost, divided by the volume measure of capital. The underlying idea is that the entire revenue is used to pay the factors of production so that the revenue that is not paid out to labour and material belongs, by definition, to capital. The residual rate of return is used to represent the unit cost of capital in some telco productivity studies and in the DOC/CTCA joint project. If we used a direct measure of the cost of capital the resulting total cost would not necessarily equal total revenue. Material volume is the deflated constant (1980) dollar value of material and various miscellaneous expenses. Its price is represented by a price index, which is equal to 1.0 in 1980.

The Törnqvist volume index is the weighted geometric mean of the individual output growth coefficients, where the weights are the (simple arithmetic) average revenue shares for the years 1980 and 1981; i.e.,

$$2.1182 = 1.8^{\frac{1}{2}(.368+.5)} \; 2.4^{\frac{1}{2}(.632+.5)}$$

$$= \exp(\tfrac{1}{2}(.368+.5)\log 1.8+\tfrac{1}{2}(.632+.5)\log 2.4).$$

The Törnqvist input volume index uses average cost shares to average the individual input growth rates; i.e.,

$$1.9229 = 1.33^{\frac{1}{2}(.298+.46)} \; 2.5^{\frac{1}{2}(.585+.44)} \; 2^{\frac{1}{2}(.117+.1)}$$

$$= \exp(\tfrac{1}{2}(.298+.46)\log 1.33+\tfrac{1}{2}(.585+.44)\log 2.5+\tfrac{1}{2}(.117+.1)\log 2).$$

Hence the productivity index is

$$1.1016 = 2.1182/1.9229.$$

The calculations of output and input volume indexes and the productivity index use Törnqvist formulae in all tables of the paper.

Explanatory notes to Table 7

The consequences of the lack of spatial price indexes can be illustrated on the numerical example in Table 3. As in the DOC/CTCA joint project, the data to be used are obtained from the firms' own productivity studies. If firms A and B calculate their own productivity gains, they are capable of giving us Tables 1 and 2. These tables are utilized in the inter-firm comparisons of Table 3. Consider prices in Table 3. Since 1980 is the base year, all price indexes are equal to one. (These are the local and toll output prices and material input prices.) However, firm A may have significantly higher or lower output and input prices than B, especially if it is considered that the firms are telephone companies serving different geographical areas under rather different operating conditions. Assume that A's local prices are 10% higher and its toll prices are 20% higher than B's. If B's prices are used as the point of reference, they remain 1.0, but A's prices will become 1.1 and 1.2 respectively. Since revenues are observed actual revenues, they remain the same as in Tables 1 and 2. The deflated revenues, expressions of volume, will be different from those in Table 3 for firm A. Table 7 shows the corrected price index and volume (deflated revenue) figures. Now, assume also that the material price of A is 10% lower than that of B and adjust material volume (deflated cost) in a similar manner. The capital volume, as noted earlier, is the restated book value of plant in service. Restatement is done by price indexes; thus, the same problem arises here as with respect to output price indexes. Price indexes to restate plant are not shown. Finally, assume that the purchase price of equipment is lower for A than for B for most or all vintages and the restated capital volume is not 200 as in Table 3 but, say, 240 as in Table 7. Table 7 shows that the output and input volume ratios change rather substantially due to the above set of corrections. Only the labour ratio remains the same (A used 3.75 times as much labour as B), because the initial data for labour are expressed as hours worked.

FOOTNOTES

(1) The term "productivity" always refers to the so called "total factor productivity" in this paper. Total factor productivity relates the output of a firm, industry, etc. to all the inputs (labour, capital, materials, etc.) that are utilized in the process of production. Output can also be related to any one individual input in the so called partial productivity measures. This generates labour, capital, material, etc. productivities. There is no elaboration on the comparison of partial productivity measures in this paper.

(2) It is necessary to abstract from the problems of aggregation in order to present the underlying issues in their purest form. Aggregation problems are referred to throughout the text, especially in Section 6.

(3) Consider two firms (A and B) and two years (0 and 1). Denoting productivity by Q/X, the productivity comparisons can be summarized in the following manner:

Temporal comparison

- of levels: $\frac{Q_1}{Q_0} \Big/ \frac{X_1}{X_0}$
- of spatial differences: $\left[\frac{Q_{A1}}{Q_{B1}} \Big/ \frac{X_{A1}}{X_{B1}}\right] \Big/ \left[\frac{Q_{A0}}{Q_{B0}} \Big/ \frac{X_{A0}}{X_{B0}}\right]$

Spatial comparison

- of levels: $\frac{Q_A}{Q_B} \Big/ \frac{X_A}{X_B}$
- of temporal changes: $\left[\frac{Q_{A1}}{Q_{A0}} \Big/ \frac{X_{A1}}{X_{A0}}\right] \Big/ \left[\frac{Q_{B1}}{Q_{B0}} \Big/ \frac{X_{B1}}{X_{B0}}\right]$

One can easily see from the second and fourth formulae that the temporal comparison of spatial differences and the spatial comparison of temporal changes are conceptually the same combined temporal-spatial comparison. The two expressions are equal. However, depending on the index measures used in the comparison, it makes a difference whether the temporal or the spatial comparison is made first. As discussed later, this circumstance creates significant problems in practical producivity comparison work.

(4) It is only for simplicity that the number of outputs is reduced to two and only three inputs are distinguished. The calculations can be made with any number of outputs and inputs.

(5) For more extended description of these indexes, see Törnqvist (1936), Theil (1967), Christensen and Jorgenson (1970), Diewert (1976, 1977) and Jorgenson and Lau (1977).

(6) Indeed, $\frac{Q_1}{X_1} \Big/ \frac{Q_0}{X_0} = \frac{Q_1}{Q_0} \Big/ \frac{X_1}{X_0}$.

(7) It will be shown later that the information developed for intra-firm productivity gain measurement is insufficient for inter-firm productivity level comparisons.

(8) Following the work of Jorgenson and Nishimizu (1978), Denny, de Fontenay and Werner (1980) recommended what amounts to a Törnqvist inter-spatial volume index measure for inter-firm productivity level comparisons in the Canadian telecommunications industry.

(9) It is difficult to generalize the possible outcomes of inter-firm productivity level comparisons, because the productivity lines may be highly irregular or may exhibit various patterns. In the Canadian telecommunications industry the two main features of firm level productivity are: (1) high rates of improvement and (2) great annual variation. There are nine basic relationships which underlie, in one form or another, any actual comparison between the trend lines of firm level productivities. Figure 4 illustrates them.

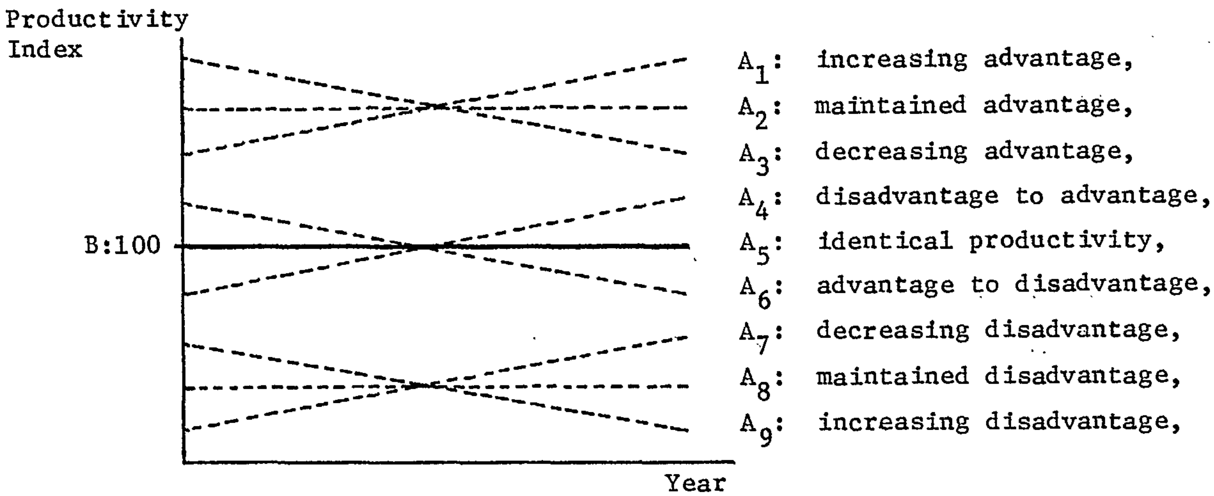


Figure 4: Productivity level changes for firm A, relative to firm B.

(10) The presence of economies of scale means that higher output levels can be produced with less input per unit of output. This is tantamount to saying that the greater the output the higher the output/input ratio (productivity). If higher output levels are produced with less input per unit of output then output must grow faster than input which is, by definition, productivity gain. Thus, growth generates productivity gains if economies of scale are present in the production process.

(11) Productivity gain decomposition models were constructed for Bell Canada by Denny, Fuss and Everson (1979) and Kiss (1983).

(12) They also suggest strategies. E.g., the expansionist policies that can be observed in many of the leading industries of Japan are based in part on the recognition of the importance of growth for productivity. The strategy that results from such a recognition is to seek growth through increasing market shares and capturing new markets on a worldwide scale even under temporarily adverse circumstances (recession), when such objectives necessitate decreases in output prices and result in losses for the firm. Similarly, it can be shown that other aspects of industrial policy (e.g., modernization, R&D) are also productivity oriented. The Japanese are successful in promoting productivity improvements, because they understand the causes of productivity and are capable of promoting them. On the other hand, the Japanese know that it is productivity their industrial policies should promote, because they understand the consequences of productivity improvements to revenues, costs and, above all, profits.

(13) Olley, Kiss and Lefebvre (1983).

(14) See Response to Interrogatory Bell(NAPO)30 MAR 81-612 (Attachment III) by Bell Canada.

(15) The continous Divisia index passes the index test of transitivity; its discrete Törnqvist approximation only approximates it. The greater the discrete changes measured by the index number the greater the approximation error. Since the discrete changes are usually far greater in inter-firm comparisons than in temporal comparisons within a given firm, the approximation problem is greater in inter-firm than in intra-firm comparisons.

(16) For further theoretical developments, see Caves, Christensen and Diewert (1982).

REFERENCES

(1) Caves, D.W., Christensen, L.R., and Diewert, W.E. (1982) The Economic theory of index numbers and the measurement of input, output and productivity, Econometrica, Volume 50, No. 6 (November).

(2) Christensen, L.R., and Jorgenson, D.W. (1970) U.S. real product and real factor input, 1929-1967, Review of Income and Wealth, ser. 16, no. 1, 19-50.

(3) Denny, M., Fuss, M., and Everson, C. (1979) Productivity, employment and technical change in Canadian telecommunications: The case for Bell Canada, Final Report to the Department of Communications.

(4) Denny, M., de Fontenay, A., and Werner, M. (1980) Comparative efficiency in Canadian telecommunications: An analysis of methods and uses, DGCE Document No. 166, Department of Communications (December).

(5) Diewert, W.E. (1976) Exact and superlative index numbers, Journal of Econometrics 4, 115-45.

(6) Diewert, W.E. (1977) Aggregation problems in the measurement of capital, Discussion paper 77-09, Department of Economics, University of British Columbia.

(7) Jorgenson, D.W., and Lau, L.J. (1977) Duality and technology (North Holland, Amsterdam).

(8) Jorgenson, D.W., and Nishimizu, N. (1978) U.S. and Japanese economic growth, 1952-74: An international comparison, Economic Journal, 88, 707-726.

(9) Kiss, F. (1983) Productivity gains in Bell Canada, in: Courville, L., de Fontenay, A. and Dobell, R. (eds.) Economic Analysis of Telecommunications (North Holland, Amsterdam).

(10) Olley, R.E., Kiss, F., and Lefebvre, B.J. (1983) Inter-firm productivity gain comparison in the Canadian telecommunications industry, Presented at the Third International Symposium on Forecasting, Philadelphia (June).

(11) Theil, H. (1967) Economics and information theory (North Holland, Amsterdam).

(12) Törnqvist, L. (1936) The Bank of Finland's consumption price index, Bank of Finland Monthly Bulletin, No. 10, 1-8.