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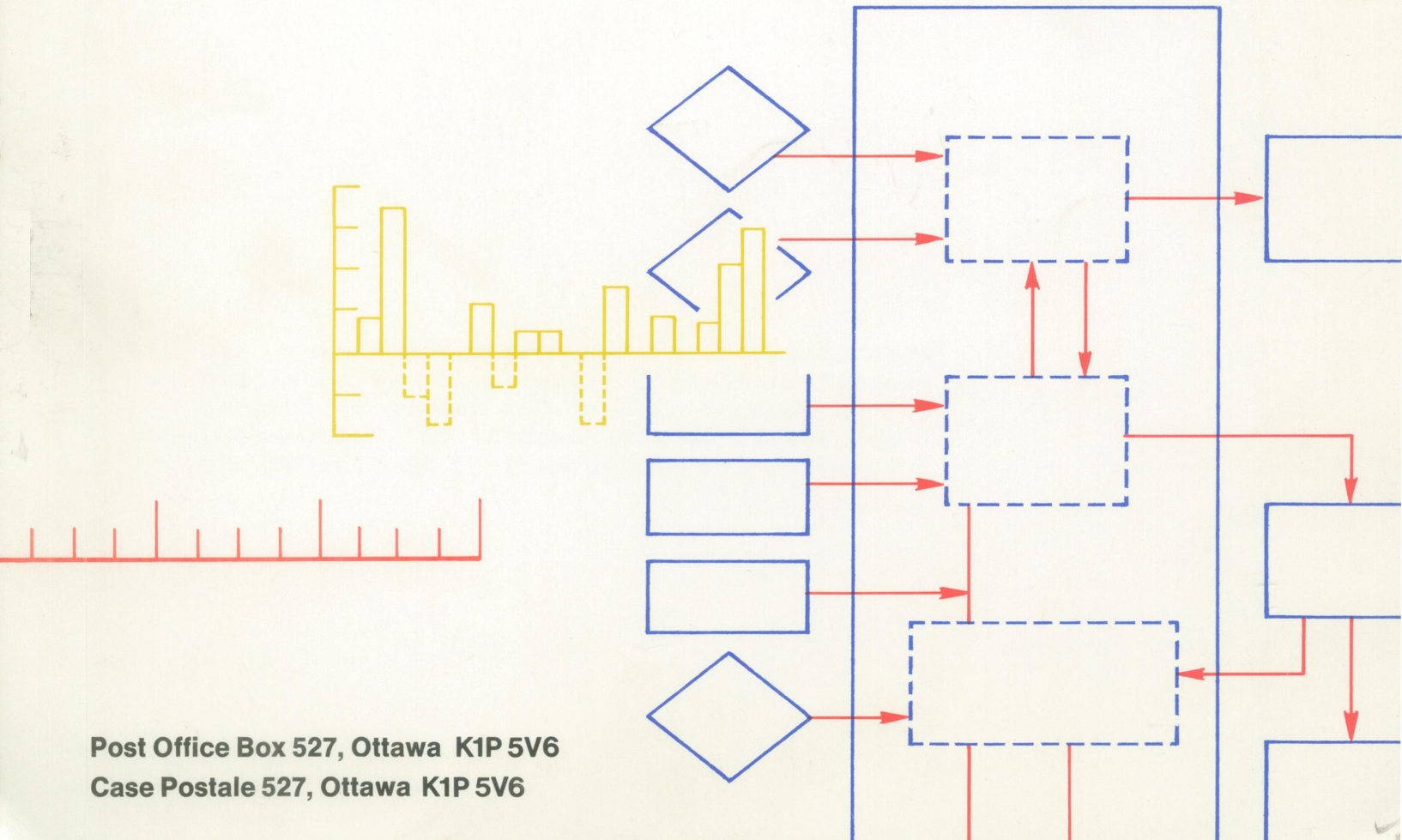
DISCUSSION PAPER NO. 125

An Econometric Analysis of Labour Productivity in Canadian Industries

by P. Someshwar Rao



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RÉSUMÉ

La productivité est un indicateur-clé, quoique complexe, de la situation économique d'une nation. Un changement dans la productivité est à la fois la cause et le résultat de plusieurs forces dynamiques agissant sur l'économie -- progrès technique, accumulation et amélioration de la qualité des ressources tant humaines que matérielles, capital, esprit d'initiative, intensité de l'effort au travail, réglementation gouvernementale, utilisation de capacité de production, etc. L'analyse de la productivité, par sa protée sur les coûts et les prix unitaires constitue une source virtuellement riche en données sur les causes profondes des conditions économiques générales qui marquent l'économie canadienne actuelle.

Voici quelques-uns des objectifs principaux du présent document:

1. Déterminer les industries qui forment les groupes à productivité élevée, moyenne et faible, en se basant surtout sur les industries particulières.

2. Analyser la croissance de la productivité et ses répercussions sur les rapports de productivité, à la longue, par industrie.

3. Estimer le paramètre du progrès technique pour chaque industrie.

4. Décomposer la croissance de la productivité de chaque industrie en composantes séculaires et cycliques pour les trois périodes allant de 1959 à 1974, de 1966 à 1974 et de 1971 à 1974.

5. Trouver les causes du ralentissement de la productivité durant les années 70.

6. Estimer l'apport des effets de niveau (modifications des parts de production et d'emploi à la longue) de chaque industrie à l'accroissement de la productivité globale.

A cette fin, nous avons d'abord établi une équation de productivité pour chacune de ces industries. Puis, nous avons employé les paramètres de ces équations pour calculer l'accroissement de la productivité corrigé des cycles pour chaque industrie, durant les trois périodes allant de 1957 à 1974, de 1966 à 1974 et de 1971 à 1974. Par après, ces résultats nous on servi pour le calcul du taux d'accroissement de la productivité globale pour chaque période. Les effets des mouvements qui se sont produits dans les parts de production et d'emploi et dans les rapports de productivité parmi les industries ont été séparés. Voici les observations importantes de l'étude; elles sont résumées et présentées dans l'ordre où elles apparaissent dans cet ouvrage.

1. Les variations, parmi les industries, tant sous le rapport de la productivité que sous le rapport du taux d'accroissement de la productivité sont assez considérables.

2. En dépit de la vaste différence dans l'accroissement de la productivité, les rapports de productivité industrielle (à quelques exceptions près) sont demeurés presque constants durant ces trois périodes.

3. En nous fondant sur le paramètre du progrès technique, nous avons classé chaque industrie dans l'une des trois catégories de productivité -- faible, moyenne et élevée. Les industries à productivité élevée sont celles dont le rythme d'accroissement de productivité est supérieur à 3 % l'an : communications et transports, produits forestiers, machines, véhicules automobiles, pièces de rechange et accessoires, produits de caoutchouc et de plastique, textiles, pétrole et produits du charbon, produits chimiques, houille et services d'utilité publique.

Les industries dont l'accroissement de productivité est inférieur à 2 % l'an sont considérées comme des industries à productivité faible. Ce sont : l'agriculture, la construction, le bois, les métaux non ferreux, les aliments et boissons, le cuir, le papier et les industries connexes, l'impriemerie et l'édition, diverses industries manufacturières, la métallurgie, le pétrole brut, le gaz naturel, les mines non métalliques, les services et l'administration publique.

Toutes les autres industries font partie du groupe à productivité moyenne.

4. L'accroissement de la productivité de la main-d'oeuvre dans les domaines de l'agriculture, des finances, de l'assurance et de l'immeuble, des utilités publiques, de la métallurgie, du pétrole brut, du gaz naturel, des services ainsi que de l'exploitation de mines non métalliques est surtout déterminé par les augmentations de leur coefficient de capitaux.

5. Dans toutes les industries manufacturières (sauf quelques exceptions), les effets à long terme du taux de chômage sur la productivité sont négatifs et importants, ce qui laisse supposer que le taux global de chômage donne une assez bonne indication de l'utilisation globale de la production.

6. Les modèles de productivité ne sont associés à des coefficients importants dans aucune des équations d'industries. Nous rejetons donc l'hypothèse d'une rupture structurale durant les années 70.

7. Pour la période allant de 1957 à 1974, la contribution de l'intensité de capital à l'accroissement mesuré de productivité est d'au moins 50 % pour l'agriculture, les finances, l'assurance et l'immeuble, le bois, les aliments et boissons, le pétrole brut et le gaz naturel, la métallurgie, les mines non métalliques et les services. Au sein du secteur de la fabrication, l'apport de capital est généralement considérable dans les industries manufacturières de biens non durables.

8. Les effets des facteurs cycliques et des autres facteurs résiduels sur le taux d'accroissement de la productivité de l'ensemble de la main-d'oeuvre varient pour les trois périodes, soit 0.19 %, 0.23 % et -0.13 % l'an respectivement, pour les périodes allant de 1957 à 1974, de 1966 à 1974 et de 1971 à 1974.

9. Pour les trois périodes, les effets des mouvements des parts d'emploi et de production parmi les industries sur la croissance de la productivité de la main-d'oeuvre globale sont négligeables.

10. La baisse récente du taux de croissance de la productivité globale a été causée surtout par une baisse dans la croissance de l'intensité de capital et une réduction de l'utilisation de la capacité. Cette baisse s'est fait sentir dans à peu près tous les secteurs de l'économie.

ABSTRACT

Productivity is a key and yet a complex indicator of a nation's economic well being. The change in productivity is both a cause and a result of several dynamic forces operating in the economy - technical progress, accumulation and improvement in the quality both human and physical capital, enterprise, intensity of work effort, government regulation, capacity utilization, et cetera. Productivity analysis through its implications for unit costs and prices is a potentially rich source of insight into the underlying causes of the general economic conditions facing the Canadian economy today.

The following are some of the major objectives of this paper:

1. Identify the industries which fall into high, medium, and low productivity groups, with special reference to individual manufacturing industries.

2. Analyse the productivity growth and its impact on productivity relatives, over time, by industry.

3. Estimate the technical progress parameter for each industry.

4. Decompose each industry's productivity growth into secular and cyclical components for all three periods: 1959-74, 1966-74, 1971-74.

5. Identify the causes of productivity slowdown in the 1970's.

6. Estimate the contribution of level effects (changes in output and employment shares over time) of each industry towards the aggregate productivity growth.

For this purpose, first we have estimated a productivity equation for each of these industries. Then the parameters of these equations are used to compute the cycle corrected productivity growth for each industry for all the three periods, 1957-74, 1966-74, and 1971-74. These in turn are used to compute the aggregate productivity growth rate for each period. The effects of movements in output and employment shares and productivity relatives among industries are separated. The important findings are summarized in order of their appearance in the study.

1. Both productivity and productivity growth rate variations among industries are quite large.

2. In spite of wide difference in productivity growth, industry productivity relatives (with a few exceptions) have almost remained constant over these three periods.

3. On the basis of technical progress parameter, we classified each industry into one of the three categories - low, medium, and high productivity industries. High Productivity industries are those whose trend productivity growth is more than 3% per annum. Communications and transportation,forestry, machinery, and motor vehicles, motor vehicle parts and accessories, rubber and plastic products, textiles, petroleum and coal products, chemicals and chemical products, coal mining and utilities.

Industries with less than 2% productivity growth are defined as low productivity industries. These are agriculture, construction, wood, nonferrous metals, food and beverages, leather, paper and allied industries, printing and publishing, natural gas, nonmetal mining, services and public administration.

All other industries fall into medium productivity group.

4. The labour productivity growth of agriculture, finance, insurance and real estate, utilities, metal mining, crude petroleum, natural gas and services and nonmetal mining is mainly determined by increases in their capital intensity.

5. In all the manufacturing industries (with a few exceptions) the long run impact of unemployment rate on productivity is negative and significant. This suggest that the macro unemployment rate is a reasonable proxy for aggregate utilization.

6. In none of the industry equations, are the productivity dummies associated with significant coefficients. Thus, we reject the hypothesis of structural break in the 70's.

7. For the period 1957-74, the contribution of capital intensity to the measured productivity growth is at least 50% for agriculture, finance, insurance and real estate,wood, food and beverages, crude petroleum and natural gas, metal mining, non-metal mining and services. Within the manufacturing industries, capital contribution is generally large for the nondurable manufacturing industries.

8. The impact of cyclical and other residual factors on the aggregate labour productivity growth rate varies among the three periods - 0,19%, 0.23% and -0.13% per annum respectively

9. In all the three periods the impact of movements in employment and output shares among the industries on aggregate labour productivity growth is small.

10. The recent decline in aggregate productivity growth rate is mostly casued by decline in the capital intensity growth and reduction in capacity utilization and this decline is broadly based in virtually all sectors of the economy.

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1. INTRODUCTION

Economists and policy-makers faced with the apparent inability of demand management to combat the stagflation phenomenon of the 70's, have increasingly directed their attention to an analysis of the supply side seeking structural solutions to this problem. The recent upsurge of interest in the measurement and explanation of productivity is one manifestion of such concerns. Productivity is a key and yet a complex indicator of a nation's well being. The change in productivity is both a cause and a result of many dynamic forces operating within the economy--technical progress, accumulation and improvement in the quality of both human and physical capital, enterprise, government regulation, capacity utilization, et cetera. Productivity analysis through its implications for unit costs and prices is a potentially rich source of insight into the underlying causes of the general economic conditions facing the Canadian economy today.

Productivity is defined as the ratio of product output to factor inputs. Hence, there are as many measures of productivity as inputs. However, the most important and the most often used measure is the index of labour productivity (output per man-hour).

Industry prices are normally hypothesized to be a mark-up over the normal unit factor costs. Labour being an important input in many industries, normal unit labour costs would be a major determinant of industry prices. The explanation of trends in unit labour costs would require an analysis of the relative trends in labour productivity and the money wage rates. Canada,

being an open economy, depends heavily on exports as a source of its economic growth. The competitiveness of Canadian exports in foreign markets depends mainly on Canadian prices relative to foreign prices. This, in turn, depends on relative unit labour costs and the exchange rate. In the long-run a nation can increase its per capita income mostly by increasing its productivity. Hence, the long-run solution to stagflation is to devise policies which would enhance productivity growth. Entrepreneurs and government policy-makers should initially focus their attention on the ways by which productivity growth could be accelerated by making a detailed analysis of productivity by industry over time. We must also make a special effort to find suitable explanations for the recent slowdown in aggregate productivity growth. Productivity analysis will also enable us to determine the wage increases that could be tolerated without imposing inflationary pressures in the economy. The general objective of this paper is to make a modest contribution towards the understanding of this complex subject. The following are some of the specific objectives:

a) Identify the industries which fall into high, medium, and low productivity groups, with special reference to individual manufacturing industries.

b) Analyse the productivity growth and its impact on productivity relatives, over time, by industry.

c) Estimate the technical progress parameter for each industry.

d) Decompose each industry's productivity growth into secular and cyclical components for all three periods: 1959-74, 1966-74, 1971-74.

e) Identify the causes of productivity slowdown in the 70's and

f) Estimate the contribution of level effects (changes in output and employment shares over time) of each industry towards the aggregate productivity growth.

The plan of the paper is as follows:

Section II gives an overview of productivity growth by industry for each of three periods: 1959-74, 1966-74, and 1971-74.

In Section III, we specify and estimate a productivity equation for each one of our industries. The empirical results are also discussed in this section.

Section IV is devoted to the discussion of results on decomposition of productivity growth by industry, for all the three periods.

Section V gives an analysis of aggregate productivity growth in each of the three periods. Finally, the important findings of this study are summarized in the last section. Some suggestions for further research are also presented in this section.

II. AN OVERVIEW OF PRODUCTIVITY TRENDS IN CANADA, 1957-74, 1966-74, 1971-74.

This section presents an overview of the time path of labour productivity[1] disaggregated by 35 industries.[2] We can see from Tables 1 and 2, that both productivity and productivity growth vary significantly across industries. In an effort to analyse causes of the recent slowdown in the rate of growth aggregate productivity, we have divided our sample period into three subperiods: 1957-74, 1966-74, and 1971-74.

The variation between industries in labour productivity[3] is large for the period 1957-74. It varies from $1.77 (1971$) for the agriculture industry to $20.2 (1971$) for the crude petroleum and natural gas (mining) industry. The relative position of these industries is the same in the latter periods, 1966-74 and 1971-74. In all three periods, productivity in the mining industry is higher than the productivity in any of the remaining industries. In each of the three periods, manufacturing industry's productivity is very close to aggregate labour productivity. However, productivity variation within manufacturing is also large--lowest $2.52 (1971$) for

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1 The sample period of our analysis is 1957-74. This choice is determined by the availability of man-hours and wage bill data. For the components of mining and manufacturing industries the data on employment, man-hours, the wage bill and value-added are available only for the period 1957-74.

2. The industry breakdown used in this paper is similiar to that used in CANDIDE Model 2.0.

3. Throughout this paper labour productivity is defined as the value-added per man-hour.

TABLE 1
OUTPUT PER MAN-HOUR
(IN 1971$)

INDUSTRY	1957-74	1966-74	1971-74
Agriculture	1.77	2.20	2.38
Construction	5.19	5.68	5.97
Communications & Trsp.	4.91	5.57	6.67
Finance, Ins., & Real Estate	8.78	9.11	9.54
Forestry	3.01	4.00	4.48
Manufacturing (Total)	4.57	5.31	5.76
DURABLES			
Wood	3.77	4.20	4.34
Furniture & fixtures	3.78	4.31	4.45
Iron & Steel	5.50	6.24	6.60
Nonferrous metal	5.21	5.94	6.15
Metal fabricating	4.92	5.60	5.95
Machinery (ex. electrical machinery)	4.21	4.97	5.51
Nonauto trsp. equipment	4.23	4.80	5.20
Motor vehicle (ex. parts & accessories)	4.77	6.47	7.17

(cont'd)

TABLE 1
(cont'd)

INDUSTRY	1957-74	1966-74	1971-74
Motor vehicle parts & access.	5.74	6.95	7.77
Electrical products	4.06	4.83	5.29
Nonmetallic mineral prod.	5.68	6.40	7.08
NONDURABLES			
Food & Beverage	4.98	5.68	6.07
Tobacco products	6.73	8.13	8.95
Rubber & plastic	4.35	5.32	5.84
Leather	2.52	2.77	2.90
Textile	2.94	3.63	4.13
Knitting & clothing	2.81	3.18	3.46
Paper & allied indust.	5.04	5.72	6.15
Printing, publishing & allied indust.	5.44	5.97	6.42
Petroleum & coal prod.	6.84	8.20	9.21
Chemical & chemical prod.	5.42	6.72	7.62
Misc. mfg.	4.87	5.41	5.76

(cont'd)

TABLE 1
(cont'd)

INDUSTRY	1957-74	1966-74	1971-74
Mining (Total)	11.19	12.56	14.22
Coal mining	4.77	5.91	8.20
Crude petroleum, natural gas, & serv. incidental to mining	20.21	22.32	25.83
Metal mining	9.43	10.01	10.73
Nonmetal mining (except coal)	6.43	9.23	10.14
Services	4.07	4.28	4.56
Wholesale & retail trade	3.29	3.78	4.11
Utility	10.63	13.17	15.58
Public adminstration	6.86	6.59	4.10
Aggregate	4.67	5.34	5.74

SOURCE: CANDIDE 2.0 DATA BANK

the leather industry and the highest $6.84 (1971$) for the petroleum and coal products industry. This industry comparison enables us to classify each industry to one of three groups : high, medium, or low with respect to productivity. These groups have been defined as follows: high productivity industries are those which exceed aggregate productivity by more than $1.0; the low productivity group consists of those industries which fall short of aggregate productivity by more than $1.0; the medium productivity industries include those industries in which productivity is within plus or minus $1.0 of aggregate productivity. With these definitions, we obtain the following results:

HIGH PRODUCTIVITY INDUSTRIES

Crude petroleum and natural gas, metal mining, nonmetal mining, iron and steel, motor vehicles, motor vehicles parts, nonmetallic mineral products, tobacco products, petroleum and coal products, chemicals and chemical products, utilities, and finance, insurance and real estate.

MEDIUM PRODUCTIVITY INDUSTRIES

Construction, communications and transportation, nonferrous metals, metal fabricating, machinery, nonauto transportation equipment, electrical products, food and beverages, rubber and plastic products, paper and allied products, printing and publishing, miscellaneous manufacturing products, construction, communication and transportation, coal mining and public administration.

TABLE 1.2

AVERAGE HOURLY WAGE RATE BY INDUSTRY
1958-1975

INDUSTRY	WAGE RATE ($)
Agriculture	0.30
Construction	3.43
Communications & Trsp.	3.32
Finance, Ins., & Real Estate	3.44
Forestry	3.23
Manufacturing (Total)	3.16
DURABLES (Total)	3.35
Wood	2.89
Furniture & fixtures	2.49
Iron & Steel	3.84
Nonferrous metal	3.67
Metal fabricating	3.26
Machinery (ex. electrical machinery)	3.48
Nonauto trsp. equipment	3.45
Motor vehicle (ex. parts & accessories)	3.90

(cont'd)

TABLE 1.2 cont'd

INDUSTRY	WAGE RATE ($)
Motor vehicle parts & access.	3.62
Electrical products	3.20
Nonmetallic mineral prod.	3.24
NONDURABLES (Total)	2.94
Food & Beverage	2.83
Tobacco products	3.36
Rubber & plastic	2.95
Leather	2.11
Textile	2.53
Knitting & clothing	2.05
Paper & allied indust.	3.60
Printing, publishing & allied indust.	3.39
Petroleum & coal prod.	4.47
Chemical & chemical prod.	3.51
Misc. mfg.	2.76

(cont'd)

TABLE 1.2 cont'd

INDUSTRY	WAGE RATE ($)
Mining (Total)	4.65
Coal mining	3.09
Crude petroleum, natural gas, & serv. incidental to mining	4.28
Metal mining	3.75
Nonmetal mining (except coal)	3.22
Services	2.57
Wholesale & retail trade	2.24
Utility	4.11
Public adminstration	4.69
Aggregate	2.78

SOURCE: CANDIDE Model 2.0 Data Bank

TABLE 2
AVERAGE ANNUAL PERCENTAGE
RATE OF GROWTH OF PRODUCTIVITY

INDUSTRY	1957-74	1966-74	1971-74
Agriculture	5.33	3.60	0.06
Construction	1.65	1.48	-0.37
Communications & Trsp.	4.51	5.48	3.82
Finance, Ins., & Real Estate	0.60	1.09	1.83
Forestry	6.96	4.77	1.69
Manufacturing (Total)	2.94	3.03	2.92
DURABLES			
Wood	1.88	1.56	0.23
Furniture & fixtures	2.11	1.89	0.72
Iron & Steel	3.37	1.67	1.86
Nonferrous metal	3.36	1.65	1.64
Metal fabricating	2.67	3.27	2.79
Machinery (ex. electrical machinery)	3.84	4.09	5.15
Nonauto trsp. equipment	2.82	2.38	3.56
Motor vehicle (ex. parts & accessories)	5.67	7.38	2.37

(cont'd)

TABLE 2
(cont'd)

INDUSTRY	1957-74	1966-74	1971-74
Motor vehicle parts & access.	4.59	4.90	4.57
Electrical products	4.31	2.54	3.87
Nonmetallic mineral prod.	2.87	2.07	4.55
NONDURABLES			
Food & Beverage	2.56	2.54	1.57
Tobacco products	4.86	3.39	3.07
Rubber & plastic	6.04	4.35	4.67
Leather	1.85	1.40	1.10
Textile	5.28	4.86	3.64
Knitting & clothing	2.68	2.73	2.61
Paper & allied indust.	2.78	2.35	2.20
Printing, publishing & allied indust.	1.69	2.02	2.47
Petroleum & coal prod.	5.02	3.84	5.12
Chemical & chemical prod.	5.21	4.55	5.21
Misc. mfg.	1.67	2.89	3.07

(cont'd)

TABLE 2
(cont'd)

INDUSTRY	1957-74	1966-74	1971-74
Mining (Total)	5.86	6.06	4.80
Coal mining	9.19	14.06	18.24
Crude petroleum, natural gas, & serv. incidental to mining	7.51	6.76	6.98
Metal mining	4.79	6.20	1.21
Nonmetal mining (except coal)	6.23	6.78	6.81
Services	1.54	1.89	1.23
Wholesale & retail trade	3.03	3.14	3.64
Utility	6.63	6.20	6.67
Public adminstration	-1.04	-0.1	0.7
Aggregate	2.83	2.86	2.27

SOURCE: CANDIDE 2.0 DATA BANK

LOW PRODUCTIVITY INDUSTRIES

Agriculture, forestry, wood, furniture and fixtures, leather, textiles, knitting and clothing, services and wholesale and retail trade.

These productivity differences provide a good support for the observed inter-industry wage structure in Canada. (See Table 1.2)

PRODUCTIVITY GROWTH

From Table 2, we see that variations in productivity growth both across industries and across time are large. Over the period 1957-74, the coal mining industry experienced the highest average annual productivity growth--9.20%. For the same period, finance, insurance and real estate has increased by a mere 0.60%. Public administration has registered a decline in productivity--productivity growth declined at an average annual rate of 1%.[4] Over the same period, aggregate productivity has increased at an annual rate of 2.83%. All four mining industries have experienced very high productivity growth. The aggregate productivity of mining and manufacturing has increased at a rate of 5.9% and 2.9% per annum, respectively. The productivity growth of agriculture, forestry, communications and transportation, trade and utilities is greater than aggregate productivity growth. As expected, the service industry

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4 Since the output of government sector is measured by labour input, productivity growth is zero by definition. However, due to the compositional changes in the government employment the measured productivity growth could be different from zero.

has a very low measured productivity.[5]

The productivity growth variations in the manufacturing sector is also large--lowest 1.67% for the miscellaneous manufacturing industries and the highest 6.04% for the rubber and plastic industries. The following manufacturing industries have recorded productivity growth rates lower than the aggregate productivity growth of the manufacturing sector: wood, furniture and fixtures, metal fabricating, food and beverages, leather, knitting and clothing, printing and publishing and miscellaneous manufacturing industries.

For the subperiod 1966-74, aggregate productivity has increased at an annual rate of 2.86% compared to 2.83% (the annual growth for the entire period, 1957-74). Except for iron and steel, nonferrous metals and electrical product industries, the relative productivity growth of the industries is the same for the entire period 1957-74. Over this period, the following industries have experienced a sharp decline in their productivity growth: agriculture, forestry, iron and steel, nonferrous metals and electrical products. As opposed to this, coal mining, metal mining, nonmetal mining, motor vehicles, metal fabricating, and communications and transportation

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5 Our service industry includes the output of both commercial and noncommercial services. The noncommercial services are: primary and secondary education, universities, hospitals, and other noncommercial services. Like public administration, the output of noncommercial services is mostly measured by labour output. Moreover, the share of noncommercial services is at least 50%. In view of these features, we would expect the service industry productivity growth to be very small.

industries have registered an increase in their productivity growth.

Aggregate annual productivity growth has declined from 2.86% in 1966-74 to 2.27% in 1971-74. Compared to this, manufacturing productivity growth is almost unchanged--2.92%. This implies that only the nonmanufacturing industries have contributed to the decline in aggregate productivity growth. Except for finance, insurance and real estate, coal mining, crude petroleum and natural gas, trade and utilities, all the other nonmanufacturing industries have experienced sharp reductions in their productivity growth. Metal mining industry's productivity growth has declined drastically--from 6.20% in 1966-74 to 1.21% in 1971-74. Because of this, the aggregate productivity of the mining industry has grown only by 4.8% compared to 6.06% for the period 1966-74.

The most disturbing thing is the decline in the productivity of the construction industry--negative productivity growth. A few manufacturing industries; wood, furniture and fixtures, and motor vehicles have also registered sharp declines in productivity growth.

Table 3 gives the productivity relatives of each industry for the three periods and the year 1965.[6] For all periods, the productivity relative of agriculture, forestry, wood, furniture and fixtures, machinery, nonauto transportation

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6 The table shows labour productivity in a given industry relative to the aggregate labour productivity.

TABLE 3
PRODUCTIVITY RELATIVES

INDUSTRY	1957-74	1965	1966-74	1971-74
Agriculture	.38	.37	.41	.41
Construction	1.11	1.10	1.06	1.04
Communications & Trsp	1.05	1.02	1.04	1.16
Finance, Ins., & Real Estate	1.88	1.92	1.71	1.66
Forestry	.64	.67	.75	.78
Manufacturing (Total)	.98	1.00	.99	1.00
DURABLES				
Wood	.81	.82	.79	.76
Furniture & fixtures	.81	.82	.81	.78
Iron & Steel	1.18	1.32	1.17	1.15
Nonferrous metal	1.12	1.20	1.11	1.07
Metal fabricating	1.05	1.03	1.05	1.04
Machinery (ex. electrical machinery)	.90	.90	.93	.96
Nonauto trsp equipment	.91	.97	.90	.91
Motor vehicle (ex. parts & accessories)	1.02	.87	1.21	1.25

(cont'd)

TABLE 3
(cont'd)

INDUSTRY	1957-74	1965	1966-74	1971-74
Motor vehicle parts & access.	1.23	1.16	1.30	1.35
Electrical products	.87	.94	.90	.92
Nonmetallic mineral prod.	1.22	1.34	1.20	1.23
NONDURABLES				
Food & Beverage	1.07	1.07	1.06	1.06
Tobacco products	1.44	1.54	1.52	1.56
Rubber & plastic	.93	.94	1.00	1.02
Leather	.54	.57	.52	.51
Textile	.63	.61	.68	.72
Knitting & clothing	.60	.61	.60	.60
Paper & allied indust.	1.08	1.12	1.07	1.07
Printing, publishing & allied indust.	1.16	1.19	1.12	1.12
Petroleum & coal prod.	1.46	1.53	1.54	1.59
Chemical & chemical prod.	1.16	1.18	1.26	1.33
Misc. mfg.	1.04	1.04	1.01	1.00
Mining (Total)	2.40	1.76	2.35	2.48

(cont'd)

TABLE 3

INDUSTRY	1957-74	1965	1966-74	1971-74
Coal mining	1.02	.68	.97	1.43
Crude petroleum, natural gas, & serv. incidental to mining	4.33	3.38	4.18	4.50
Metal mining	2.02	1.44	1.87	1.87
Nonmetal mining (except coal)	1.33	1.41	1.73	1.77
Services	.87	.88	.80	.79
Wholesale & retail trade	.70	.71	.71	.72
Utility	2.28	2.19	2.47	2.71
Public adminstration	1.43	1.45	1.23	.71
Aggregate	1.00	1.00	1.00	1.00

SOURCE: Computed from man-hour and gross output data.

equipment, electrical products, rubber and plastic products, leather, textiles, knitting and clothing, services, trade is less than one. This implies that these industries' productivity growth rates are not large enough to compensate for the low productivity in the base year. In the case of wood, furniture and fixtures, leather and service industries, productivity relative shows a declining trend, implying a relative decline in productive growth over time. For construction, finance, insurance and real estate, iron and steel, nonferrous metals, printing and publishing, miscellaneous manufacturing, metal mining and public administration, the productivity relative is greater than one, however, it exhibits a declining trend. This suggests that the relative productivity growth of these industries is also declining over time.

III. PRODUCTIVITY ESTIMATES BY INDUSTRY

Productivity indices can be constructed either from an explicitly defined production function[7] or from distribution theory[8] where the production function is implicit.

If we assume a two factor, twice differentiable homogeneous function f, with

$$(1.1) \qquad Y = A\, f(K,L)$$

disembodied technical progress, A, differentiating (1.1) with respect to time and dividing by Y, gives

$$(1.2) \qquad \frac{dA}{A} = \frac{dY}{Y} - \left[F_K \frac{K}{Y} \frac{dK}{K} + F_L \frac{L}{Y} \frac{dL}{L}\right]$$

where F_K and F_L are the partial derivatives of capital and labour with respect to output, respectively.

It is clear from equation (1.2), that both the magnitude and the stability of the technical progress parameter (dA) depends on: 1) the functional form of f, 2) the appropriate measurement of output and inputs and, 3) the importance of other variables which are left out (such as enterpreneural ability, capacity utilization, government regulation, et cetera).

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7 Solow (1957), Brown (1966), Ferguson (1965), Jorgenson (1965), Mitchell (1968), Nordhaus (1972), Star (1974), Gollop and Jorgenson (1977), and Denny and May (1978).

8 Kendrick (1961), Denison (1962), Griliches (1968), Jorgenson and Griliches (1967), and Kendrick (1970).

In this section, we will use the production function approach to estimate a technical progress parameter for each industry. The output measure used in this paper is value-added as opposed to gross output.[9] Our productivity equations are based on the popular Cobb-Douglas production function with Hicks-Neutral technical change and constant returns to scale.

$$(1.3) \qquad Y_{it} = A_{oi} \; e^{\lambda_i t} \; M_{it}^{\alpha_i} \; K_{it}^{1-\alpha_i}$$

where y_{it} is value-added (constant 1971$) in the i-th industry in the t-th time period. M_{it} is the man-hours in the i-th industry in the t-th time period. K_{it} is the capital stock (in constant 1971$) in the i-th industry in the t-th time period. t is a time trend and λ_i is a Hicks-Neutral technical progress parameter of the i-th industry and α_i and $(1 - \alpha_i)$ are the labour and capital elasticities respectively.[10] From the equation (1.3), we can write labour productivity of the i-th

$$(1.4a) \qquad \frac{Y_{it}}{M_{it}} = A_{oi} \; e^{\lambda_i t} \left(\frac{K_{it}}{M_{it}}\right)^{1-\alpha_i}$$

or

$$(1.4b) \qquad \bar{Y}_{it} = A_{oi} \; e^{\lambda_i t} \; k_{it}^{1-\alpha_i}$$

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9 We are aware of the restrictive assumptions about factor substitution implied by using the VA concept. In the last section, we will discuss these assumptions and the direction of bias in the measurement of technical progress parameter once these assumptions are relaxed.

10 It can be easily shown that α_i and $(1 - \alpha_i)$ also represent the labour and the capital shares of total output (VA) in the i-th industry.

where Y_{it} is output per man-hour and k_{it} is the capital-labour ratio.

It is well known that the cyclical movements in output influence productivity. Hence to get better estimates of λ_i and $(1 - \alpha_i)$, a cyclical correction should be used, such as the level of capacity utilization. The production equation with cyclical correction is written as

$$(1.5) \qquad Y_{it} = A^*_{oi} \; e^{\lambda^*_{it}} \; k_{it}^{1 - \alpha^*_i} \; e^{\lambda_i u_{it}}$$

where u_{it} is the capacity utilization of the i-th industry in t-th period.

Since the time series on capacity utilization is not readily available, for the estimation of equation (1.5), we have used the aggregate unemployment rate as a proxy for the capacity utilization.[11] Hence, the estimable version of equation (1.5) can be written as

$$(1.6) \qquad Y_{it} = A^*_{oi} \; e^{\lambda^*_{it}} \; k_{it}^{1 - \alpha^*_i} \; e^{\alpha_i \text{URATE}_t}$$

where URATE_t is the aggregate unemployment rate in the t-th period.

Klein and Preston [1967], Bodkin and Klein [1967],

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11 Due to the interdependency among industries, the aggregated unemployment rate may not be a bad proxy for the capacity utilization. Moreover, the deviation of observed unemployment rate from the natural unemployment rate could be interpreted as the deviation of actual output from normal output (Nordhaus 1972).

Preston [1967], and Hickman and Coen [1976], have argued against the direct estimation of equation (1.6). Moreover, due to the expected multicollinearity between the time trend and the capital labour ratio, we will not be able to get precise estimates of the parameters. In view of these problems, we have chosen to use a constrained estimation on equation (1.6). From the observed factor shares data, we get an estimate for α_i^* as

$$(1.7) \qquad \hat{\alpha}_i^* = \frac{1}{T} \sum_{i=1}^{T} (WB\$_{it} \; / \; Y\$_{it})$$

where $WB\$_{it}$ is the wage bill of the i-th industry (current \$) and $Y\$_{it}$ is the value added of the i-th industry (current \$). The logarithmic form of the estimated productivity equation is written as

$$(1.8) \qquad \ln(y_{it}) - (1 - \hat{\alpha}_i^*) \ln(k_{it})$$

$$= \ln(A_{oi}^*) + \lambda_i^* t + \alpha_i \; URATE_t + V_t$$

where V_t is a disturbance term.

To test the hypothesis of structural change in the 70's we have introduced both an intercept and slope (for time trend) dummy, taking the value of 1 from 1970 onwards and zero prior to 1970.

TABLE 4
PRODUCTIVITY EQUATIONS
DEPENDENT VARIABLE: ln(Q/L)

INDUSTRY	ln(K/L)	TIME TREND	PROD. DUMMY	PROD. DUMMY * TIME TREND	U RATE	ESTIMATION PERIOD	$\bar{R}^2$	D.W.	RHO
Agriculture	0.87170	-0.00338 (1.29)				1950-1974	0.029	1.695	
Construction	0.34144	0.01534 (12.26)			-0.00592 (0.87)	1956 1974	0.880	1.310	
Communications & Trsp	0.31447	0.03651 (16.44)			-0.01686 (2.52)	1953-1974	0.976	0.596	-0.680
Finance, Ins., & Real Estate	0.55001	-0.03003 (6.69)				1950-1976	0.837	0.100	
Forestry	0.14130	0.04793 (7.22)			-0.01617 (0.97)	1956-1974	0.891	0.295	0.764
MANUFACTURING DURABLES									
Wood	0.25343	0.01233 (3.38)			-0.02103 (1.72)	1957-1974	0.945	1.225	0.841
Furniture & fixtures	0.29923	0.29925 (18.90)			-0.03778 (4.82)	1957-1974	0.961	1.717	
Iron & Steel	0.29923	0.02568 (13.81)			-0.02404 (2.61)	1957-1974	0.927	2.00	
Nonferrous metal	0.30259	0.01855 (2.60)	-0.21505 (1.50)	0.00709 (0.84)	-0.02617 (1.38)	1957-1974	0.954	2.483	
Metal fabricating	0.32154	0.024206 (52.97)			-0.02280 (10.08)	1957-1974	0.995	2.419	
Machinery (ex.electrical machinery)	0.16563	0.03664 (36.26)			-0.01295 (2.59)	1957-1974	0.988	1.551	

(cont'd)

TABLE 4
(cont'd)

INDUSTRY	ln(K/L)	TIME TREND	PROD. DUMMY	PROD. DUMMY * TIME TREND	U RATE	ESTIMATION PERIOD	$\bar{R}^2$	D.W.	RHO
Nonauto trsp equipment	0.13017	0.02688			-0.03720	1957-1974	0.943	1.303	
Motor vehicle (ex. parts & accessories)	0.29199	0.07637 (20.81)			-0.09282 (3.80)	1957-1974	0.965	1.757	
Motor vehicle parts & access.	0.23956	0.03261 (12.60)			0.00429 (0.25)	1957-1974	0.916	2.155	
Electrical products	0.23466	0.02763 (3.93)	-0.25864 (1.84)	0.01283 (1.54)	-0.03544 (1.89)	1957-1974	0.979	2.012	
Nonmetallic mineral prod.	0.41317	0.02047 (9.57)				1957-1974	0.842	1.677	
MANUFACTURING NONDURABLES									
Food & Beverage	0.44877	0.01677 (30.76)			-0.01669 (4.59)	1957-1974	0.984	1.185	
Tobacco products	0.46673	0.02727 (23.61)			0.00475 (0.62)	1957-1974	0.974	1.472	
Rubber & plastic	0.32431	0.04275 (7.80)			-0.03505 (1.96)	1957-74	0.890	0.642	0.599
Leather	0.11667	0.01825 (21.61)			-0.00845 (2.02)	1957-74	0.967	1.685	
Textile	0.22255	0.05046 (27.86)			0.01015 (1.13)	1957-1974	0.979	0.039	
Knitting & clothing	0.26936	0.02710 (30.55)				1958-1974	0.982	1.548	

(cont'd)

TABLE 4
(cont'd)

INDUSTRY	ln(K/L)	TIME TREND	PROD. DUMMY	PROD. DUMMY * TIME TREND	U RATE	ESTIMATION PERIOD	$\bar{R}^2$	D.W.	RHO
Paper & allied indust.	0.34991	0.01793 (19.27)			-0.01508 (0.24)	1957-1974	0.963	1.909	
Printing, publishing & allied indust.	0.35406	0.01270 (5.61)				1957-1974	0.838	0.535	0.606
Petroleum coal prod.	0.42680	0.03346 (8.98)			-0.02729 (2.44)	1957-1974	0.942	0.783	0.648
Chemical & chemical prod.	0.42081	0.03755 (32.91)			-0.01448 (2.57)	1957-1974	0.985	1.487	
Misc. mfg.	0.41957	0.01032 (2.08)			0.00331 (0.31)	1957-1974	0.098	0.255	0.801
MINING									
Coal mining	0.23859	0.04515 (3.36)			0.11858 (2.49)	1957-1974	0.733	0.560	0.691
Crude petroleum natural gas, & serv. incidental to mining	0.79149	0.01328 (5.29)			0.03522 (2.11)	1957-1974	0.686	1.458	
Metal mining	0.59561	-0.01023 (2.49)			0.02334 (1.15)	1957-1974	0.288	1.243	
Nonmetal mining (except coal)	0.64065	0.00234 (1.04)			0.06875 (4.57)	1957-1974	0.777	2.137	

(cont'd)

TABLE 4
(cont'd)

INDUSTRY	ln(K/L)	TIME TREND	PROD. DUMMY	PROD. DUMMY * TIME TREND	U RATE	ESTIMATION PERIOD	$\bar{R}^2$	D.W.	RHO
Services	0.27679 (2.43)	0.008156 (2.49)			-0.01727 (4.96)	1957-1975	0.979	1.154	
Wholesale & retail trade	0.39472	0.024898 (11.10)			0.02221 (4.11)	1956-1974	0.952	0.380	0.779
Utility	0.63097	0.03144 (29.48)			0.01539 (2.31)	1956-1974	0.981	1.776	

EMPIRICAL RESULTS

The productivity equation (1.8) is estimated with annual time series data. The exact definition and sources of the variables are given in Appendix A. The estimation period varies across industries. The regression results are recorded in Table 4. Each column contains the estimated coefficient of the variable, with the t-ratio in parenthesis.[12] A blank space in any column means that the variable was not included in that particular equation. The last four columns give 1) the period over which the equation is estimated, 2) $\bar{R}^2$ (the coefficient of determination adjusted for degrees of freedom), 3) D. W. (Durbin-Watson Statistic) and 4) RHO (the autocorrelation coefficient).

The results are sensible in several aspect. First with the exception of agriculture and metal mining, 80% of the variations in the residual of labour productivity[13] is explained by the time trend and/or the unemployment rate.[14] Second, with the exception of agriculture, metal mining and finance and real estate, both the signs and the magnitude of the coefficient of the time trend is in accordance with a

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12 Since the coefficient on capital-labour ratio is a nonstochastic point estimate, t-ratio is not available.

13 Residual productivity is designed as

$$R_{it} = \ln(y_{it}) - (1 - \hat{\alpha}_i)\ln(k_{it})$$

14 To allow for the differential impact of capacity utilization over time, we have estimated all the equation with a distributed lag on the unemployment rate (usually four periods). However, due to space limitation in the table, we have recorded only the long-run coefficient.

prior expectation. Third, in all the equations (with a few exceptions) the unemployment rate is an important determinant of productivity. This supports its use as a proxy for the capacity utilization. Fourth, for most of the equations the Durbin-Watson statistic shows no autocorrelation.

Except agriculture, finance, insurance and real estate, metal mining, and nonmetal mining, the coefficient of the time trend has a significant positive coefficient. The nonmetal mining industry has the expected positive sign but does not pass the significance test. In the case of agriculture, finance, and metal mining, the coefficient of the time trend has an unexpected negative sign but is significantly different from zero only for metal mining and finance. As mentioned earlier for these industries, the $\bar{R}^2$ for both agriculture and metal mining is low (0.029 for agriculture, and 0.288 for metal mining), suggesting that some variables specific to these industries have been left out. This in turn has resulted in the biased estimates of the technical progress parameter.[15] Finance and insurance industry is a residual category in the construction of the industry accounts. Moreover, it includes a very heavy share of imputed income for owner occupants and financial institutions. In view of these odd

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15 See Johnston (1972), pp. 168-169

features, we might expect perverse results for these cases.

The coefficient on time trend represents the rate of growth of trend productivity per annum. The size of this coefficient varies considerably across industries--as small as -3.0% for finance, insurance and real estate, and as big as 7.6% for motor vehicle parts industry. As one would expect, the rate of growth of technical progress for the service industry is small relative to other industries.[16]

In about 2/3 of the manufacturing industries, the rate of growth of labour productivity is at least 2% per annum. Even for the remaining industries, productivity growth is not less than 1% per annum. These results imply approximately 2% productivity growth for the manufacturing industry as a whole. Only one of the mining industries,coal, has recorded an annual productivity growth of 2% or more. For the remaining industries, only communications and transportation, forestry, trade and utilities show productivity increases of at least 2% per annum.

On the basis of trend productivity, we can classify each industry into one of the three categories--low, medium, and high productivity growth industries. Low productive industries are those whose trend productivity is less than 2% per annum;

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16 The improper measure of service industry output could be partly responsible for the low growth of productivity.

industries with 2 to 3% annual productivity growth are classified as medium productivity; and industries with 3% or more productivity growth are defined as high productivity industries. With these definitions, we obtain the following results:

HIGH PRODUCTIVITY INDUSTRIES

Communications and transportation, forestry, machinery, motor vehicles, motor vehicle parts and accessories, rubber and plastic products, textiles, petroleum and coal products, chemicals and chemical products, coal mining, and utilities.

MEDIUM PRODUCTIVITY INDUSTRIES

Furniture and fixtures, iron and steel, metal fabricating, nonauto transportation equipment, electrical products, nonmetallic mineral products, tobacco products, knitting and clothing and trade.

LOW PRODUCTIVITY INDUSTRIES

Agriculture, construction, wood, nonferrous metals, food and beverages, leather, paper and allied industries, printing and publishing, miscellaneous manufacturing, metal mining, crude petroleum and natural gas, nonmetal mining, and services.

As one would expect, the coefficient on the capital-labour ratio shows considerable variation--as small as 0.14 for forestry and as high as 0.87 for agriculture. In more than half of the manufacturing industries, the coefficient on the capital-labour ratio is at least 0.3--implying a 10% increase in capital-labour ratio would increase labour productivity only by 3%, whereas

in the case of the mining industries only the coal industry has a coefficient less than 0.6. This implies that capital intensity is a major determinant of labour productivity in the mining industry. Moreover, labour productivity of agriculture, finance, insurance, and real estate and utilities are mainly determined by capital intensity.

In all the manufacturing equations (with the exception of motor vehicle parts and accessories, textiles and miscellaneous manufacturing), the long-run impact of unemployment rate on labour productivity is negative and is statistically significant in most cases. In none of the manufacturing industries does the unemployment rate enter with a significant positive coefficient. Moreover, in all the manufacturing industries the short-run impact is also negative. These results imply that the aggregate unemployment rate has a significant negative impact on the labour productivity of the manufacturing industries. Whereas all four mining industries, trade and utilities have a significantly positive long-run coefficient for the unemployment rate. However, for these industries, the short-run impact of the unemployment rate on the productivity is negative. This suggests that if the aggregate unemployment rate is to be consistently high for a year or so, these industries might reduce employment proportionally more than the normal adjustment, resulting in productivity gains. In none of the industry equations, are the productivity dummies significant. Thus, we reject the hypothesis of a structural break in the 70's.

IV DECOMPOSITION OF PRODUCTIVITY GROWTH BY INDUSTRY 1957-74, 1966-74 and 1971-74.

In order to understand the causes of the recent slowdown in productivity growth, we decompose actual productivity growth of each industry by its source--technical progress, capital contribution, capacity utilization, et cetera for all three subperiods. Using the estimated coefficients of the productivity equations in Table 4 and the capital-labour ratio growth rates given in Table 5, productivity growth is broken into cycle corrected productivity growth and residual. Cycle-corrected productivity growth is further divided into the contributions of technical progress and the contributions of capital.[17] These results are recorded in Tables 6, 7, and 8.

For the period 1957-1974, the contribution of capital intensity to measured productivity growth is at least 50% for agriculture, finance, insurance and real estate, wood, food and beverages, crude petroleum and natural gas, metal mining, nonmetal mining and services. Within the manufacturing sector, capital contribution is generally large for the nondurable manufacturing industries. Capital contribution is also fairly large in the case of forestry and utilities.

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17 This procedure is explained in detail in Appendix B.

TABLE 5

AVERAGE RATE OF GROWTH CAPITAL-LABOUR RATIO

INDUSTRY	1957-74	1966-74	1971-74
Agriculture	6.06	6.13	5.39
Construction	1.25	2.38	0.51
Communications & Trsp.	2.90	2.62	1.94
Finance, Ins., & Real Estate	6.55	4.38	5.66
Forestry	7.28	6.63	6.67
Manufacturing (Total)	2.94	3.72	2.82
DURABLES			
Wood	4.32	7.43	6.96
Furniture & fixtures	2.17	4.27	3.13
Iron & Steel	3.10	2.41	4.03
Nonferrous metal	2.76	3.43	2.49
Metal fabricating	1.61	3.71	1.43
Machinery (ex. electrical machinery)	2.23	2.73	1.84
Nonauto trsp. equipment	4.63	3.62	4.87
Motor vehicle (ex. parts & accessories)	-0.44	0.44	-2.92

(cont'd)

TABLE 5 cont'd

INDUSTRY	1957-74	1966-74	1971-74
Motor vehicle parts & access.	4.84	6.20	-2.37
Electrical products	2.40	3.59	2.97
Nonmetallic mineral prod.	1.71	2.37	-0.16
NONDURABLES			
Food & Beverage	2.74	2.97	2.30
Tobacco products	4.43	3.44	2.93
Rubber & plastic	3.95	5.74	6.12
Leather	1.96	3.75	3.05
Textile	2.26	3.46	3.02
Knitting & clothing	0.75	2.63	2.22
Paper & allied indust.	2.93	3.43	2.32
Printing, publishing & allied indust.	1.72	1.23	1.53
Petroleum & coal prod.	3.98	5.06	5.76
Chemical & chemical prod.	4.15	4.68	4.69
Misc. mfg.	1.48	1.92	-1.53

(cont'd)

TABLE 5 cont'd

INDUSTRY	1957-74	1966-74	1971-74
Mining (Total)	8.59	8.45	5.86
Coal mining	13.34	22.36	5.06
Crude petroleum, natural gas, & serv. incidental to mining	7.93	6.18	7.23
Metal mining	6.64	9.18	5.84
Nonmetal mining (except coal)	6.80	8.58	2.62
Services	6.91	6.21	4.81
Wholesale & retail trade	1.48	1.13	0.34
Utility	4.19	3.55	3.00

SOURCE: CANDIDE 2.0 DATA BANK

TABLE 6

DECOMPOSITION OF PRODUCTIVITY GROWTH BY INDUSTRY, 1957-74

INDUSTRY	ACTUAL PRODUCTIVITY	CAPITAL CONTRIBUTION	HICKS NEUTRAL TECHNICAL PROGRESS	CYCLE CORRECTED PRODUCTIVITY	RESIDUAL
Agriculture	5.33	5.28	-.338	4.94	-0.39
Construction	1.65	.43	1.534	1.96	- .31
Communications & Trsp.	4.51	.91	3.651	4.56	- .05
Finance, Ins., & Real Estate	0.60	3.60	-3.003	.60	.0
Forestry	6.96	1.03	4.793	5.82	1.14
DURABLES					
Wood	1.88	1.09	1.233	2.32	-0.44
Furniture & fixtures	2.11	.65	2.225	2.88	- .77
Iron & Steel	3.37	.93	2.568	3.50	- .13
Nonferrous metal	3.36	.84	1.855	2.70	.66
Metal fabricating	2.67	.52	2.421	2.94	- .27
Machinery (ex. electrical machinery)	3.84	.37	3.664	4.03	- .19
Nonauto trsp. equipment	2.82	.60	2.688	3.29	- .47
Motor vehicle (ex. parts & accessories)	5.67	- .13	7.637	7.51	-1.84

(cont'd)

TABLE 6 cont'd

INDUSTRY	ACTUAL PRODUCTIVITY	CAPITAL CONTRIBUTION	HICKS NEUTRAL TECHNICAL PROGRESS	CYCLE CORRECTED PRODUCTIVITY	RESIDUAL
Motor vehicle parts & access.	4.59	1.16	3.261	4.42	.17
Electrical products	4.31	.56	2.763	3.32	.99
Nonmetallic mineral prod.	2.87	.71	2.047	2.76	.11
NONDURABLES					
Food & Beverage	2.56	1.23	1.677	2.91	- .35
Tobacco products	4.86	2.07	2.727	4.80	.06
Rubber & plastic	6.04	1.28	4.275	5.56	.48
Leather	1.85	.23	1.825	2.06	- .21
Textile	5.28	.50	5.046	5.55	- .27
Knitting & clothing	2.68	.20	2.710	2.91	- .23
Paper & allied indust.	2.78	1.03	1.793	2.82	- .04
Printing, publishing & allied indust.	1.69	.61	1.270	1.88	- .19
Petroleum & coal prod.	5.02	1.70	3.346	5.05	- .03
Chemical & chemical prod.	5.21	1.75	3.755	5.51	- .30
Misc. mfg.	1.67	.62	1.032	1.65	.02

(cont'd)

TABLE 6 cont'd

INDUSTRY	ACTUAL PRODUCTIVITY	CAPITAL CONTRIBUTION	HICKS NEUTRAL TECHNICAL PROGRESS	CYCLE CORRECTED PRODUCTIVITY	RESIDUAL
MINING					
Coal mining	9.19	3.18	4.515	7.70	1.49
Crude petroleum, natural gas, & serv. incidental to mining	7.51	6.28	1.328	7.61	- .10
Metal mining	4.79	3.95	-1.023	2.93	1.86
Nonmetal mining (except coal)	6.23	4.36	0.234	4.59	1.64
Services	1.54	1.91	.0816	1.99	- .45
Wholesale & retail trade	3.03	.58	2.490	3.07	- .04
Utility	6.63	2.64	3.144	5.78	.85

SOURCE: COMPUTED AS EXPLAINED IN APPENDIX B.

TABLE 7
DECOMPOSITION OF PRODUCTIVITY GROWTH BY INDUSTRY, 1966-74

INDUSTRY	ACTUAL PRODUCTIVITY	CAPITAL CONTRIBUTION	HICKS NEUTRAL TECHNICAL PROGRESS	CYCLE CORRECTED PRODUCTIVITY	RESIDUAL
Agriculture	3.60	5.34	-.338	5.00	-1.40
Construction	1.48	.81	1.534	2.34	- .86
Communications & Trsp.	5.48	.82	3.651	4.471	1.01
Finance, Ins., & Real Estate	1.09	2.41	-3.003	- .59	1.68
Forestry	4.77	.94	4.793	5.73	- .96
DURABLES					
Wood	1.56	1.88	1.233	3.01	-1.45
Furniture & fixtures	1.89	1.28	2.225	3.51	-1.62
Iron & Steel	1.67	.72	2.568	3.29	-1.62
Nonferrous metal	1.65	1.04	1.855	2.90	-1.25
Metal fabricating	3.27	1.19	2.421	3.61	- .34
Machinery (ex. electrical machinery)	4.09	.45	3.664	4.11	- .02
Nonauto trsp. equipment	2.38	.47	2.688	3.16	- .78
Motor vehicle (ex.parts & accessories)	7.38	.13	7.637	7.77	- .39

(cont'd)

TABLE 7 cont'd

INDUSTRY	ACTUAL PRODUCTIVITY	CAPITAL CONTRIBUTION	HICKS NEUTRAL TECHNICAL PROGRESS	CYCLE CORRECTED PRODUCTIVITY	RESIDUAL
Motor vehicle parts & access.	4.90	1.49	3.261	4.75	.15
Electrical products	2.54	.84	2.763	3.60	-1.06
Nonmetallic mineral prod.	2.07	.98	2.047	3.03	- .96
NONDURABLES					
Food & Beverage	2.54	1.33	1.677	3.01	- .47
Tobacco products	3.39	1.61	2.727	4.34	- .95
Rubber & plastic	4.35	1.86	4.275	6.14	-1.79
Leather	1.40	.44	1.825	2.27	- .87
Textile	4.86	.77	5.046	5.82	- .96
Knitting & clothing	2.73	.71	2.710	3.42	- .69
Paper & allied indust.	2.35	1.20	1.793	2.99	- .64
Printing, publishing & allied indust.	2.02	.44	1.270	1.71	.31
Petroleum & coal prod.	3.84	2.16	3.346	5.51	-1.67
Chemical & chemical prod.	4.55	1.97	3.755	5.73	-1.18
Misc. mfg.	2.89	.81	1.032	1.84	1.05

(cont'd)

TABLE 7 cont'd

INDUSTRY	ACTUAL PRODUCTIVITY	CAPITAL CONTRIBUTION	HICKS NEUTRAL TECHNICAL PROGRESS	CYCLE CORRECTED PRODUCTIVITY	RESIDUAL
MINING					
Coal mining	14.06	5.33	4.515	9.85	4.21
Crude petroleum, natural gas, & serv. incidental to mining	6.76	4.89	1.328	6.22	.54
Metal mining	6.20	5.47	-1.023	4.45	1.75
Nonmetal mining (except coal)	6.78	5.50	.234	5.73	1.05
Services	1.89	1.72	.0816	1.80	.09
Wholesale & retail trade	3.14	.45	2.490	2.94	.20
Utility	6.20	2.24	3.144	5.38	.82

SOURCE: COMPUTED AS EXPLAINED IN APPENDIX B

TABLE 8
DECOMPOSITION OF PRODUCTIVITY GROWTH BY INDUSTRY, 1971-74

INDUSTRY	ACTUAL PRODUCTIVITY	CAPITAL CONTRIBUTION	HICKS NEUTRAL TECHNICAL PROGRESS	CYCLE CORRECTED PRODUCTIVITY	RESIDUAL
Agriculture	.06	4.70	-.338	4.36	-4.30
Construction	- .37	.17	1.534	1.70	-2.07
Communications & Trsp.	3.82	.61	3.651	4.26	- .44
Finance, Ins., & Real Estate	1.83	3.11	-3.003	.11	1.72
FOrestry	1.69	.94	4.793	5.73	-4.04
DURABLES					
Wood	.23	1.76	1.233	2.99	-2.76
Furniture & fixtures	.72	.94	2.225	3.17	-2.45
Iron & Steel	1.86	1.21	2.568	2.57	- .71
Nonferrous metal	1.64	.75	1.855	2.61	- .97
Metal fabricating	2.79	.46	2.421	2.88	- .09
Machinery (ex.electrical machinery)	5.15	.30	3.664	3.96	1.19
Nonauto trsp. equipment	3.56	.63	2.688	3.32	.24
Motor vehicle (ex. parts & accessories)	2.37	- .85	7.637	6.79	-4.42

(cont'd)

TABLE 8 cont'd

INDUSTRY	ACTUAL PRODUCTIVITY	CAPITAL CONTRIBUTION	HICKS NEUTRAL TECHINICAL PROGRESS	CYCLE CORRECTED PRODUCTIVITY	RESIDUAL
Motor vehicle parts & access.	4.57	- .57	3.261	2.69	1.88
Electrical products	3.87	.70	2.763	3.46	.41
Monmetallic mineral prod.	4.55	- .07	2.047	1.98	2.57
NONDURABLES					
Food & Beverage	1.57	1.03	1.677	2.71	-1.14
Tobacco products	3.07	1.37	2.727	4.10	-2.53
Rubber & plastic	4.67	1.98	4.275	6.26	-1.59
Leather	1.10	.36	1.825	2.19	-1.09
Textile	3.64	.67	5.046	5.72	-2.08
Knitting & clothing	2.61	.60	2.710	3.31	- .70
Paper & allied indust.	2.20	.81	1.793	2.60	- .40
Printing, publishing & allied indust.	2.47	.54	1.270	1.81	.66
Petroleum & coal prod.	5.12	2.46	3.346	5.81	- .69
Chemical & chemical prod.	5.21	1.97	3.755	5.73	- .52
Misc. Mfg.	3.07	- .64	1.032	.39	2.68

(cont'd)

TABLE 8 cont'd

INDUSTRY	ACTUAL PRODUCTIVITY	CAPITAL CONTRIBUTION	HICKS NEUTRAL TECHNICAL PROGRESS	CYCLE CORRECTED PRODUCTIVITY	RESIDUAL
MINING					
Coal mining	18.24	1.21	4.515	5.73	12.51
Crude petroleum, natural gas, & serv. incidental to mining	6.98	5.72	1.328	7.05	- .07
Metal mining	1.21	3.48	-1.023	2.46	- 1.25
Nonmetal mining (except coal)	6.81	1.68	.234	1.91	4.90
Services	1.23	1.33	.0816	1.41	- .18
Wholesale & retail trade	3.64	.13	2.490	2.62	1.02
Utility	6.67	1.89	3.144	5.03	1.64

SOURCE: COMPUTED AS EXPLAINED IN APPENDIX B.

For the same period, in all the industries (with the exception of forestry, motor vehicles, coal mining, metal mining and nonmetal mining) the cycle corrected productivity growth--the sum of technical progress parameter and the capital contribution is almost identical to the measured productivity growth. This suggests that the cyclical factors were not the important determinants of productivity growth in this period. As opposed to this, in the case of forestry, coal mining, crude petroleum, and natural gas and the nonmetal mining industries, cyclical factors have contributed significantly to productivity growth. With the exception of forestry, this result is consistent with the sign and size of the coefficient of the unemployment rate in the productivity equations. Similarly the large negative residual in the motor vehicle industry can be explained in terms of the coefficient on the unemployment rate.

For the subperiod 1966-74, the average annual rate of growth of capital intensity is generally higher than that for the period 1957-74 (See Table 5). This in turn has resulted in an increase in the cycle corrected productivity growth (See Table 7). But the residual in productivity growth is consistently larger than that for the period 1957-74. This differential impact of cyclical factors during these two period can be explained in terms of differences in the year to year changes (average) in the unemployment rate [18] over the period 1971-74. In almost

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18 The average yearly changes in the unemployment rate for the periods 1957-74, 1966-74, and 1971-74 are 0.18, 0.31, and 0.22 respectively.

all the industries the capital labour ratio growth has slowed. In particular, the following industries have experienced a sharp decline in capital intensity growth: motor vehicles, motor vehicle parts, nonmetallic mineral products, coal mining, metal mining, nonmetal mining and trade. In addition to this general decline in cycle corrected productivity growth, the residuals productivity growth is generally negative and larger than the residuals in the other two periods. The productivity growth decline (residual growth) in agriculture, forestry, and construction industries is very large and moreover this decline cannot be explained in terms of the yearly increase in unemployment rate for this period. As we see in the next section, all these factors have contributed significantly to the decline in aggregate productivity growth in this period.

V TRENDS IN AGGREGATE LABOUR PRODUCTIVITY

We note from Table 2 that aggregate labour productivity growth has declined from 2.86% per annum for the period 1957-74 to 2.27% per annum for the subperiod 1971-74. This decline in productivity growth might be the result of a) a decline in labour productivity growth in almost all the industries, caused either by decline in cycle-corrected productivity growth or low capacity utilization (cyclical factors); b) a sharp decline in productivity in a few isolated sectors; c) a change in the composition of employment and output. In this section, we attempt to quantify the impact of each of these factors on aggregate labour productivity growth, for all three periods.

Making use of the cycle-corrected productivity growth rate estimates of individual industries developed in the last section, each industry contribution to aggregate productivity is broken into four components:[19]

1. Cycle-corrected productivity growth fixed weight
2. Changes in the fixed weight term
3. Growth in the employment share fixed weight term
4. Actual weight term

The sum of each of these four components for all the 35

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19 This procedure is explained in detail in Appendix B and is similar to Nordhaus (1972).

industries is recorded in a separate table (see Table 9).

The first term shows the predicted rate of growth of productivity in the absence of changes in output and employment shares and changes in productivity relatives over time.

The second term shows the impact of changes in output among industries, still ignoring productivity differences (levels) among them. Movement of output shares towards sectors with low productivity growth rates will depress the aggregate productivity growth and vice versa.

The third term gives the effect of changing employment shares among industries, if the relative productivity levels among them remained constant over time.

The fourth term shows the interaction of changing productivity relatives.

The predicted productivity growth for each period is calculated as sum of these four components. These predicted productivity growth rates are recorded in line 5 of Table 9. For all three periods the predicted productivity growth is very close to actual productivity growth. This implies that the impact of cyclical factors on aggregate productivity growth is small. We also notice that the magnitude of the first term is almost identical to the predicted growth rate in each period, implying that the observed aggregate productivity growth rate variation among the three periods is mostly due to variations in capital-intensity rates, and the effects of changes in employment and output shares and changes in productivity relatives among industries are very small.

TABLE 9

DECOMPOSITION OF AGGREGATE LABOUR
PRODUCTIVITY GROWTH, 1957-74, 1966-74, 1971-74

COMPONENT		1957-74	1966-74	1971-74
PREDICTED RATE TERMS				
1.	Fixed weight (1965 weight)	2.68	2.624	2.335
2.	Change in fixed weight terms	-0.039	0.008	0.065
LEVEL TERMS				
3.	Fixed weight (1965 weight)	0.0045	.0032	0.003
4.	Actual weight	0.00007	-0.0013	-0.0013
5.	Predicted growth rate of aggregate productivity, cyclically corrected	2.645	2.634	2.402
6.	Actual rate of growth of productivity	2.83	2.86	2.27

SOURCE: Derived from equation (B.7), discussed in Appendix B, and basic data cited in Appendix A. Each of the first four is derived as the sum of respective components in (B.7) for all the 35 industries. Line 5 is the sum of items 1 through 4.

For the period 1957-74, both the changes in employment shares and changes in productivity relatives among industries have increased the aggregate labour productivity growth by 0.0045% per annum. For this period, the results further imply productivity increases of 0.19% per annum due to cyclical and other residual factors.

Over the period 1966-74, the predicted productivity growth rate is 2.63% per annum, but the measured productivity increased by 2.86% per annum. This implies that the cyclical and other residual factors accelerated the productivity growth rate by 0.23% per annum. The results also suggests that most of the increase in predicted growth is the result of increase in capital intensity.

For subperiod 1971-74, the predicted productivity growth is only 2.40% per annum, compared to actual growth rate of 2.27%. This suggests that the cyclical factors have reduced the growth rate by 0.13% per annum. The results also show that the effects of changes in employment and output shares and changes in productivity relatives among industries are small. This further implies that the recent decline in productivity growth is mostly caused by reductions in the rate of growth of capital-labour ratio, and decline in capacity utilization. As we see from Tables 10,11, and 12, this decline is broadly based in virtually all sectors of the economy. However, the following sectors have experienced sharp reductions in their capital-intensity growth: agriculture, construction, iron and steel, motor vehicle parts and accessories, electrical products, nonmetallic mineral products, metal mining, nonmetal mining, services, trade and utilities.

TABLE 10
INDUSTRY CONTRIBUTION TO AGGREGATE LABOUR PRODUCTIVITY, 1957-1974

INDUSTRY	PREDICTED RATE TERMS: FIXED WEIGHT (1965 WEIGHT)	PREDICTED RATE TERMS: CHANGE IN FIXED WEIGHT TERMS	LEVEL TERMS: FIXED WEIGHT (1965 WEIGHT)	LEVEL TERMS: ACTUAL WEIGHT
Agriculture	.2304	-.00562	0.003351	-0.000053
Construction	.1490	-.00392	0.000001	0.000000
Communications & Trsp	.3830	.00456	0.000039	0.000060
Finance, Ins., & Real Estate	.0450	.00120	0.000927	-0.000040
Forestry	.0466	.0000	0.000102	0.000009
Manufacturing (Total)	0.8003			
Durables (Total)	0.4013			
Wood	.02552	.0000	0.000004	0.000000
Furniture & Fixtures	.0132	-.00086	-0.000004	-0.000000
Iron & Steel	.0483	-.00770	0.000011	-0.000004
Nonferrous metal	.0230	-.00027	-0.000014	0.00000
Metal fabricating	.0588	-.00352	0.000001	0.000000
Machinery (ex. electrical machinery)	.0399	-.00241	-0.000012	0.000000
Nonauto trsp. equipment	.0290	.00460	0.000008	0.000001
Motor vehicle (ex. parts & accessories)	.0503	-.00150	-0.000023	0.000002
Motor vehicle parts & access.	.0296	-.00176	0.000022	0.000000

(cont'd)

TABLE 10
INDUSTRY CONTRIBUTION TO AGGREGATE LABOUR PRODUCTIVITY, 1957-1974

INDUSTRY	PREDICTED RATE TERMS		LEVEL TERMS	
	FIXED WEIGHT (1965 WEIGHT)	CHANGE IN FIXED WEIGHT TERMS	FIXED WEIGHT (1965 WEIGHT)	ACTUAL WEIGHT
Electrical products	.0561	-.00730	0.000000	0.000000
Nonmetallic mineral prod.	.0276	-.00303	0.000010	-0.000000
Nondurables (Total)	0.3990			
Food & Beverage	.0984	.00116	-0.000012	0.000000
Tobacco products	.0115	-.00096	-0.000021	0.000000
Rubber & plastic	.0300	-.00278	0.000005	-0.000000
Leather	.0056	.00041	0.000044	-0.000000
Textile	.0405	-.00166	0.000059	-0.000002
Knitting & clothing	.0306	.00058	0.000058	0.000001
Paper & allied indust.	.0570	.00112	-0.000014	-0.000004
Printing, publishing & allied industries	.0226	.00018	0.000000	-0.000000
Petroleum & coal prod.	.0202	-.00151	-0.00014	0.000000
Chemical & chemical prod.	.0705	-.00770	-0.000001	0.000001
Misc. mfg.	.0119	-.00033	0.000002	0.000000

(cont'd)

TABLE 10
INDUSTRY CONTRIBUTION TO AGGREGATE LABOUR PRODUCTIVITY, 1957-1974

INDUSTRY	PREDICTED RATE TERMS		LEVEL TERMS	
	FIXED WEIGHT (1965 WEIGHT)	CHANGE IN FIXED WEIGHT TERMS	FIXED WEIGHT (1965 WEIGHT)	ACTUAL WEIGHT
Mining (Total)	0.1818			
Coal mining	.0085	.00616	0.000014	-0.000001
Crude petroleum, natural gas, & serv. incidental to mining	.105	-.01750	0.000088	0.000003
Metal mining	.0483	-.00029	-0.000000	-0.000000
Nonmetal mining (except coal)	.020	-.00183	0.000000	-0.000000
Services	.358	.00398	-0.000616	-0.000050
Wholesale & retail trade	.353	-.00307	-0.000188	-0.000006
Utility	.133	.01156	0.000042	0.000003
Public adminstration			0.000548	-0.000002
Aggregate	2.67992	-.03915	0.0045	-0.00074

SOURCE: Derived from equation (B.7), discussed in Appendix B, and basic data cited in Appendix A.

TABLE 11

INDUSTRY CONTRIBUTION TO AGGREGATE LABOUR PRODUCTIVITY, 1966-74

	PREDICTED RATE TERMS		LEVEL TERMS	
INDUSTRY	FIXED WEIGHT (1965 WEIGHT)	CHANGE IN FIXED WEIGHT TERMS	FIXED WEIGHT (1965 WEIGHT)	ACTUAL WEIGHT
Agriculture	.23288	-.04544	.0002436	-.000677
Construction	.17784	-.01404	-0.000003	.000001
Communications & Trsp.	.37556	.01341	0.000044	.000044
Finance, Ins., & Real Estate	-.04425	-.00177	.001061	-0.000242
Forestry	.04584	.0000	.000133	-0.000032
Manufacturing (Total)	0.8554			
Durables (Total)	0.4361			
Wood	.03421	-.00373	-0.000025	.000004
Furniture & fixtures	.01614	.0000	.000006	.000000
Iron & Steel	.04540	-.00526	.000004	-0.000002
Nonferrous metal	.02465	-.00116	-0.000008	.000000
Metal fabricating	.07220	-.00072	-0.000006	.000004
Machinery (ex. electrical machinery)	.04068	.00287	-0.000007	.000002
Nonauto trsp equipment	.02780	-.00252	.000005	.000001
Motor vehicle (ex. parts & accessories)	.05205	.02331	-0.000006	.000001
Motor vehicle parts & access.	.03182	.00617	.000007	.000000

(cont'd)

TABLE 11

INDUSTRY CONTRIBUTION TO AGGREGATE LABOUR PRODUCTIVITY, 1966-74

INDUSTRY	PREDICTED RATE TERMS		LEVEL TERMS	
	FIXED WEIGHT (1965 WEIGHT)	CHANGE IN FIXED WEIGHT TERMS	FIXED WEIGHT (1965 WEIGHT)	ACTUAL WEIGHT
Electrical products	.06084	.00072	0.000002	.000001
Nonmetallic mineral prods.	.03030	-.00272	-0.000001	.0000000
Nondurables (Total)	0.4193			
Food & Beverage	.10173	-.00421	-0.000027	.000003
Tobacco products	.01041	-.00086	-0.000019	.000000
Rubber & plastic	.03315	.00736	-0.00000	.000000
Leather	.00612	-.00113	0.000050	
Textile	.04248	.00116	0.000095	-0.000017
Knitting & clothing	.03591	-.00342	0.00103	.000002
Paper & allied indust.	.06039	-.00179	-0.000021	.000008
Printing, publishing & allied industries	.02052	-.00102	-0.000003	.000001
Petroleum & coal prod.	.02204	.0000	-0.00000	.000000
Chemical & chemical prod.	.07334	.00515	-0.00000	.000000
Misc. mfg.	.01324	.00018	-0.00000	.000000

(cont'd)

TABLE 11

INDUSTRY CONTRIBUTION TO AGGREGATE LABOUR PRODUCTIVITY, 1966-74

	PREDICTED RATE TERMS		LEVEL TERMS	
INDUSTRY	FIXED WEIGHT (1965 WEIGHT)	CHANGE IN FIXED WEIGHT TERMS	FIXED WEIGHT (1965 WEIGHT)	ACTUAL WEIGHT
Mining (total)	0.1953			
Coal mining	.01083	.00098	0.000012	-0.000011
Crude petroleum, natural gas, & serv. incidental to mining	.08583	.01368	-0.000076	-0.000025
Metal mining	.07342	-.00222	-0.000108	-0.000105
Nonmetal mining (except coal)	.02521	.00114	-0.00032	-0.000025
Services	.32400	.00198	-0.000773	-0.00227
Wholesale & retail trade	.33810	.0000	-0.000202	.000000
Utility	.12374	.02152	0.000111	.000026
Public adminstration			0.000484	-.000242
Aggregate	2.62442	.00762		

SOURCE: Derived from equation (B.7), discussed in Appendix B, and basic data cited in Appendix A.

TABLE 12

INDUSTRY CONTRIBUTION TO AGGREGATE LABOUR PRODUCTIVITY, 1971-74

INDUSTRY	PREDICTED RATE TERMS: FIXED WEIGHT (1965 WEIGHT)	PREDICTED RATE TERMS: CHANGE IN FIXED WEIGHT TERMS	LEVEL TERMS: FIXED WEIGHT (1965 WEIGHT)	LEVEL TERMS: ACTUAL WEIGHT
Agriculture	.20664	-.005544	0.001842	-.000116
Construction	.12920	-.01360	0.000123	-.000073
Communications & Trsp.	.35784	..03834	0.000019	.000142
Finance, Ins., & Real Estate	.00825	..00044	0.000585	-.000165
Forestry	.04584	-.00573	0.000111	-.000036
Manufacturing (Total)	0.7642			
Durables (Total)	0.3729			
Wood	.03289	-.00358	0.000001	.000000
Furniture & fixtures	.01458	-.00031	0.000004	.000000
Iron & Steel	.03546	-.00436	-0.000001	.000000
Nonferrous Metal	.02218	-.00261	-0.000040	.000026
Metal fabricating	.05760	-.00230	-0.000006	-.000002
Machinery (ex. electrical machinery)	.03920	..00356	-0.00001	..000000
Nonauto trsp. equipment	.02921	-.00597	0.000009	.000018
Motor vehicle (ex. parts & accessories)	.04549	.02648	-0.000026	.000077
Motor vehicle parts & access.	.01802	.00645	0.000030	.000035

(cont'd)

TABLE 12

INDUSTRY CONTRIBUTION TO AGGREGATE LABOUR PRODUCTIVITY, 1971-74

INDUSTRY	PREDICTED RATE TERMS		LEVEL TERMS	
	FIXED WEIGHT (1965 WEIGHT)	CHANGE IN FIXED WEIGHT TERMS	FIXED WEIGHT (1965 WEIGHT)	ACTUAL WEIGHT
Electrical products	.05847	.0000	0.000020	.000006
Nonmetallic mineral prod.	.01980	-.00138	0.000005	-.000001
Nondurables (Total)	0.3913			
Food & Beverage	.09159	-.00731	-0.000040	.000006
Tobacco products	.00984	-.00123	-0.000024	-.000000
Rubber & plastic	.03380	.01064	0.000001	-0.000001
Leather	.00591	-.00175	0.000047	.000006
Textile	.04175	.00343	0.000464	.000130
Knitting & clothing	.03475	-.00397	0.000099	.000002
Paper & allied industries	.05252	-.00260	-0.000053	.000022
Printing, publishing & allied industries	.02172	-.00181	-0.000020	.000007
Petroleum & coal prod.	.02324	.00058	-0.000014	-.000001
Chemical & chemical prod.	.07334	.00744	-0.000016	-.000013
Misc. mfg.	.00280	.0000	-0.000001	.000001

(cont'd)

TABLE 12

INDUSTRY CONTRIBUTION TO AGGREGATE LABOUR PRODUCTIVITY, 1971-74

INDUSTRY	PREDICTED RATE TERMS		LEVEL TERMS	
	FIXED WEIGHT (1965 WEIGHT)	CHANGE IN FIXED WEIGHT TERMS	FIXED WEIGHT (1965 WEIGHT)	ACTUAL WEIGHT
Mining (Total)	0.1526			
Coal mining	..00630	.00229	-0.000001	.000003
Crude petroleum, natural gas, & serv. incidental to mining	.09729	.02608	-0.000248	-.000117
Metal mining	.04059	-.00319	-0.000054	-.000052
Nonmetal mining (except coal)	.00840	.00038	-0.000042	-.000036
Services	.25380	.01833	-0.000373	-.000280
Wholesale & retail trade	.30130	.00786	-0.000358	.000011
Utility	.11569	.03018	0.000043	.000018
Public adminstration			0.000572	-.000954
Aggregate	2.33530	.06534		

SOURCE: Derived from equation (B.7), discussed in Appendix B, and basic data cited in Appendix A.

The contribution of manufacturing industry to the predicted term (component 1) has declined from 0.80% in 1957-74, and 0.86% in 1966-74 to 0.76% in 1971-74. Similarly the contribution of mining industry declined from 0.18% in 1957-74 and 0.20% for 1966-74 to 0.15% in 1971-74.

VI CONCLUSIONS

The major objective of this paper has been to analyse the causes of recent decline in the aggregate labour productivity growth, disaggregated to 35 industries. For this purpose, first we have estimated a productivity equation for each of these industries. Then the parameters of these equations are used to compute the cycle corrected productivity growth for each industry for all the three periods, 1957-74, 1966-74, and 1971-74. These in turn are used to compute the aggregate productivity growth rate for each period. The effects of movements in output and employment shares and productivity relatives among industries are separated. The important findings are summarized in order of their appearance in the study.

1. Both productivity and productivity growth rate variations among industries are quite large.

2. In spite of wide difference in productivity growth, industry productivity relatives (with a few exceptions) have almost remained constant over these three periods.

3. On the basis of technical progress parameter, we classified each industry into one of the three categories--low, medium, and high productivity growth industries. High Productivity growth industries are those whose trend productivity growth is more than 3% per annum. These are communications and transportation, forestry, machinery, motor vehicles, motor vehicle parts and accessories, rubber and plastic products, textiles, petroleum and coal products, chemicals and chemical products, coal mining and utilities.

Industries with less than 2% productivity growth are

defined as low productivity industries. These are agriculture, construction, wood, nonferrous metals, food and beverages, leather, paper and allied industries, printing and publishing, miscellaneous manufacturing metal mining, crude petroleum, and natural gas, nonmetal mining, services and public adminstration.

All other industries fall into medium productivity group.

4. The labour productivity growth of agriculture, finance, insurance and real estate, utilities, metal mining crude petroleum, natural gas and services and nonmetal mining is mainly determined by increases in their capital intensity.

5. In all the manufacturing industries (with a few exceptions) the long run impact of unemployment rate on productivity is negative and significant. This suggests that the macro unemployment rate is a reasonable proxy for aggregate utilization.

6. In none of the industry equations, are the productivity dummies associated with significant coefficients. Thus, we reject the hypothesis of structural break in the 70's.

7. For the period 1957-74, the contribution of capital intensity to the measured productivity growth is at least 50% for agriculture, finance, insurance and real estate, wood, food and beverages, crude petroleum and natural gas, metal mining, nonmetal mining and services. Within the manufacturing industries, capital contribution is generally large for the non-durable manufacturing industries.

8. The impact of cyclical and other residual factors on the aggregate labour productivity growth rate varies among

the three periods--0.19%, 0.23% and -0.13% per annum for the periods 1957-74, 1966-74, and 1971-74 respectively.

9. In all the three periods the impact of movements in employment and output shares among industries on aggregate labour productivity growth is small.

10. The recent decline in aggregate productivity growth rate is mostly caused by decline in the capital intensity growth and reduction in capacity utilization and this decline is broadly based in virtually all sectors of the economy.

In spite of its success, this empirical analysis is far from complete. It does, however, indicate that future work and continued refinement of the model both theoretically and empirically should yield significant returns.

As mentioned earlier, the accuracy of productivity estimates largely depends on the accuracy of both output and input measurement. Improved measures of service and government sector output should prove fruitful.

Labour input should reflect changes in skill, age, sex, education,et cetera. With these quality adjustments, we should be able to quantify the contribution of demographic changes to the recent slow down in aggregate productivity [Perry (1971), Denison (1962), Nordhaus (1972)].

If possible, we should also try to relax the assumption of perfect substitutability between new and old capital (vintage effect.)

Throughout this paper labour productivity is defined in terms of value added rather than gross output. This can be

justified by assuming strict separability between materials and other inputs. In spite of this restrictive assumption, the use of value added is popular mainly because the alternative of using output is not usually available. Recently, Star (1974), Denny and May (1978) have put forward a strong case against the use of value added in productivity analysis. Making use of the industry-gross output data recently developed by CANDIDE Group, we should be able to check for the robustness of our results. Development of good industry specific capacity utilization measures might isolate the impact of cyclical forces on productivity more effectively.

As a first approximation, we have derived our productivity equations by assuming Cobb-Douglas production with Hicks-Neutral technical change. For the sake of analytical simplicity, we have also imposed constant returns to scale on each industry. It is well known that CD function implies unitary elasticity of substitution.[20] We should check for the sensitivity of our reults to each one of these assumptions.

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20 Frohn (1972) has estimated the rate of technical change coefficient for the sixteen industrial sectors of the Federal Republic of Germany, using both CES and Cobb-Douglas functional forms. His results showed almost no difference between these two estimates, even though the estimate of elasticity of substitution in a number of industries is significantly different from unity.

Using CANDIDE 2.0, we should also try to quantify the impact of fiscal, monetary and trade policies, government regulations, and demographic changes on labour productivity, through their impact on capital formation, capacity utilization and quality of inputs, et cetera.

APPENDIX A

DATA SOURCES

All data series are drawn from the CANDIDE Model 2.0 data bank. However, I will explain briefly the primary source for each variable used in the research reported in this paper.

Employment series for the eleven major industries[21] are obtained from the Labour Force Survey Division, Statistics Canada. Since the LF Survey does not give the employment breakdown either for manufacturing or for mining, we had to construct the employment series for 22 manufacturing and 4 mining industries. For this purpose, we made use of the employment data from the Establishment Survey, obtained from the Labour Division, Statistics Canada.

The employment data from these two sources is not compatible primarily due to differences in coverage. Generally, the Establishment Survey covers companies having 20 or more employees. This drawback limits the usage of this data. The coverage varies from industry to industry. For example, in 1972, the coverage for service industry is only 20%. For the same year, the coverage for the manufacturing industries is about 95%. Generally the coverage for both the mining and the manufacturing industries is fairly good--between 90 to 95%.

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21 The eleven industries are: agriculture, fishing and trapping construction, communications and transportation, finance insurance and real estate, forestry, manufacturing, trade, services, utilities and public adminstration.

Making use of the data from these two surveys, we constructed employment series for all mining and manufacturing industries. Let N_{ML} be the total employment for the manufacturing industry, obtained from the LF Survey

N_{MiE} is the employment of the i-th manufacturing industry given by the Establishment Survey, and N_{ME} is the total employment of the total manufacturing industry from the ES Survey $\sum_{i=1}^{22} N_{MiE}$

then, the employment data for the i-th manufacturing industry is constructed as:

$$(A.1) \qquad N_{MiL} = N_{Mi}E^{*}(N_{ML}/N_{ME})$$

$$i = 1, 2, \ldots 22$$

Equation (A.1) implicitly assumes that the coverage for each of the components is the same as the coverage of total manufacturing industry. This assumption is somewhat restrictive. However, in the absence of any information on individual industry coverage, this assumption may not be unreasonable. Moreover, without much effort the components add up to the LF total. A similar procedure is used for the construction of employment data for the components of the mining industry.

For the eleven major industries, the data on average weekly hours worked is obtained from Mr. A. B. McCormick of the Productivity Section, Statistics Canada. To construct the average weekly hours series for each of the manufacturing and the mining industries, the ES Survey data on average weekly hours of production workers, and production and nonproduction worker employment is used. For each component industry the following

four steps are involved in the construction of the average weekly hours series:

Step 1

Construction of the ES average weekly hours series for each industry. For this purpose we have used the ES data on the production and nonproduction workers and the average weekly hours of production workers. Let H_{PMiE} be the average weekly hours worked by the production workers of the i-th manufacturing industry. N_{PMiE} is the number of production workers in the i-th manufacturing industry, and H_{MiE} is the average weekly hours worked in the i-th manufacturing industry. Then H_{MiE} is calculated as:

$$(A.2) \qquad H_{MiE} = H_{PMiE} * (N_{PMiE} / N_{ME}) + 40.0 * [1 - (N_{PMiE} / N_{ME})]$$

$$i = 1, 2, \ldots 22$$

Equation (A.2) assumes that the nonproduction workers work 40 hours a week and it is invariant over time.

Step 2

Making use of the employment, average weekly hours data computed in (A.2), we construct a pseudo man-hour series for each component.

$$(A.3) \qquad \hat{M}_{Mi} = H_{MiE} * N_{MiL} * 52.0$$

$$i = 1, 2, \ldots 22$$

where M_{Mi} is the pseudo man-hours for the i-th manufacturing industry.

Step 3

Using employment data from the LF Survey and average hours data given by the productivity division, first we have constructed the man-hour series for the eleven major industries.

$$(A.4) \qquad M_M = N_{ML} * H_{MP} * 52.0$$

where N_{ML} is total manufacturing employment--LF Survey, H_{MP} is the average weekly hours of the manufacturing industry and M_M is the total man-hours of the manufacturing industry. The corresponding pseudo man-hours is given by

$$(A.5) \qquad \hat{M}_M = \sum_{i=1}^{22} \hat{M}_{Mi}$$

Next, we construct the man-hours series for each individual manufacturing industry as:

$$(A.6) \qquad M_{Mi} = M_{Mi} * (M_M / \hat{M}_M)$$

$$i = 1, 2, \ldots 22$$

Step 4

Using the man-hours series from (A.6) and the employment series from (A.1), the average weekly hours are computed.

$$(A.7) \qquad H_{Mi} = M_{Mi} / (N_{Mi} * 52.0)$$

$$i = 1, 2, \ldots 22$$

Similarly the average weekly hours data is constructed for all four mining industries.

For all the industries, both the current and constant

dollar value added data are obtained from the Industry Product Division, Statistics Canada.

For the eleven major industries, wage bill data is drawn from CANSIM data bank. Using the ES Survey data on average weekly earnings, we have constructed the wage bill series for each of the manufacturing and the mining industries.

$$(A.8) \qquad WB_{Mi} = W_{MiE} * N_{Mi} * 52.0$$

where W_{MiE} is the average weekly earnings of the i-th manufacturing industry from the ES Survey, and WB_{Mi} is the wage bill of the i-th manufacturing industry. Similarly the wage bill data for the individual mining industries is computed.

Making use of bench mark capital stock data time series on investment and an industry specific depreciation into capital stock series are constructed. All the raw data are obtained from the Construction Division, Statistics Canada.

APPENDIX B

A) DECOMPOSITION OF AN INDUSTRY'S LABOUR PRODUCTIVITY GROWTH

The i-th industry's productivity equation estimated is of the following form:

$$(B.1) \qquad y_{it} = a_i k_{it}^{\beta_i} e^{(\lambda_i t + \gamma_i DURATE_t)}$$

where y_i = value added per man-hour for the i-th industry (Y_i/M_i), li 1971\$, k_i = capital-labour ratio for the i-th industry (K_i/M_i), in 1971\$, t = time trend and $DURATE_t$ = unemployment rate.

For the productivity equation in (B.1), we can write the rate of growth productivity relation as the following:

$$a_{it} = \lambda_i + \beta_i (\dot{k}_i/k_i)_t + \gamma_i \dot{DURATE}_t$$

where a_i = rate of growth of labour productivity of the i-th industry $(\dot{y}_i/y_i)$, $\dot{k}_i$ = time derivative of k_i and $\dot{DURATE}_t$ = time derivative of unemployment rate.

For any time interval, the rate of growth of labour productivity (a_i) of an industry can be decomposed as follows:

(B.2) (Actual Productivity Growth) =

Hicks-Neutral technical progress

+ capital contribution

+ cyclical productivity

The results of the decomposition productivity growth

where a_t = rate of growth of aggregate labour productivity, a_{it} = rate of growth of i-th industry's labour productivity, (y_{ik}/y_t) = i-th industry's productivity relative to aggregate productivity in t-th period, and s_i = time derivative of i-th industry's man-hour share.

Equation (B.6) can be broken down into five terms

(B.7)

Predicted fixed weight rate term

$$a_t = \sum_{i=1}^{n} \hat{a}_{it} (Y_i/Y)_{1965}$$

Change in predicted term fixed weight

$$+ \sum_{i=1}^{n} a_{it}[(Y_i/Y)_t - (Y_i/Y)_{1965}]$$

Fixed weight level term

$$+ \sum_{i=1}^{n} s_i \left[\left(\frac{y_i}{y}\right)_{1965} - 1\right]$$

Actual weight level term

$$+ \sum_{i=1}^{n} s_i \left[\left(\frac{y_i}{y}\right) - \left(\frac{y_i}{y}\right)_{1965}\right]$$

+ unexplained term

where a_i is the cycle corrected productivity growth of the i-th industry, as calculated in (B.2). The first four terms constitute the decomposition given in Table 9.

are shown in Table 6. The sum of the first two terms on the right-hand side is referred to as the cycle corrected productivity.

B) DECOMPOSITION OF AGGREGATE PRODUCTIVITY GROWTH

The decomposition of aggregate productivity is discussed in the text, pages 50-63. Let Y_i and M_i be the value added and man-hours of the i-th industry, then the aggregate labour productivity y_i can be written as follows:

$$(B.3) \qquad y_t = Y_t/M_t = \sum_{i=1}^{n} (Y_{it}/M_{it}) \frac{(M_{it})}{M_t} = \sum_{i=1}^{n} y_{it} m_{it}$$

where y_t = aggregate labour productivity and m_{it} = i-th industry's share of total man-hours.

The total differential of (B.3) is:

$$(B.4) \qquad \dot{y}_t = \sum_{i=1}^{n} \dot{y}_{it} m_{it} + \sum_{i=1}^{n} \dot{m}_{it} y_{it}$$

where $\dot{y}_t, \dot{y}_{it}$, and $\dot{m}_{it}$ are the time derivatives of y_t, y_{it}, and m_{it} respectively.

Dividing through (B.4) by y_t gives:

$$(B.5) \qquad \dot{y}_t/y_t = \sum_{i=1}^{n} (\dot{y}_{it}/y_{it}) \frac{y_{it} m_{it}}{y_t} + \sum_{i=1}^{n} (\dot{m}_{it}) \frac{(y_{it})}{y_t}$$

Equation (B.5) can be rewritten as :

$$(B.6) \qquad a_t = \sum_{i=1}^{n} a_{it} (y_{it}/y_t) m_{it} + \sum_{i=1}^{n} s_i \frac{(y_{it})}{y_t}$$

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