Employment and the Productivity Slowdown 1958 to 1980

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EMPLOYMENT AND THE PRODUCTIVITY SLOWDOWN

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I. Introduction

The productivity slowdown, which has gripped the western industrial economies during the 1970s and early 1980s, remains a mystery. The subject has been discussed widely in the popular press and in scholarly journals of every persuasion.[1] There has been no shortage of reasons given for the slowdown nor solutions for resuming productivity's historical growth path. Yet a widespread consensus explaining the slowdown has yet to emerge and none of the solutions tried has proved effective. This paper offers neither a full explanation for the slowdown nor remedies to correct it. Rather the paper is concerned with the role of one important factor, employment: to what extent has employment growth or the lack of it been associated with the slowdown. During the course of the discussion in the paper evidence will also be presented on the behaviour of capital and other inputs as they affect the growth rate of productivity.

In the following section, II, the relevant productivity literature is reviewed and in Section III a statistical analysis is undertaken of the employment-productivity relationship, using both correlation and regression methods. Section IV concludes the paper.

II. Review of Literature

No fixed date has been set for the commencement of the productivity decline although most writers appear to believe that it began in the late 1960s or early 1970s depending on country and the particular data used. Nor

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is there agreement on the extent of the decline, that too depending on country and the data, and also the base date chosen to mark the beginning of the decline.

We can arbitrarily select 1973 as a base date. It is the year of the international oil crisis and the year many writers prefer to mark the turnaround in productivity growth. In Canada, according to Statistics Canada, output per person hour (labour productivity) in the commercial sector slowed from an annual growth rate of 4.2% between 1946 and 1973 to 0.9% since 1973, a fall-off of almost 80 per cent. The table below shows the extent of the drop off in different sectors of the Canadian economy using different measures of labour productivity and different time periods.

Table 1

Rates of Growth of Productivity, 1946-82, by Sub-Period, Sector and Labour Measure

	Commercial		Commercial Goods Producing		Commercial Services	
	Per Person-Hour	Per Employed Person	Per Person-Hour	Per Employed Person	Per Person-Hour	Per Employed Person
1946-73	4.2	3.4	5.6	4.9	2.3	1.5
1973-82	0.9	0.2	1.3	0.7	0.7	0.1
1946-66	4.3	3.5	5.8	5.1	3.2	2.3
1966-82	2.3	1.5	2.9	2.3	0.7	0.9

Source: Statistics Canada, Aggregate Productivity Measures, 1982, Catalogue 14-201 Annual, Ottawa, 1983.

Table 2 shows the widespread international pattern of the slowdown. It has been occurring in virtually all of the western industrial countries, even in Japan which enjoys the highest rate of productivity growth among the advanced industrial nations. Japan's productivity growth in manufacturing fell from 10.7% between 1960 and 1973 to 7.2% between 1973 and 1982, a drop of almost one-third (compared to a fall off of almost two-thirds in Canadian manufacturing during the same period).

Why productivity has slowed down is still being hotly debated and until answers are found appropriate measures cannot be designed to restore its growth. In this debate it has not escaped the attention of the media and influential scholars that the slowdown has occurred at almost precisely the same time as employment has accelerated.

Returning to our statistics, while productivity in Canada was advancing rapidly in the 50s and 60s, employment was growing only 1 or 2 per cent per year. In the 1970s employment growth accelerated to about 3% per year. When employment grows slowly, productivity grows rapidly. When employment accelerates productivity decelerates. Thus, it may appear that if we want more productivity we need only slow or halt the growth of employment.

Table 2

Annual Percent Change in Manufacturing Productivity, 12 Countries 1960-82

(output per hour)

	YEAR 1960-82	1960-73	1973-82
United States	2.6	3.0	1.7
Canada	3.6	4.5	1.6
Japan	9.2	10.7	7.2
France	5.8	6.7	4.5
Germany	5.1	5.7	3.6
Italy	5.7	6.9	3.7
United Kingdom	3.6	4.4	1.8
Belgium	7.2	7.0	6.0
Denmark	5.9	6.4	4.1
Netherlands	7.0	7.6	4.8
Norway	3.7	4.5	2.0
Sweden	4.8	6.6	2.2
Eleven Foreign Countries	5.6	6.6	3.8

Source: U.S. Bureau of Labor Statistics, Monthly Labor Review, January, 1984, Page 83.

How much truth is there to this dictum? It is difficult to say. The issue is much more complicated than stated.

For example, much of the employment growth in the 1970s occurred in the service and trade sectors where output measures are suspect or inadequate. To the extent that productivity can be measured in that sector it grew by 2.7% per year in the 1960s and 1.9% in the 1970s.[2]

Productivity also fell off sharply in manufacturing (a drop off of almost two-thirds from the 1960s to the 1970s) where output measures are considered satisfactory. Employment growth, however, declined from 2.2 per cent per year in the 1960s to 1.1 per cent in the 1970s.[3]

If employment growth is a culprit in the productivity decline one would not have expected the sharp drop in productivity in manufacturing.

Further, use of labour productivity (LP) to measure productivity contains an inherent bias against employment. Since productivity is a measure of efficiency, it is doubtful that LP can really be called a measure of productivity since changes in labour productivity can reflect either changes in efficiency or simple substitution between labour and other inputs with no change in efficiency. Thus, substitution of capital for labour without changing output will raise labour productivity (output per labour input) but not efficiency since the same total quantity of inputs is used to produce the same output. Since this is one way to raise labour productivity we could easily fall into the trap of promoting the increasing use of other factor inputs in place of labour reducing not only employment but also overall efficiency through overuse of these factors.

Recent studies of productivity have turned to the development and use of total factor productivity (TFP). TFP is output per unit of input. Thus, a change in TFP reflects a change in efficiency. But there are problems with TFP measures that have restricted its development. For example, no acceptable method of measuring capital, an important input, is available nor is it possible to measure all inputs in the production process.[4] This situation has posed difficulties in the development and publication of official TFP measures by government statistical agencies. Thus much of the work on TFP measures comes from private researchers or government non-statistical agencies.[5] Nevertheless, pressures are building up on statistical agencies to review their position on this matter and it is likely that the development of standard series on TFP paralleling those on LP is not far off.[6]

In the meantime, the decline in the rate of growth of labour productivity coincidental with the employment problems of the 1970s has given rise to research and debate both in North America and Europe on the relative contributions of the different factor inputs in productivity. In the debate in Europe and international organizations, in particular, the question is being raised about the efficiency of investment aids as opposed to employment incentives as a means of creating more employment. One international report noted that "there have not been many studies of alternative mixes of factors of production to get the best result for society as a whole ... because labour productivity has been unquestioned as the measure of efficiency". "For what matters in measuring the efficient use of resources is not just the productivity of labour but the productivity of all the factors of production combined-labour, capital, land, energy, raw materials and knowledge. Therefore, a fresh assessment of the mixture of factors of production is required, and that fresh assessment must break with traditional attitudes"[7] (underlining mine). On this side of the Atlantic, the research emphasis has been on the development of TFP measures. Progress has been slow, but the problems involved have stirred controversy.

These problems reflect different views of the importance of capital and labour, the two primary inputs, in productivity. To explain the relative contributions of these two factors, writers express them in the form of a ratio, a measure of capital divided by some measure of labour. The ratio itself is affected by the particular measure that is used to represent the two factors. Capital can be expressed in gross or net terms, or can include or exclude components. The more components included in capital the heavier its weight and the greater the impact on productivity of a given change in capital.[8] Similarly labour can be expressed in terms of number of workers, hours paid for or hours worked, with each measure having a different impact on the behaviour of the labour factor and its contribution to productivity.

For these reasons the capital/labour (K/L) ratio has had a chequered history in North American productivity studies. Some writers claim that the ratio has declined in the 1970s and this explains the decline in LP, while others claim the ratio has risen.[9] Writers are also undecided about the actual importance of the ratio with some writers stating that the impact is insignificant while others believe it to be significant.[10]

For example, in Canada the Department of Finance estimates that changes in the K/L ratio contributed to about 25 per cent of the decline in labour productivity; the Economic Council, on the other hand, puts the contribution at about 7 per cent, and the Bank of Canada contends "that this factor did not contribute substantially to the decline in productivity growth".[11] Each gives capital a different weight in its statistical analysis.

Recent refinements in productivity methodology further confuse the picture. One refinement, which results in reducing the relative weights of capital and labour in the productivity equation, is the formal recognition of other inputs. Traditionally the productivity equation is specified to comprise labour and capital.

Recent work, by Jorgensen in the U.S. and the Economic Council in Canada has demonstrated that materials and energy have a "life of their own" in productivity determination. For example, savings in materials and energy or the possibility of substitution between these inputs and labour and capital can affect productivity. To ignore these inputs is to miss this source of productivity change. Their inclusion changes the weights of the input factors and therefore, their effects on productivity. In most industries, the materials input comprises one-half to two-thirds of output. Productivity studies that include other inputs are fairly new and still few and far between. In Canada, the incorporation of materials and energy in the productivity models of the Economic Council and of Berndt and Watkins may have been another reason why they found K/L ratios to have been relatively unimportant in labour productivity determination.[12]

Another recent innovation allows for interactions among the inputs, that is substitutability. Thus, studies using older methods find energy to be unimportant because its weight in the production process is so small. Recent studies, for example Jorgensen in the U.S., find that energy prices and energy shortages are changing the whole production function.[13] Therefore, what may appear to be a capital/labour ratio problem is in reality an energy problem that is causing premature obsolescence of capital and greater use of labour. Berndt and Watkins tested this Jorgensen hypothesis for Canada but found no effect from energy, perhaps because we did not experience the same energy trauma as did the U.S.[14]

The confusion mounts when the focus of productivity is shifted from labour productivity to total factor productivity. Capital/labour ratios, for example, are found to have different impacts depending on the productivity measure used. Kendrick in the U.S. finds the K/L ratio important in LP determination but unimportant in TFP determination.[15] Berndt and Watkins in Canada find that the behaviour of K/L ratios are not related to the slowdown in LP but they are negatively related to TFP, that is, rising K/L ratios actually caused productivity to decline, suggesting that the use of more capital relative to labour has reduced efficiency.[16]

In summary, labour productivity is not a proper measure of productivity since it is not a measure of efficiency. Further its use has often been a source of misunderstanding of the role of labour and employment growth in productivity determination. Since labour constitutes the denominator of labour productivity measurements, an increase in employment or the labour factor, ceteris paribus, is bound to result in a fall in labour productivity. Similarily substituting capital for labour is bound to raise labour productivity whether or not output has increased.

These limitations of labour productivity are being overcome by the development of total factor productivity measures, which include other inputs besides labour in the productivity calculation. At the same time, closer consideration is being given to the role of the different inputs in productivity determination. Although a consensus is yet to appear, evidence is emerging that capital is not necessarily or automatically a source of productivity improvement any more than labour or employment growth is a productivity inhibitor.

III. A Statistical Analysis

(1) Introduction

The recent development of total factor productivity data by the Economic Council of Canada provides an opportunity for a fresh analysis of productivity determination in this country. The data base includes productivity estimates (both labour productivity and total factor productivity) as well as information on output, capital, labour, materials and energy for some 30 manufacturing and non-manufacturing industries for the period 1958 to 1980. The Council data base was developed directly from various statistical series collected and produced by Statistics Canada. The information made available for this study is in the form of growth rates of these variables.[17] Both correlation and regression analyses are used in this study to test the relations between the various input factors especially labour and capital and producutivity.

The data base is not without its problems. For example, the capital input is not a measure of capital services or the amount of capital expended to produce output in a particular period. Rather, as in much of the literature, it is net capital stock and the assumption is made that changes in this stock measure changes in capital services.[18] Nor does the measure distinguish among different types or qualities of capital. Each unit of capital is treated like any other unit of capital.

Also, the labour input is measured by person-hours paid. For a significant proportion of the employees covered by the study it is an estimate since hours information is not directly available. Further, hours paid is not as good a measure of the labour input as hours worked. Finally, the hours paid figure applies equally to all workers. No distinctions are made to reflect the characteristics and contributions of different categories of workers.

Despite these and related problems, the methodology used in the Council study and the extensiveness of the information give this data base certain advantages not found in other productivity studies. For example, it provides consistent estimates of both LP and TFP;[19] it offers the opportunity to examine the employment-productivity relationship in the context of the behaviour and role of several other important input factors; and the development of productivity estimates by industry allows for a greater degree of uniformity and homogeneity than could be achieved in national estimates. Moreover, working with a disaggregated data base assists in the identification of unusual situations which distort national aggregates, as well as identify the sources of changes in these aggregates.

(2) Correlation Analysis

(a) Productivity and K/L Ratios

Table 3 provides information on correlations of productivity (both LP and TFP measures) and the various input factors for the four time periods, 1958-66, 1967-73, 1974-80 and 1958-80.[20] The first two periods (1958-66 and 1967-73) are characterized by high output and productivity growth and the third (1974-80) by a significant slowdown in these variables (see Table A-1). For example, the annual rate of growth of output (Q) for the 30 industries averaged 5.0 per cent in the first sub-period, 5.3 per cent in the second sub-period and 3.4 per cent in the third sub-period. Labour productivity and total factor productivity growth averaged 3.4 and 2.2 per cent respectively in the first two sub-periods. In the third sub-period, LP growth fell to 1.1 per cent per year and TFP growth to -0.3 per cent per year (see Table A-1).

The correlations in Table 3 show little relationship between productivity (whether LP or TFP) and K/L ratios. For LP and K/L ratios, the coefficients are significant (at the 10% level of significance) and positive for the 1958-66 sub-period and for the period as a whole (1958-80) but insignificant for the last two sub periods (1967-73 and 1974-80). In the case of TFP and K/L ratios, the coefficients are negative for all four time periods, and significantly negative for the sub-period 1967-73.

Table 4, which divides the 30 industries into manufacturing and non-manufacturing and provides a count of the positive and negative, significant and insignificant correlation coefficients for these two major sectors and the two combined, confirms these general findings. Only four (of a possible 12) correlations between growth rates of LP and K/L ratios are positive and significant. Six of the remaining eight are positive but insignificant and two are negative with one of these significant.

Table 3

Correlation Coefficients, 30 Industries
by Variables Correlated and Time Period*

	1958-80	1958-66	1967-73	1974-80
TFP and LP	.5870[1]	.6588[1]	.7269[1]	.7401[1]
	(.001)	(.001)	(.001)	(.001)
TFP and K/L	-.2183	-.0269	-.4092[2]	-.2067
	(.123)	(.444)	(.012)	(.137)
TFP and K	-.3326[2]	-.3567[2]	-.1593	-.5129[1]
	(.036)	(.027)	(.200)	(.002)
TFP and L	-.2001	-.3935[2]	.2234	-.4438[1]
	(.145)	(.016)	(.118)	(.007)
TFP and Q	.3460[2]	.2187	.6398[1]	.3081[2]
	(.031)	(.123)	(.001)	(.049)
TFP and M	.3695[2]	.2263	.5666[1]	.1569
	(.022)	(.115)	(.001)	(.204)
TFP and M/L	.5388[1]	.6467[1]	.5593[1]	.6328[1]
	(.001)	(.001)	(.001)	(.001)
TFP and M/K	.6907[1]	.5165[1]	.7369[1]	.5691
	(.001)	(.002)	(.001)	(.001)
LP and K/L	.2945[3]	.4469[1]	-.0368	.0922
	(.057)	(.007)	(.423)	(.314)
LP and K	-.0625	-.1007	.1259	-.3676[2]
	(.371)	(.298)	(.254)	(.023)
LP and L	-.4139[2]	-.5870[1]	.1803	-.5975[1]
	(.011)	(.001)	(.170)	(.001)
LP and Q	-.5211[1]	.3439[2]	.8032[1]	.4188[2]
	(.002)	(.031)	(.001)	(.011)
LP and M	.6111[1]	.3636[2]	.8046[1]	.3354[2]
	(.001)	(.024)	(.001)	(.035)
LP and M/L	.9613[1]	.9895[1]	.8746[1]	.9731[1]
	(.001)	(.001)	(.001)	(.001)
LP and M/K	.6311[1]	.3859[2]	.8281[1]	.5466[1]
	(.001)	(.018)	(.001)	(.001)

Figures in brackets indicate value of p

1 significant at level of one per cent, that is, $p \leq .001$
2 significant at level of five per cent, that is, $p \leq .05$
3 significant at level of ten per cent, that is, $p \leq .10$
* See Table A-2 for legend

Source: Table A-1

In the case of growth rates of TFP and K/L ratios, some 10 of them are negative with two of these significant. There are no positive significant coefficients.

Table 4

Number of Positive and Negative Correlations,
Three Industrial Categories,[1] and Four Time Periods, 1958-80
By Variables Correlated*

	Number of Positive Correlations		Number of Negative Correlations	
	Not Significant	Significant[2]	Not Significant	Significant[2]
LP and KL	6	4	1	1
TFP and KL	2	-	8	2
LP and K	5	-	5	2
TFP and K	1	-	5	6
LP and L	2	1	2	7
TFP and L	4	1	3	4
LP and Q	2	10	-	-
TFP and Q	3	9	-	-
LP and M	3	9	-	-
TFP and M	6	6	-	-
LP and ML	-	12	-	-
TFP and ML	1	11	-	-
LP and MK	-	12	-	-
TFP and MK	-	12	-	-

1 Manufacturing, non-manufacturing and the two combined
2 P = 0.10 or less
* See Table A-2 for legend

Source: Table A-1

Positive correlations between LP and K/L ratios would be expected because of the arithmetic relationship between the two. The fact that there are so few that are significant and the absence of positive significant coefficients between TFP and K/L ratios suggest the very minor positive relationship between this ratio and productivity. Contrary to the traditional view that a rising (falling) K/L ratio should be associated with rising (falling) productivity, there is a hint that the very opposite is occurring: productivity and K/L ratios are moving in opposite directions. Further, the relationship between the two appears to be deteriorating over time.

That is, the correlation coefficients since 1966 have smaller positive or larger negative values compared to the 1958-66 sub-period.

A failure of productivity and K/L ratios growth rates to be positively correlated may signify that substituting capital for labour or using more capital relative to labour is not the route to higher productivity. It is possible however that a potential positive relationship is being obscured by other intervening factors. For example, the presence of the input factor, materials, may swamp the K/L-productivity association because of its heavy weight. On average, some two-thirds of manufacturing output comprise the materials input. Thus changes in the growth rates of that input would have a significant effect on the rate of growth of output and hence productivity. Correlations coefficients between growth rates of materials and growth rates of output are in the 0.9 range.

In order to determine whether materials is overwhelming or hiding positive associations between K/L ratios and productivity, partial correlations were computed holding constant the effects of the materials input. The association is not improved by removing the influence of materials. Indeed it is weaker. As can be seen from Table 5, the number of negative significant correlations between the rate of growth of K/L ratios and the rate of growth of TFP is increased. Some 11 of the 12 correlation coefficients are negative with five of them significant. The number of positive and significant correlations between LP and K/L is reduced from four to two.

(b) Productivity and Capital

The failure of K/L ratios to be positively associated with productivity raises the question of the role of capital (K) in productivity behaviour in this country. The conventional wisdom is that capital, the traditional carrier of new technology, is vital to productivity improvement. In the cross-industry method used in this study K/L ratios may hide the positive effects of capital.

Table 5

Number of Positive and Negative Partial Correlations, Three Industrial Categories[1] and Four Periods, 1958-80, By Variables Correlated, Holding Constant*

	Number of Positive Correlations		Number of Negative Correlations	
	Not Significant	Significant[2]	Not Significant	Significant[2]
LP and KL	9	2	1	-
TFP and KL	1	-	5	6
LP and K	-	-	3	9
TFP and K	-	-	1	11
LP and L	-	-	-	12
TFP and L	-	-	5	7

1 Manufacturing, Non-Manufacturing and the Two Combined
2 P = .10 or less
* See Table A-2 for legend

<u>Source:</u> <u>Table A-3</u>

For example, a situation can be envisaged in which large infusions of capital occur at the same time as large additions of labour. Should productivity also be growing rapidly (perhaps because of the rapid growth of capital) a correlation between K/L ratios and productivity would produce a low or insignificant coefficient.

To meet this problem a parallel correlation analysis was undertaken of the capital-productivity association.

The results are reported in Tables 3, 4, and 5. It can be seen that separating K from the K/L ratio rather than improving the correlation with productivity actually weakens it. Both the number of negative and significantly negative correlations is increased. Further, holding the effects of M constant increases the number of significant negative correlations between K and TFP to 11 of the 12 correlations. The negative association occurs in all three sub-periods but tends to be stronger in the last two sub-periods encompassing the period of the productivity slowdown, compared to the first sub-period (1958-66). What these results suggest is that industries with rapidly growing capital usually suffer a slow growth in productivity. Examples of the experience in individual industries are indicative of this relationship. Finance, insurance and real estate and mining enjoyed the fastest and third fastest growth in capital stock of the 30 industries, but ranked last in productivity (TFP) growth (Table A-1). Motor vehicle parts and accessories and chemical products also ranked high in capital growth (nine per cent and 6-1/2 per cent per year respectively compared to an average of 5 per cent) but low in TFP growth (less than one per cent per year compared to the average of 1 1/2 per cent per year for all 30 industries).

At the other end, industries experiencing the slowest growth in capital, textiles, and knitting and clothing experienced TFP growth in the top 10 of the 30 industries.

One reason for the negative association between capital and productivity may be found in the weakness of the concept of capital used in this study. This matter has already been discussed and it can only be added here that there is no reason to suspect a particular bias one way or the other. The same concept has been used elsewhere with different results. A more plausible and popular explanation provided in the recent literature is that a growing proportion of capital is being directed to non-productive uses. For example, requirements to meet pollution, occupational health and safety and similar regulations are forcing the diversion of resources which would otherwise have gone into productive uses. Another explanation is the need to replace capital made prematurely obsolete by the energy situation. This would accelerate capital spending with no appreciable increase in output.

These explanations, particularly the last two, emanate from the U.S. where there is more solid evidence to support them. Canadian studies have downplayed them in this country.[21] In any event, they are explanations appropriate for the 1970s and were given for that purpose.[22] They do not explain the failure of capital and productivity growth rates to be positively associated in the earlier sub-periods.

This is not to suggest that capital is not important or that technolgy is never embodied in capital.[23] There is no question that capital does play a role in this respect. We need only witness the recent computer revolution and indeed past technological revolutions. What it does suggest however, is that capital is susceptible, like any other factor input, to over-utilization or inefficient application.[24] Inducing additions to the capital stock for the sake of adding to that stock because of the popular belief that this is the principal way to improve productivity may instead be hurting productivity and causing lower levels of employment than would otherwise be the case.

(c) Productivity and Labour

The correlation between growth rates of the labour factor and growth rates of productivity (TFP) was also generally negative. Some seven of the 12 correlation coefficients are negative with four significantly negative (see Table 3).

Holding the effects of the materials input constant increases the number of significant negative correlations from 4 to 7. The presence of the materials input factor operated to obscure the extent of the negative association between labour and productivity (TFP). Removing the effects of that factor results in a rather significant increase in the negative association.

The general negative association might be, in part, a result of the greater adjustments to the labour factor compared to the other factor inputs. In virtually all of the industries, manufacturing and non-manufacturing alike, the rate of growth of person-hours was below that of the other three inputs and of output. This was the case for the period as a whole and for each of the three sub-periods.

Labour was also the only input factor to experience negative rates of growth throughout the 1958-80 period. Negative rates of growth occurred in tobacco products, leather, agriculture and forestry. That is, these industries used fewer person-hours in 1980 than in 1958 to produce their output.

In part, the negative association may also reflect a too rapid growth or insufficient decline in the labour factor (that is, the adjustments were not sufficient). However, regardless of the reasons for the negative association, which is an expected result based on findings from the productivity literature, two observations are worth noting: 1) the negative association between labour and productivity growth rates is no worse than that between capital and productivity growth rates. Indeed, the relationship between capital and productivity is worse. The negative associations between capital and productivity as measured by TFP are stronger (Table 3) and there are more negative and significantly negative correlation coefficients between capital and productivity than between labour and productivity (Tables 4 and 5). This may imply that the adjustment to the labour factor by substituting capital for labour went too far, causing inefficiencies. Further, compared to labour, there is a greater tendency for a negative capital-productivity association to be concentrated in the last two sub-periods. The negative labour-productivity association occurs in the first and third sub-periods. The association between labour and productivity tends to be positive in the 1967-73 sub-period.

2) the negative associations with labour based on LP as the measure of productivity are much higher than those using TFP as the measure of productivity. For example, for the period as a whole (1958-80), the correlation coefficient between labour and labour productivity is -.4139, which is significant at the five per cent level, but only -.2001 between total factor productivity and labour, which is not significant (see Table 3).

On the other hand, the negative associations between capital and productivity increase when we move from the LP to the TFP measure of productivity. In other words, the association of the capital input with productivity is more favourable (that is, positive) using the LP measure compared to the TFP measure as would be expected, while the labour input shows up more favourably using the TFP measure.

(d) Productivity and the Materials Input

The correlation analysis reveals a strong positive association between materials and productivity. The association is stronger when materials is substituted for labour or capital. All of the correlation coefficients between the growth rates of materials and productivity (both TFP and LP) are positive, although only one-half involving TFP are significant. However, virtually all of the coefficients involving correlations between growth rates of productivity and the growth rates of materials-labour and materials-capital ratios are positive and significant. The growth rates of productivity appear to go hand-in-hand with the growth rates of materials. Utilizing materials so saves on capital and labour that it raises productivity.

It is not clear from the evidence why materials and productivity improvement are so strongly related. The improvement may reflect scale economies or new technologies being introduced into the Canadian production system through the materials input (as opposed to capital).25

The scale effect argument would find its support in the high correlation between output and materials growth rates, the smaller correlations between output growth rates and the growth rates of the other inputs and an accompanying strong correlation between output and productivity (TFP) growth rates. This pattern of association would suggest that more output could be achieved by relatively less capital and labour. The savings in these two inputs more than offsets the increase in materials so that productivity advances.

The technology argument would find some support in a relatively low correlation between TFP and output and a very high correlation between the M/L and M/K ratios and productivity. The savings generated in the use of the inputs as a consequence of the utilization of the materials input regardless of the behaviour of output may be what is driving up the growth rate of productivity.

The evidence is too general and speculative to be supportive of one effect or the other (for example, the association between output and productivity is not uniformily strong). Further investigation is required particularly of these relationships in each specific industry. But whichever effect is dominant, it is clear that productivity improvement in Canada, since 1958 is strongly associated with the materials input. This may suggest that encouraging the use of this input (or not discouraging its use) in the production process has greater payoffs for productivity gains than direct encouragement of either capital or labour.

(3) Regression Analysis

Correlation analysis measures degrees of association and is a useful technique for the cross-industry approach utilized in this study. We turn to regression analysis for cause and effect relationships and for the determination of the approximate magnitude of the effects of the factor inputs on productivity. These estimates are reproduced in Table 6. They represent the expected impact on TFP of assumed changes in the growth rates of the inputs.

The estimates were generated from a series of regression equations with the TFP growth rate as the dependent variable and the growth rates of the inputs as the independent variables.

Four basic functions were computed for each of the three industrial categories, manufacturing, non-manufacturing and the two combined in each of the four time periods. These functions are as follows:

TFP as a function of K,L,M, and E*

TFP as a function of K/L, M and E*

TFP as a function of K, M/L and E*

TFP as a function of L, M/K and E*

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*Manufacturing only. (See Table A-2 for legend).

The equations represent the various combinations of the input variables studied in the correlation analysis. Other possible combinations of these variables could have been used but the results produced would have been difficult to interpret. For example, in an equation based on TFP as a function of K, L, M/L and E, "L" appears twice, once by itself and once in the M/L ratio, which in growth rate terminology is M minus L. Thus, the coefficient for the M/L ratio would not be a true reading of that ratio since the effects of L have been removed.

Table 6

Estimated Change in The Growth Rate of TFP As A Result of 10 Per Cent Increase In The Growth Rates of K/L, K, L, M, E, M/L, And M/K by Time Period and Industrial Sector, 1958-80*

(Percentage Change in Growth Rate of TFP)**

	K/L	K	L	M	E***	M/L	M/K
1958-80							
All Industry	-2	-3	N/S	4	-	3	3
Manufacturing	N/S	-1	N/S	2	N/S	2	2
Non-Manufact-uring	N/S	-7	N/S	6	-	N/S	6
1958-66							
All Industry	N/S	-2	-3	4	-	3	2
Manufacturing	N/S	-1	N/S	2	N/S	2	1
Non-Manufact-uring	N/S	N/S	N/S	N/S	-	N/S	4
1967-73							
All Industry	-2	-3	N/S	2	-	2	2
Manufacturing	-2	-2	N/S	1	-2	2	2
Non-Manufact-uring	N/S	-6	N/S	3	-	N/S	3
1974-80							
All Industry	N/S	-1	-3	3	-	3	2
Manufacturing	N/S	-1	-2	2	N/S	2	1
Non-Manufact-uring	N/S	N/S	N/S	N/S	-	N/S	N/S

* See Table A-2 for legend
** Rounded to nearest whole number
N/S = significant, that is p > .10
***Measured in manufacturing only

Source: Computer runs (available from author)

All of the equations were run with the growth rate of output included as one of the independent variables. But the presence of Q presented two problems. First, the very high correlation between Q and M suggests severe multicollinearity. Indeed with Q present, M became insignificant in the equations as did M/L and M/K, although not in all cases. That is, the effects of M, were sometimes being captured by Q; at other times it was capturing the effects of Q.

A second problem raised by the inclusion of Q is that it being the numerator and the principal component of TFP (the dependent variable) it could be argued that including it introduces a strong element of circular reasoning.[26] For these reasons Q was dropped from the equations. These considerations in developing the regression equations have an impact on their fit resulting in relatively low corrected R^2s (see Table 7). For this reason care must be exercised in interpreting the results.

Given this caution the estimates in Table 6 show the probable impact on the growth rate of TFP of a 10 per cent increase in the growth rate of the factor inputs. For all industry (manufacturing and non-manufacturing combined), each 10 per cent increase in the growth rate of the capital-labour ratio or capital can be expected to <u>reduce</u> the rate of growth of TFP by between 2 and 3 per cent for the 1958-80 period as a whole. A 10 per cent increase in the growth rate of labour, on the other hand, would be expected to have <u>no effect</u> on TFP, and a 10 per cent increase in the growth rate of materials, the materials-labour ratio or the materials-capital ratio would <u>raise</u> the growth rate of TFP by between 3 and 4 per cent.

By sub-period, the negative impact of K/L ratios is evident in the 1967-73 period only. However, the very low corrected R^2's make the evidence for the first and third sub-period suspect. In the case of capital, a 10 per cent increase in its growth rate can be expected to reduce the TFP growth rate in each of the sub-periods. But the impact is least in the 1974-80 sub-period. Labour, on the other hand has relatively large negative impacts in the first and third sub-periods and no impact of significance in the 1967-73 sub-period. In the first and third sub-periods a 10 per cent increase in the labour factor would be expected to reduce the rate of growth of TFP by some 3 per cent.

Materials, materials-labour ratio and materials-capital ratio have positive impacts in each sub-period with no discernible trend in the impact over the period and with the magnitude of the impacts roughly similar to that for the period as a whole.

Table 7

Corrected R^2 And Durbin Watson (DW) Values, Regression Equations For Three Industrial Categories and Four Time Periods, 1958-80

	1958-80		1958-66		1967-73		1974-80	
	$\bar{R}^2$	DW	$\bar{R}^2$	DW	$\bar{R}^2$	DW	$\bar{R}^2$	DW
ALL INDUSTRY								
TFP=f(K,L,M)	.447	2.50	.448	2.25	.507	2.36	.429	1.53
TFP=f(K/L,M)	.171	2.18	0	1.62	.429	2.19	.056	1.69
TFP=f(K,M/L)	.359	2.45	.455	2.28	.356	2.66	.449	1.52
TFP=f(L,M/K)	.442	2.32	.390	1.95	.509	2.56	.411	1.48
MANUFACTURING								
TFP=f(K,L,M,E)	.305	2.00	.392	1.78	.727	1.73	.490	1.40
TFP=f(K/L,M,E)	.168	2.04	.147	2.00	.712	1.39	.093	1.65
TFP=f(K,M/L,E)	.271	2.05	.365	1.64	.586	2.37	.518	1.41
TFP=f(L,M/K,E)	.340	1.95	.384	1.78	.715	1.99	.474	1.60
NON-MANUFACTURING								
TFP=f(K,L,M)	.703	2.43	.511	2.79	.292	1.89	0	1.29
TFP=f(K/L,M)	.202	1.58	0	1.79	.183	1.75	0	2.08
TFP=f(K,M/L)	.322	1.80	.525	2.19	.124	2.93	.104	0.92
TFP=f(L,M/K)	.752	2.45	.571	2.48	.262	2.72	.078	1.15

Source: Computer runs (available from author)

The regression analysis for manufacturing shows somewhat similar results in terms of direction but the magnitudes of the impacts are less than for all industry combined. Thus the negative impact of K/L ratios, capital and labour and the positive impact of materials and materials-labour and materials-capital ratios are all less than for all industry combined. The labour impact is not significant for the period as a whole and for each sub-period except the third, 1974-80. Capital, on the other hand, has a negative effect in each of the four time periods although less than that for all industry combined.

The results for non-manufacturing are erratic showing very large values in some periods and small or not significant values in others. However, the eight observations in the non-manufacturing sector is a very small number for purposes of providing reliable estimates from regression equations.

The energy input factor was measured in manufacturing only. The insignificant numbers for that factor reflect its very small weight in the production process. However, this does not measure its true impact since the rising cost of energy may have an effect on the use of other factor inputs. This particular impact of the energy factor was not measured in this study.

The regression analysis substantially supports the correlation analysis. The primary inputs, capital and labour individually or in the form of the capital-labour ratio have had minimal positive effects on productivity during the 1958-80 period. Most of the impact has been negative. Increases in the utilization or employment of these inputs would be expected to reduce productivity (or efficiency). The negative impact has been particularly clear in the last two sub-periods: 1967-73 and 1974-80 which encompass the period of the productivity slowdown. It appears that increasing the use of capital and labour during these periods has reduced the rate of productivity growth by an amount equal to 10 to 30 per cent of each unit increase in these input factors. Capital would be expected to produce a larger negative impact than labour, although in the third sub-period the evidence suggests a larger impact from the labour input.

The major source of productivity improvement is materials. A 10 per cent increase in its utilization raises the growth rate of productivity by some two to four per cent.

IV Summary and Conclusions

The great debate on the productivity slowdown has yielded little on its causes or solutions but considerable on concept and measurement improvement.

This paper has taken advantage of these improvements to test statistically relationships between productivity and the input factors that directly affect it. In particular, the purpose of the paper is to test the relation between productivity and the labour factor. Traditionally that factor, at least in a quantitative sense, has been viewed in a negative manner in terms of its relation to productivity. More of it reduces productivity, less of it raises productivity. Labour's positive contribution to productivity has historically been seen in the form of improvements in its quality (example more education).

The view of a negative relation between labour in a quantitative sense and productivity is generally supported by the statistical analysis undertaken in the paper. But the analysis also reveals a number of interesting aspects of the relationship that both temper this conclusion and the policy implications that may flow from it. The following summarizes the principal findings of the analysis.

1) Labour productivity (LP) is not a measure of productive efficiency despite its widespread use in this vein. Its use as a measure of productivity is misleading. This is particularly important when assessing the relationship between employment and productivity. The direct arithmetical relation between the two suggests a strong bias to a negative relation. If employment increases, ceteris paribus, LP can be expected to fall.

2) Total factor productivity (TFP) or the more appropriate term multifactor productivity, is a far superior measure of productive efficiency and, hence, productivity. Its growing use can be expected to yield important new insight into the sources of productivity improvement and fundamental changes in policy directions to raise productivity.[27]

3) Contrary to the conventional wisdom rising rates of growth of capital-labour ratios and of capital itself are not necessarily associated with

positive rates of growth of productivity. This finding is as applicable historically (at least back to 1958) as it is currently in the 1970s. And it is applicable in periods of rapidly growing output (1958-73) as in periods of slow-growing output (1974-80). The association between capital and productivity changed very little over the 1958-80 period. It was equally negative throughout the period. Substituting capital for labour or indiscriminately increasing capital (often at the expense of employment) could generate lower productivity.

4) The relation between labour and productivity displays much the same characteristics as that between capital and productivity. Negative associations are found throughout the period. But the evidence suggests that labour's negative impact on productivity is less than that of capital.

5) When TFP is substituted for LP as the measure of productivity the relationships between labour and productivity and capital and productivity change significantly. The labour factor's relationship becomes less negative when TFP measures are used whereas capital's relationship becomes more negative.

6) During the past 22 years (up to 1980) the materials input has shown a surprisingly strong positive association with productivity, particularly when it replaces labour or capital. Substituting materials for these inputs has resulted in net savings of the inputs, thereby generating higher productivity. This may imply that technical change is coming through the materials input rather than through capital as is often believed.

7) Materials itself comprises capital and labour and therefore its relation to productivity may be the result of embodied technical change in the capital component. If this were so it should have shown up in the

capital-productivity relation. Since it did not the superior performance of the materials input is probably a product of its own production process and its use in receiving industries.

These findings suggest the need for further investigation for they challenge traditional notions about the input factors and productivity, notions that have grown with the use of LP as the measure of productivity. First, use of a TFP measure puts the role of the input factors into proper perspective. Capital is seen like any other input. It can be a source of productivity improvement, just as labour, if used judiciously and not indiscriminately. Second, following from this first point, labour (and employment) is not necessarily in a trade-off relationship with productivity. More labour does not automatically mean less productivity. It can mean less productivity if used inefficiently, or if too much is used relative to other factors. But if it is being underutilized adding to it can also be a source of productivity improvement. Third, technological change may be coming through capital but its contribution to productivity might have been swamped through overutilization of capital. Or, technological improvement may be finding its way into the production system through the materials input. This latter possibility suggests that encouraging the use of that input relative to that of capital or labour will have payoffs for both productivity and employment.

FOOTNOTES

1. Rusty Stieff Byrne, "Sources on Productivity", Harvard Business Review, September-October 1981, p. 38.

2. The fact that service productivity did not fall off to the same extent as in manufacturing has been attributed by some observers to a relatively more rapid advance in technology in that sector. See S. Magun, The Rise of Service Employment in the Canadian Economy, mimeographed, Economic Council of Canada, February 1981.

3. Statistics Canada, op.cit., p. 28.

4. See, for example, Department of Finance, Recent Changes in Patterns of Productivity Growth in Canada, Ottawa, April 1980.

5. Two recent mammoth efforts are Dale W. Jorgensen and F. Gallop, "U.S. Productivity Growth by Industry", in J. Kendrick and B. Vaccaro, editors, New Developments in Productivity Measurement and Analysis, Studies in Income and Wealth, Volume 44, National Bureau of Economic Research, New York, 1980; and Economic Council of Canada, A Climate of Uncertainty, Seventeenth Annual Review, Ottawa, 1980.

6. National Resarch Council, Measurement and Interpretation of Productivity, A. Rees, editor, Washington, 1979 and A. Cas, New Measures of Multifactor Productivity and Structural Change for Canadian Industries, paper presented to Canadian Economics Association, July 1984.

7. Organization for Economic Co-operation and Development, The Broader Economic and Social Questions as they Relate to Youth Unemployment, mimeographed, restricted, November 1980, p. 13. Other studies in Europe on a similar theme include: K. Pankhurst, Training and Job Creation Schemes for Young People: Lessons from Overseas Experience, Organization for Economic Co-operation and Development, mimeographed, February, 1981; Commission of the European Communities, Outlook for Employment in the European Community to 1980, Brussels, July 1976; W. Driehuis, "Capital-Labour Substitution and Other Potential Determinants of Structural Employment and Unemployment", in Organization for Economic Co-operation and Development, Structural Determinants of Employment and Unemployment, Volume II, Paris, 1979, p. 101; C. Sautter, "Investment and Employment on the Assumption of Slower Growth", in ibid., p. 135; G. Caire, "A European Perspective", in ibid., Volume I, p. 72, L. Frey, "Industrial Investment Strategy and its Effects on Employment", in ibid., Volume II, p. 172; E. Malinvaud, "Capital-Labour Substitution, Technology and Employment", in ibid., Volume I, p. 23.

8. For a summary of the capital measure employed in productivity studies see National Research Council, op.cit.

9. In Canada, the Department of Finance says that it has declined, while the Bank of Canada and the Economic Council say that it has not. See Department of Finance, op.cit.; Economic Council of Canada, op.cit. Chapter 5; and Bank of Canada, "The Recent Slowdown in the Growth of Productivity: Some Explanations of the Puzzle", Bank of Canada Review, June 1981.

10. In the United States, J. Kendrick says that ratio is important and E. Denison argues that it is unimportant. Kendrick gives capital a weight of 30 per cent in his productivity equations, while Denison gives it a weight of only 10 per cent. See E.F. Denison, "Discussion" in Federal Reserve Bank of Boston, The Decline in Productivity Growth, June 1980, pp. 26-54, and J. Kendrick, "Survey of the Factors Contributing to the Decline in U.S. Productivity Growth", in Federal Reserve Bank of Boston, ibid, p. 3.

11. Bank of Canada, op.cit., p. 3.

12. E.R. Berndt and G.C. Watkins, Energy Prices and Productivity Trends in the Canadian Manufacturing Sector, 1957-76, Some Exploratory Results Economic Council of Canada, 1981.

13. Dale W. Jorgensen, Energy Prices and Productivity, Economic Council of Canada, mimeographed, 1980 and Dale W. Jorgensen, "The Answer is Energy", Challenge, Nov./Dec. 1980.

14. E.R. Berndt and G.C. Watkins, op.cit.

15. J. Kendrick, op.cit., p. 17 and J. Kendrick and E.S. Grossman, Productivity in the United States, the John Hopkins University Press, Baltimore and London, 1980, pp. 34 and 44.

16. E.R. Berndt and G.C. Watkins, op.cit., pp. 12-13.

17. Economic Council of Canada, op.cit., Appendix C; and S.Rao and R. Preston, Inter-Factor Substitution and Total Factor Productivity Growth: Evidence from Canadian Industries, mimeographed, Economic Council of Canada, February 1983, provide details of this data base. The terminal year for some of the data is 1979. However, for ease of reference 1980 is used as the end year in this study.

18. The net capital stock concept prallels that published by Statistics Canada. For a description, see Statistics Canada, Fixed Capital Flows and Stocks, Catalogue No. 13-211, Annual, Ottawa.

19. TFP is a misnomer since not all inputs are included in the measure developed by the Economic Council. A more accurate term would be multifactor productivity. However, for purposes of this study the term TFP is used on the understanding that it is not a true measure of total factor productivity.

20. The data, which are available for these time periods only, correspond to the periods used by the Economic Council in their productivity study. See references in footnote 17.

21. See Department of Finance, op.cit., p. 44; E.R. Berndt and G.C. Watkins, op.cit.; Economic Council of Canada, op.cit, pp. 101 and 103; Bank of Canada, op.cit. The first three generally do not attach much importance to pollution abatement expenditures, environmental regulations or energy. The Bank of Canada study hints that non-productive uses of capital might be a factor but does not explore the matter. In another respect, however, the Department of Finance and Bank of Canada studies note the large decline in labour productivity in certain extractive industries,

particularly petroleum and natural gas. They attribute this situation largely to falling output and increasing employment associated with development drilling and exploration work. The Department of Finance estimates that the fall in labour productivity in oil and gas related industries to be about one-quarter of the decline in national or aggregate labour productivity (page 48). The possibility of having to work harder or divert more resources to get the same returns is also hinted at by the Economic Council (the figures in column 9 "Residual" of Table C-1, p. 154, 17th Annual Review may be indicative of this situation) and may also be suggested by the acceleration of capital and labour growth rates over the 1958-80 period despite the slowdown in output growth. For example at the aggregate level capital and labour growth rates rose from 4.9 per cent and 1.1 per cent per year respectively in 1958-66 to 5.3 and 2.3 per cent respectively in 1974-80 (see Table A-1).

22. See footnote 13 and William C. Brainard, John B. Shoven and Laurence Weiss, "The Financial Valuation of the Return to Captial" in Brookings Papers on Economic Activity, 2, 1980, William C. Brainard and George L. Perry, ed., 1981, pp. 453-512; and Martin Neil Bailey, "Productivity and the Services of Capital and Labour" in Brookings Papers on Economic Activity, 1, 1981, William C. Brainard and George L. Perry, ed., 1981, pp. 1-66. Also see National Research Council, op.cit., p. 133.

23. The failure to find a positive relation between productivity and the capital-labour ratio has led writers in other countries to question the capital embodiment thesis. For example, J. Kendrick and E.S. Grossman, op.cit., p. 35 and R. Wragg and J. Robertson, Post War Trends in Employment, Productivity, Output, Labour Cost and Prices by Industry in the United Kingdom, Research Paper No. 3, Department of Employment, United Kingdom, June 1978, p. 79 specifically raise this question as a result of their failure to find a positive correlation coefficient.

24. Economic Council of Canada, op.cit., page for a statement of the possible recent inefficient use of capital in this country.

25. However, capital could be the source of improvements in the materials input as could the method by which capital and labour may be combined to produce materials for use in other industries.

26. For a discussion of this problem see J. Kendrick and E.S. Grossman, op.cit., p. 101.

27. For Canada, see the two Economic Council studies cited in footnote 17.

TABLE A-1

Average Annual Growth Rates, by Industry and Time Period, 1958-80[1,2]

Period and Variables

Industry	1958-80						1958-66					
	Q	TFP	L	M	K	E	Q	TFP	L	M	K	E
2	5.06	0.86	1.88	5.64	4.20	4.41	6.69	1.10	2.90	6.86	4.46	7.55
3	4.13	0.53	1.99	3.97	5.48	6.51	4.62	0.73	2.21	4.58	3.09	10.17
4	4.22	0.67	1.90	4.32	3.22	3.35	6.69	1.07	4.06	6.72	3.91	6.62
5	5.09	0.80	2.18	5.34	4.39	5.89	7.13	1.35	2.91	7.08	6.78	8.22
6	4.19	0.52	0.90	4.55	3.01	3.13	5.68	1.37	0.91	5.63	2.59	6.96
7	4.19	0.74	2.04	4.08	3.29	3.87	6.51	1.04	3.65	6.61	3.57	7.89
8	7.14	1.43	2.42	7.34	5.09	5.57	8.68	1.27	4.36	9.13	5.70	9.00
9	2.62	0.19	0.14	3.53	3.55	1.95	2.71	0.24	-0.72	3.96	3.58	0.25
1	8.57	1.23	3.69	8.31	4.24	4.43	9.90	0.80	6.09	9.88	5.57	8.00
11	6.43	0.79	2.95	6.71	9.07	7.07	9.96	1.08	5.68	10.22	11.27	13.35
12	4.93	1.25	1.20	4.95	3.45	3.45	8.23	2.12	3.04	7.97	3.88	6.69
13	3.80	0.83	1.29	3.56	3.39	3.88	5.50	0.84	3.36	5.29	4.11	5.90
14	4.35	0.60	1.45	4.46	4.09	4.65	5.26	0.73	2.03	5.35	4.08	6.42
15	3.62	0.26	1.36	3.71	3.60	2.85	4.58	0.41	2.17	4.55	4.36	6.18
16	3.27	0.74	-1.15	3.27	2.77	4.55	4.19	1.07	-0.84	3.83	4.71	9.94
17	8.71	0.98	2.84	9.19	5.42	4.90	11.93	1.23	4.73	12.21	6.61	7.63
18	1.70	0.79	-0.76	1.80	1.20	1.02	2.36	0.74	0.66	2.28	0.53	3.42
19	5.85	1.68	0.09	6.21	1.54	3.89	7.33	1.54	1.41	7.95	2.66	5.72
20	3.71	1.09	0.26	4.17	0.74	2.03	4.72	1.12	1.70	5.30	0.30	4.31
21	4.15	0.81	1.51	4.07	3.51	4.52	5.32	0.73	1.97	5.57	4.65	5.33
22	4.20	0.92	1.88	4.45	3.04	2.82	3.81	0.46	2.22	4.15	4.06	6.12
23	4.83	0.08	1.58	5.23	3.81	5.03	5.70	0.84	-0.43	5.81	1.54	4.81
24	6.19	0.87	1.84	6.11	6.35	7.23	7.24	1.54	2.16	6.91	5.58	10.44
25	4.45	0.60	2.11	4.92	3.44	3.37	5.14	0.57	4.18	5.31	5.73	10.40
26	2.91	-0.18	-3.07	3.93	3.01	N/A	4.56	1.68	-4.74	5.03	2.28	N/A
27	5.40	3.46	-1.98	6.86	3.53	N/A	4.75	5.05	-4.37	4.75	3.76	N/A
28	4.55	-0.19	1.05	5.35	7.11	N/A	5.11	1.09	-1.53	5.11	7.14	N/A
29	2.78	0.27	1.45	2.85	3.82	N/A	3.90	0.79	2.22	3.93	1.84	N/A
30	5.59	2.34	1.44	5.24	4.00	N/A	5.17	2.41	0.46	5.00	4.30	N/A
31	7.56	1.84	1.94	10.02	6.95	N/A	8.14	3.24	1.08	8.43	4.67	N/A
32	5.31	2.14	2.49	5.97	3.58	N/A	5.98	2.90	2.89	6.09	4.45	N/A
33	5.39	-1.64	4.46	6.02	10.53	N/A	4.12	-3.09	4.36	4.19	12.91	N/A
34	4.60	1.52	1.92	N/A	5.05	N/A	5.00	2.17	1.60	N/A	4.88	N/A

Table A-1 (continued)

Period and Variables

Industry	1967-73						1974-80					
	Q	TFP	L	M	K	E	Q	TFP	L	M	K	E
2	6.44	1.23	1.53	6.70	4.52	4.74	1.57	0.17	0.93	3.00	3.54	0.56
3	5.28	0.46	2.89	5.01	9.00	8.22	2.35	0.33	0.82	2.15	5.04	0.11
4	5.35	0.64	1.98	5.93	4.84	4.27	-0.08	0.19	-0.95	-0.39	0.71	-1.79
5	4.87	0.95	1.62	5.31	2.90	4.14	2.70	-0.07	1.79	3.13	2.81	4.63
6	2.99	0.28	0.62	2.97	4.96	3.60	3.46	-0.34	1.17	4.74	1.61	-2.28
7	3.56	0.89	1.02	3.07	4.21	2.96	1.84	0.22	0.99	1.83	2.00	-0.38
8	5.81	1.49	1.39	5.70	4.72	6.22	6.50	1.59	0.95	6.69	4.69	0.50
9	1.01	0.45	-1.96	1.83	2.36	5.47	4.11	-0.12	3.34	4.67	4.69	0.71
10	14.54	2.95	5.06	13.59	3.12	7.80	0.88	0.06	-0.77	1.01	3.66	-3.52
11	12.15	2.28	5.09	12.43	7.68	9.92	-3.84	-1.06	-2.69	-3.53	7.63	-3.85
12	5.27	1.14	0.90	5.62	5.23	4.08	0.35	0.25	-0.87	0.40	1.11	-1.36
13	4.23	1.33	0.83	3.63	3.86	4.13	1.19	0.31	-0.92	1.28	2.01	1.03
14	5.03	0.88	0.72	5.14	4.52	4.17	2.49	0.14	1.45	2.65	5.67	2.87
15	3.62	0.44	0.28	3.62	4.02	1.87	2.40	-0.11	1.40	2.72	2.19	-0.46
16	2.60	0.78	-1.05	2.35	1.96	3.59	2.76	0.27	-1.65	3.48	1.09	-1.42
17	10.54	1.15	4.40	11.53	9.87	6.13	2.73	0.49	-1.16	2.96	-0.56	0.17
18	0.66	0.62	-1.63	0.78	2.79	1.45	1.90	1.04	-1.72	2.21	0.47	-2.50
19	8.85	2.36	1.16	9.39	2.53	5.74	0.94	1.18	-2.69	0.78	-0.90	-0.30
20	5.28	1.18	0.23	5.98	3.86	5.15	0.85	0.96	-1.56	0.91	-1.80	-4.02
21	4.42	1.09	0.62	4.35	4.02	4.64	2.36	0.62	1.82	1.86	1.54	3.37
22	4.89	1.67	0.95	4.99	3.05	3.31	4.01	0.76	2.37	4.29	1.71	-1.91
23	6.57	0.22	0.86	6.84	7.82	7.45	1.96	-1.04	4.87	2.87	2.71	2.88
24	6.44	1.38	0.60	6.48	4.52	5.13	4.59	-0.51	2.67	4.70	9.18	5.21
25	5.40	0.29	1.92	6.61	4.02	1.29	2.61	0.96	-0.36	2.74	-0.10	-3.58
26	1.14	-0.78	-3.51	2.83	1.90	N/A	2.55	-1.96	-0.49	3.63	5.06	N/A
27	10.68	5.05	-0.94	15.08	3.49	N/A	0.96	-0.19	0.04	1.35	3.29	N/A
28	7.97	1.44	-0.58	9.34	7.52	N/A	0.40	-3.48	5.99	1.67	6.65	N/A
29	3.05	0.70	0.25	3.22	3.88	N/A	1.08	-0.82	1.66	1.08	6.30	N/A
30	7.48	3.09	2.40	7.03	4.10	N/A	4.24	1.49	1.75	3.75	3.50	N/A
31	9.56	1.14	2.90	18.08	8.36	N/A	4.82	0.73	2.08	4.02	8.47	N/A
32	5.94	2.55	1.55	7.05	2.27	N/A	3.82	0.75	2.92	4.72	3.76	N/A
33	7.37	-0.20	4.04	9.16	8.46	N/A	5.05	-1.23	5.00	5.24	9.53	N/A
34	5.31	2.23	1.91	N/A	5.02	N/A	3.39	-0.03	2.34	N/A	5.30	N/A

1 To save space only the growth rates of the primary variables are supplied in this table. The growth rates of the other variables can be derived as follows:

LP = Q - L; K/L = K-L; M/K = M-K; M/L = M-L

2 Legend to industries and variables are in Table A-2

Source: Derived from data in S. Rao and R. Preston, op cit.

Table A-2

Legend to Industries and Variables

2. Total Durables
3. Wood
4. Furniture and Fixtures
5. Iron and Steel
6. Non-Ferrous Metal
7. Metal Fabricating
8. Machinery (except electrical machinery)
9. Non-Auto Transportation Equipment
10. Motor Vehicle (except parts & accessories)
11. Motor Vehicle Parts & Accessories
12. Electrical Products
13. Non-Metallic Mineral Products
14. Total Non-Durables
15. Food and Beverages
16. Tobacco Products
17. Rubber and Plastics
18. Leather
19. Textiles
20. Knitting and Clothing
21. Paper and Allied Industries
22. Printing, Publishing & Allied Industries
23. Petroleum and Coal products
24. Chemicals and Chemical Products
25. Misc. manufacturing
26. Agriculture
27. Forestry
28. Mining (non-metal mining, coal, metal, crude, petroleum)
29. Construction
30. Transportation and Communication
31. Utilities
32. Trade
33. Finance, Insurance & Real Estate
34. All Industry

Q	=	Growth rate of gross output in real terms
L	=	Growth rate of person-hours paid
K	=	Growth rate of real net capital stock
E	=	Growth rate of energy in real terms. Separate energy information not available for non-manufacturing industries
M	=	Growth rate of materials in real terms. Materials input information for non-manufacturing includes energy.
LP	=	Growth rate of labour productivity, that is output per unit of labour (L)
TFP	=	Growth rate of total factor productivity, that is output per unit of input, the inputs being L,K,E and M.
K/L	=	Growth rate of the capital - labour ratio
M/L	=	Growth rate of the materials - labour ratio
M/K	=	Growth rate of the materials - capital ratio

Table A-3

Correlation Coefficients Manufacturing and Non-Manufacturing by Variables Correlated and Time Period

Variables	1958-80 Mfg.	1958-80 Non-Mfg	1958-66 Mfg.	1958-66 Non-Mfg.	1967-73 Mfg.	1967-73 Non-Mfg.	1974-80 Mfg.	1974-80 Non-Mfg.
TFP and K/L	-.2219	-.4125	-.0517	-.1921	-.6882[1]	-.3357	-.2727	-.0397
	(.160)	(.155)	(.410)	(.324)	(.001)	(.208)	(.110)	(.463)
TFP and K	-.0994	-.5996[2]	.0934	-.7094[2]	-.1287	-.2503	-.5457[1]	-.3340
	(.330)	(.058)	(.340)	(.024)	(.284)	(.275)	(.004)	(.209)
TFP and L	.0981	-.3003	.1632	-.5322[3]	.5347[1]	.0395	-.3573[3]	-.3885
	(.332)	(.235)	(.234)	(.087)	(.005)	(.463)	(.051)	(.171)
TFP and Q	.5019[1]	.4270[2]	.5500[1]	.4607	.7520[1]	.6621[2]	.3433	.58633
	(.008)	(.146)	(.004)	(.125)	(.001)	(.037)	(.056)	(.063)
TFP and M	.4462[2]	.4100	.5001[1]	.5161[3]	.7022[1]	.4480	.2466	.3573
	(.014)	(.157)	(.008)	(.095)	(.001)	(.133)	(.134)	(.192)
TFP and M/K	.5805[1]	.8947[1]	.4708[2]	.7949[1]	.8419[1]	.6877[2]	.6072[1]	.5561[3]
	(.002)	(.001)	(.014)	(.009)	(.001)	(.030)	(.001)	(.076)
TFP and M/L	.5640[1]	.5559[3]	.5309[1]	.7006[2]	.7020[1]	.4605	.6739[1]	.5775[3]
	(.003)	(.076)	(.006)	(.026)	(.001)	(.125)	(.001)	(.067)
LP and K/L	.1095	.3648	.3080[2]	.3962	-.4422[2]	.4123	.0320[1]	.5336[3]
	(.314)	(.187)	(.082)	(.166)	(.020)	(.155)	(.444)	(.087)
LP and K	.1401	-.4314	.1720	-.4757	.1338	.0700	-.3134[3]	-.2137
	(.267)	(.143)	(.222)	(.117)	(.276)	(.435)	(.078)	(.306)
LP and L	.0887	-.7768[2]	-. 089	-.9175[1]	.5970[1]	-.3106	.4564[2]	-.7442
	(.347)	(.012)	(.346)	(.001)	(.002)	(.227)	(.016)	(.017)
LP and Q	.7355[1]	.2514	.6036[1]	.2910	.8973[1]	.6865[2]	.4581[2]	.6009[3]
	(.001)	(.274)	(.001)	(.242)	(.001)	(.030)	(.016)	(.058)
LP and M	.7494[1]	.4340	.6058[1]	.3868	.8884[1]	.6569[2]	.4153[2]	.4670
	(.001)	(.141)	(.001)	(.172)	(.001)	(.038)	(.027)	(.122)
LP and M/L	.9730[1]	.9709[1]	.9755[1]	.9984[1]	.9630[1]	.8564[1]	.9768[1]	.9663[1]
	(.001)	(.001)	(.001)	(.001)	(.001)	(.001)	(.001)	(.001)
LP and M/K	.6188[1]	.7531[2]	.5084[1]	.5482[3]	.8603[1]	.7434[2]	.5284[1]	.5126[3]
	(.001)	(.016)	(.008)	(.080)	(.001)	(.017)	(.006)	(.097)

Figures in bracket represent p values. See Table 3

Table A-4

Partial Correlation Coefficients by Industrial Category, Variables Correlated and Time Period, Holding the Effects of M Constant, 1958-80

Variables and Industrial Category		Time Period 1958-80	1958-66	1967-73	1974-80
TFP and K/L	Mfg	−.2980[3] (.095)	−.0707 (.380)	−.6375[1] (.001)	−.2027 (1.89)
	Non-Mfg	.5611[3] (.095)	−.0925 (.422)	−.5195 (.116)	−.0004 (.500)
	Combined	−.3257[2] (0.42)	0.659 (.367)	−.4655[1] (.005)	−.1782 (.178)
TFP and K	Mfg	−.4653[2] (.017)	−.3111[3] (.085)	−.6600[1] (.001)	−.5886[1] (.003)
	Non-Mfg	−.8719[1] (.005)	−.7129[2] (.036)	−.6659[3] (.051)	−.4855 (.135)
	Combined	−.6362[1] (.001)	0.4772[1] (.004)	−.5823[1] (.001)	−.5633[1] (.001)
TFP and L	Mfg	−.3694[2] (.050)	−.3325[3] (.070)	−.2363 (.151)	−.6559[1] (.001)
	Non-Mfg	−.4285 (.169)	−.6264[3] (.066)	−.1518 (.373)	−.4962 (.129)
	Combined	−.4233[2] (.011)	−.6221[1] (.001)	−.1566 (.209)	−.6300[1] (.001)
LP and K/L	Mfg	.0668 (.387)	.3727[2] (.048)	−.2404 (.147)	.2161 (.173)
	Non-Mfg	.3092 (.250)	.5364 (.107)	.3370 (.230)	.5477 (.102)
	Combined	.2145 (.132)	.5498[1] (.001)	.0007 (.498)	.1822 (.172)
LP and K	Mfg	−.4639[2] (.017)	−.3166[3] (.081)	−.5817[1] (.003)	−.3875[2] (.041)
	Non-Mfg	−.6932[2] (.042)	−.4341 (.165)	−.4634 (.147)	−.4076 (.182)
	Combined	−.5275[1] (.002)	−.2605[3] (.086)	−.4766[1] (.004)	−.4723[1] (.005)
LP and L	Mfg	−.9408[1] (.001)	−.9614[1] (.001)	−.8228[1] (.001)	−.9762[1] (.001)
	Non-Mfg	−.9793[1] (.001)	−.9985[1] (.001)	−.7899[2] (.017)	−.9570[1] (.001)
	Combined	−.9375[1] (.001)	−.9879[1] (.001)	−.5917[1] (.001)	−.9718[1] (.001)

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