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Cyclical and Trend Behaviour of Labour Productivity

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CYCLICAL AND TREND BEHAVIOUR OF LABOUR PRODUCTIVITY

One of the stylized facts regarding the cyclical behaviour of the economy is a tendency for the growth of labour productivity to slow down during recessions and to increase during the expansion phase. It is often suggested that high costs incurred by a firm in hiring and training new employees would lead to a tendency to hoard (especially skilled) labour in a recession. An alternative explanation for the same phenomenon involves the use of dynamic production models in which one or more factors of production are treated as quasi-fixed (Morrison and Berndt (1979, 1981)). If demand increases, a firm would tend to use relatively more of those variable inputs (such as materials) that were substitutable with the quasi-fixed input (such as capital). In the longer run, the levels of the quasi-fixed input and those variable inputs that were complementary with it would be increased while there would be a decline in the use of other variable inputs. Hence if labour was complementary with capital, this could explain why the short-run output elasticity of labour might be smaller than its long-run output elasticity. It is of interest to observe that Morrison and Berndt found that complementarity between capital and aggregate labour in U.S. manufacturing was consistent with both capital-skilled labour complementarity and capital-unskilled labour substitutability.

In a previous analysis of the labour productivity slowdown (Blain (1977)), this cyclical factor was identified as an important cause of the decline in productivity growth in Canada over the 1974-76 period.[1] In more recent work, Helliwell (1984) found that over one half of the decline in labour productivity between 1973 and 1982, relative to a steady growth scenario, was the result of unexpectedly low demand and low profitability. In turn, these latter developments were caused by increases in world oil prices and related changes in external inflation and output. Helliwell, Sturm and Salou (1984) were able to attribute most of the slowdown in the growth of output per employee in Canada between the 1962-73 and 1973-82 periods to cyclical factors.

The work of Helliwell and his colleagues starts with the observation that it is costly for firms to make adjustments to factor input levels, especially for capital and labour. In response to unexpected shocks to demand or costs, firms may vary factor utilization levels in the

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1. The Economic Council of Canada (1980) attributed over one quarter of the slowdown in productivity growth in the 1974-76 period to cyclically weak demand. See also Rao (1979) and Ostry and Rao (1980). Nadiri (1980) and Nadiri and Schankerman (1981) found weak demand to have been a factor in explaining the productivity slowdown in the United States.

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short run, leading to changes in measured factor productivity. Capacity utilization for Canada as measured in Helliwell's model rises almost uninterruptedly between 1961 and 1973 and then falls almost continuously between 1973 and 1982. This latter phenomenon appears to be mainly attributable to a slow rate of adjustment of actual factor input levels to desired levels, a common result in econometric studies. However, there is some reason to believe that the speed of adjustment of factor input usage might also vary with economic conditions. For instance, there is some anecdotal evidence that firms reacted much more quickly than usual to adjust labour and other inputs during and after the 1981-82 recession, in the face of unfavourable relative price movements. In Canada, the average annual growth of real GNE per employee was about 1.2 per cent during the 1981-84 period, about the same as over the 1974-77 period. On the other hand, real GNE growth was only 1.2 per cent per year during the 1981-84 period, compared to 3 per cent per year during the 1974-77 period. Rao and Preston (1984) have also addressed this issue, attributing the slowdown in total factor productivity growth at the industrial level in part to a decline in the rate of growth of world aggregate demand. Sectoral cost functions are estimated in which allowance is made for the possibility of increasing or decreasing returns to scale. Increasing returns to scale are found for most non-manufacturing industries. Given less output growth after 1973, this would have led to less factor productivity growth.

In focusing exclusively on returns to scale, Rao and Preston implicitly assumed that production and factor usage are always in equilibrium, aside from random errors. Helliwell (1984) has suggested that they may have mixed capacity utilization effects with longer-run scale economy effects, by not allowing for a dynamic adjustment process for factor usage. One other general point about the above studies may be made. The slowdown in productivity growth has lasted more than one full business cycle, which might indicate that a non-cyclical explanation is needed in addition, though aggregate utilization rates in the 1978-79 period were substantially lower than in 1973-74.

I next examine the behaviour of aggregate labour productivity over each business cycle since 1953.[2] Presented in Tables 1-3 are average

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2. The dating of cyclical peaks and troughs was taken from WP5 (Ferley, O'Reilly and Dunnigan (1984)). Data on real GNE were taken from the national income and expenditure accounts of Statistics Canada. Data on real aggregate gross domestic product and sectoral output were taken from the gross domestic product statistics of Statistics Canada; links in 1961 and 1971 were constructed at the Bank of Canada. Labour force survey data were used for the series on total employment and employment in the sector comprising goods-producing (excluding agriculture), transportation, storage, communications and trade industries; a link in 1975 was made at the Bank of Canada. Employment data for the commercial sector (excluding agriculture and fishing and trapping) were taken from the all-establishment employment survey. In order to provide information for recent periods, Table 1 also presents calculations for the 1981Q2-1984Q2 period while Table 3 presents data for the 1982Q4-1984Q2 period.

annual per cent changes in labour productivity and output using four different measures of aggregate activity: real GNE; real gross domestic product; commercial (excluding agriculture and fishing and trapping); and the sector comprising goods-producing (excluding agriculture), transportation, storage, communications and trade industries[3]. These annual rates of change in Tables 1-3 are respectively for peak-to-peak, peak-to-trough, and trough-to-peak periods. Movements in labour productivity (solid line) and in output (dotted line) during seven cycles since 1953 are shown for real GNE in Figure 1A and for the sector comprising goods-producing (excluding agriculture), transportation, storage, communications and trade industries in Figure 1B.

The rate of growth of aggregate labour productivity was relatively constant over the 1953Q2-1974Q1 period, with the notable exception of the business cycle covering the 1956Q4-1960Q1 period (Table 1). In this latter period there was a substantial slowing of growth both in output and in labour productivity. After 1974Q1, there was a distinct break in the rate of labour productivity growth;[4] for instance, there was virtually no change in real GNE per employee between 1974Q1 and 1981Q2, compared to average annual growth of about 2.3% between 1953Q2 and 1974Q1. The rate of growth of real GNE per employee has increased since mid-1981, though it is still well below the average rate of growth over the 1953Q2-1974Q1 period.

The pro-cyclical nature of aggregate labour productivity change is quite evident from both Tables 2[5] and 3, as well as in Figures 1A and 1B. Aggregate output per employee (solid line) declines in most recessions, in conjunction with a decline in aggregate output (dotted line). The initial recovery in output is also generally characterized by strong rates of growth in labour productivity; in the later stages of the expansion, some slowing in the rate of growth of productivity is generally observable (relative to output growth) (Figure 1A). In many business cycles, the troughs in aggregate labour productivity and output have tended to coincide. However, in the latest recession which was unusually deep and long, the trough in productivity took place well before the trough in output. The decline in labour productivity during the latest recession was also much smaller than normal relative to the decline in output. The size and duration of the recovery in labour productivity since the end of 1982 has also been unusual in terms of experience since the mid-1970s.

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3. Output data for the remaining commercial service industries were not available before 1961.

4. For a discussion of some of the factors which may have been responsible for the slowdown in labour productivity growth after 1973, see Stuber (1981).

5. It may be remarked that the 1966-68 and 1969-70 "recessions" shown in Table 2 were periods when output growth slowed rather than fell in absolute terms.

I now turn to the behaviour of labour productivity in various industrial sectors in recent business cycles.[6] In Tables 4-6, data on average annual per cent changes in output and labour productivity for various industrial sectors are presented for peak-to-peak, peak-to-trough, and trough-to-peak periods. From Table 4, a distinct break in the trend rate of both output and labour productivity growth in the commercial sector is quite apparent between the 1966Q1-1974Q1 and 1974Q1-1981Q2 periods. As well, the mining, manufacturing, transportation and other utilities, and trade sectors all experienced a substantial slowdown in productivity growth between the same two periods. Over the 1981Q2-1984Q2 period, the rate of growth of output per employee in the mining and manufacturing sectors has been as high or higher than during the 1966Q1-1974Q1 period. Labour productivity growth also increased between the 1974Q1-1981Q2 and 1981Q2-1984Q2 periods in the construction and trade sectors. However, given the change in the employment survey near the beginning of 1983, some caution should be exercised in interpreting recent disaggregated labour productivity estimates.

The pro-cyclical nature of labour productivity growth is again quite evident from Tables 5 and 6. In the last three recessions, both output and labour productivity have declined in the commercial sector. It is of interest to observe that the rate of decline of productivity in the 1981-82 recession was lower than in the 1974-75 and 1979-80 recessions, even though the output decline was much larger. Labour productivity in the mining industry actually increased during the 1981-82 recession, even though output declined; in the previous two recessions, there were substantial decreases in labour productivity in this sector. While output per man-hour in the manufacturing sector fell during the 1974-75 and 1979-80 recessions, this measure of labour productivity was practically unchanged in the 1981-82 recession, even though the fall in production was larger than in the previous two recessions. Similarly, the decline in labour productivity relative to the output decline in the transportation and other utilities sector has been much smaller in the latest recession. One might speculate that the very tight financial position of many firms in the most recent recession induced a greater than normal degree of cost-cutting. As well, the pro-cyclical tendency of labour productivity in the construction industry appears to have disappeared in the late 1970s.

From Table 6, it is evident that labour productivity growth in Canada tends to rise during the expansionary phases of the cycle. However, the

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6. GDP statistics were used for output data, while all-establishment employment data from Statistics Canada were used as the main labour input indicator. Data after February 1983 were taken from the revised monthly Survey of Employment, Payrolls and Hours and were linked to the old series at the Bank of Canada. For several sectors (mining, manufacturing and construction), man-hours data were constructed using average hours paid from large-establishment data. Sectoral employment and average hours paid data were only available starting in 1961.

average annual rate of productivity growth in the commercial sector has tended to be smaller in the two most recent full expansions. Among individual sectors, this slowdown has been especially evident in the mining (also accompanied by a much lower rate of output growth) and manufacturing sectors. In the expansion that began in 1983, the growth of labour productivity has apparently been relatively strong in a number of sectors, including mining, manufacturing, transportation and other utilities, and trade.

The cyclical behaviour of sectoral labour productivity is also shown in Figures 1C-11. Output per employee is shown for the following sectors: commercial (excluding agriculture, fishing and trapping); mining; manufacturing; construction; transportation, communications and other utilities; trade; finance, insurance and real estate; and other commercial services. Output per man-hour is also shown for the mining, manufacturing and construction sectors. In each figure, productivity (solid line) and output (broken line) are shown for the following cycles: 1966Q1-1969Q4, 1969Q4-1974Q1, 1974Q1-1979Q4 and 1979Q4-1984Q2.[7] (We treat the brief expansion from mid-1980 to mid-1981 as an interruption of the recession which began at the end of 1979.)

The pro-cyclical nature of labour productivity in the commercial sector (Figure 1C) has been especially evident in the last two business cycles. However, the cyclical rebound in the expansionary phase has tended to become weaker in recent cycles. Indeed, during the 1980-81 expansion, output per employee remained virtually flat after a substantial decline earlier in 1980. This figure also confirms that the growth in productivity tends to end before the output peak. Gordon (1979) speculates that this "end-of-expansion phenomenon" results in part from expectational errors and lags in adjusting employment to output changes. As well, there may be differences in the timing of cyclical peaks in various industries. Perhaps most importantly, productivity gains arising from the underutilization of the capital stock will eventually be exhausted during the course of the expansion and it may only be possible to increase output by installing additional machines and hiring inexperienced and presumably lower quality workers. The increase in productivity which began well before the end of the last recession was highly unusual and may have reflected the need to cut costs as a result of the extremely weak financial position of many corporations and the extremely long duration of the recession.

Data on output per employee and per man-hour respectively for the mining sector are shown in Figures 2 and 3. Output per man-hour increased almost continuously over the 1966-72 period and then fell almost uninterruptedly between 1972 and 1981. Some of the factors that may have

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7. Data on output per man-hour (in mining, manufacturing and construction) and for output per employee in the commercial sector are available only up to 1983Q1.

influenced productivity performance after 1972-73 are as follows. First, a substantial part of the workforce is engaged in activities designed to find and develop new reserves of natural resources rather than in functions directly related to current production. After 1974, demand for most natural resources tended to be more restrained, either because of increases in relative prices or possibly because of structural shifts in the composition of demand. Secondly, depletion of easily accessible reserves may have had an adverse effect on labour (and factor) productivity in this sector. Profitability in the oil and gas mining industry was relatively high after 1973 and may have masked an underlying trend towards lower rates of growth of factor efficiency. Finally, given anecdotal evidence (at least before mid-1981) with respect to the high level of difficulty in retaining skilled workers in this industry, it would seem logical to suppose that labour would be hoarded for a longer period than is normal in other sectors. More recently, there seems to have been an improvement in labour productivity as firms have cut costs in order to improve profitability in the face of relatively modest increases in the prices of many mining products. However, recent labour force survey data for non-farm primary industries do not support this development, so it is possible that the large increase in labour productivity shown in Figure 2 is partly related to the break in the all-establishment employment series.

Information on the manufacturing sector is shown in Figures 4 (output per employee) and 5 (output per man-hour). It is apparent that in the 1974-75 recession, part of the adjustment in labour input took the form of a reduction in average hours worked rather than a reduction in employment, suggesting that manufacturing firms were trying to retain employees (Blain, 1977, p. 9). In the latest recession, output per man-hour reached a trough in 1982Q1, whereas output continued to fall up to 1982Q4. Experience in previous cycles has suggested more synchronization of troughs in output and labour productivity. However, the severity of the 1981-82 downturn may have led to increased efforts at improving efficiency given extremely low levels of profitability, which was probably responsible for a sizeable improvement in output per man-hour in the second half of the recession. According to the data for output per employee, further substantial increases in productivity have taken place so far in the recovery. However, on a labour force survey basis, the recovery in labour productivity has been less pronounced.

Productivity in the construction industry has sometimes followed a pro-cyclical pattern, measured in terms of either output per employee (Figure 6) or output per man-hour (Figure 7). In the early and late 1970s, productivity tended to decline in absolute terms. However, since the beginning of 1981, there has been some growth in measured labour productivity, even though output levels fell sharply after mid-1981.

Output in the transportation, communications and other utilities sector has displayed little of the cyclical volatility so apparent in most

goods-producing industries, with the exception of the present cycle (Figure 8). Similarly, output per employee exhibited little variation up to 1979, though the trend rate of growth has been declining (Table 4). The trough in labour productivity was reached well before the trough in output during the 1981-82 recession. In the recovery since the end of 1982, the increase in output per employee has been very pronounced. As in other sectors, lower levels of profitability have led to unusually intensive efforts to reduce costs, which partly explain the rise in labour productivity.

Since 1966, productivity in the trade sector (Figure 9) has experienced only one period of sustained growth (1971-73). Output per employee was pro-cyclical over the 1974-76 period, but thereafter it remained relatively flat in spite of sizeable gains in output. The declines in output and productivity were sizeable and of comparable orders of magnitude in the most recent recession. In percentage terms, the per cent recovery in productivity since the end of 1982 has been almost as large as the increase in output, which might be suggestive of special efforts to improve efficiency.

Output in the finance, insurance and real estate sector has shown little volatility since 1966, and there has been relatively little change in the measured level of labour productivity (Figure 10). There has however been some growth in output per employee since the middle of 1982. Productivity in the other commercial services sector has been relatively flat over the entire 1966-1983 period (Figure 11).

To illustrate this phenomenon further, a number of different specifications for labour productivity equations were estimated for the commercial sector excluding energy and the manufacturing sector excluding energy. The energy sector was defined to include mineral fuels, petroleum and coal products, electric power and gas distribution and pipelines. The variables used in various equations are:

Y = output,
L = man-hours,
K = capital stock,
CAPU = rate of capacity utilization,
PE = price of energy,
PY = output price,
E = real energy input,
T = time trend,
T1 = time trend starting in 1974,
T2 = time trend starting in 1979,
RNU = national unemployment rate,
RNUTØ = unemployment rate at trend output,
GAPL = a measure of the labour market gap which equals (100-RNU)/(100-RNUTØ), and

GAP = either CAPU or GAPL.[8]

In all cases, estimation results are shown in Table 7.

The simplest specification included only cyclical and time trend variables

$$\log(Y/L) = a + b*\log(GAP) + c*T. \qquad (1)$$

In the case of the equation for the manufacturing excluding energy sector, only an output gap measure was used, while both output and labour market gap measures were used in alternative equations for the commercial excluding energy sector. In all cases, both the cyclical and time trend variables were highly statistically significant, though there was evidence of first-order autocorrelation.

From the data presented in Tables 1 and 4, there was evidence of a break in the trend rate of labour productivity after 1973 and perhaps another in 1979. In a second equation, additional time trend variables were introduced to allow for this phenomenon

$$\log(Y/L) = a + b*\log(GAP) + c*T + d*T1 + e*T2. \qquad (2)$$

In the case of the commercial excluding energy sector, the results suggest that there was a highly statistically significant decline in the trend

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8. Data sources were as follows. Output for the 1961-1980 period was defined as the sum of value added by labour and capital (measured in constant prices) and the energy input and was obtained from input-output matrices supplied by Statistics Canada. These data were extended over the 1956-60 and 1981-83 periods employing the growth rate of the following proxy -- gross domestic product in constant prices from Statistics Canada, Gross Domestic Product by Industry (61-213) and earlier publications. Man-hours data were taken from Statistics Canada, Aggregate Productivity Measures (14-201); employment data from Statistics Canada, Employment, Earnings and Hours (72-002) were used to construct a proxy for the share of total man-hours of the non-energy components of the commercial and manufacturing sectors. Capital stock information was taken from Statistics Canada, Fixed Capital Flows and Stocks (13-211) and unpublished data. Rates of capacity utilization were derived from data published in the Bank of Canada Review; the rate of capacity utilization in the commercial excluding energy sector was proxied by that for the goods excluding energy sector. These data were extended over the 1956-61 period using unpublished data at the Bank of Canada. Data on the energy price, output price and real energy input for the 1961-80 period were obtained from the input-output matrices mentioned above. The energy price series were extended over the 1956-60 and the 1981-83 periods using the growth rate of the CPI for energy. The output price for manufacturing excluding energy was extended over the same periods employing proxies as well as the Industry Selling Price Index for 1982 and 1983 (Statistics Canada). The output price for the commercial excluding energy sector was extended over the same periods using data in Statistics Canada, National Income and Expenditure Accounts (13-201), Gross Domestic Product by Industry (61-213) and earlier publications. Data on RNU and RNUTØ were taken from the RDXF data base. A listing of data is shown in an appendix.

rate of productivity growth starting in 1974. A further though smaller decline in trend productivity growth is apparent starting in 1979 in the commercial excluding energy sector. In the manufacturing excluding energy sector the decline in trend productivity growth beginning in 1979 was even larger than that in 1974. There is also a large decline in the size of the coefficient of the cyclical variable.

Unfortunately, such simple equations provide no economic explanation for changes in the longer-run rate of labour productivity change. More interesting specifications were estimated which bear some similarity to models developed by Rasche and Tatom (1981) and Tatom (1980). One form of the equation was

$$\log(Y/L) = a + b*\log(K/L) + c*\log(PE/PY) + d*\log(GAP) + e*T. \qquad (3)$$

The specification is essentially derived from a constant returns-to-scale Cobb-Douglas production function with three factors of production: labour, capital and energy. The relative energy price, instead of the real energy input, was used as an additional explanatory variable, as in Rasche and Tatom (1981). Finally, a measure of the output (labour market) gap was included as an additional explanatory variable to allow for cyclical influences on labour productivity. The estimation results are supportive of the view that the capital stock-labour ratio and the relative energy price are important determinants of labour productivity. As expected, the coefficient on the capital stock-labour ratio is positive, though the size of the estimated coefficient for the manufacturing excluding energy sector seems much larger than would have been expected on the basis of cost share considerations.[9] A separate equation was also estimated in which the coefficient b was constrained to be consistent with cost share information. The coefficient on the relative energy price variable is negative in all cases, presumably reflecting substitutability between energy and the other two factors of production. Finally, the time trend variable coefficient is much smaller than before. It is also worth noting that the coefficients of the equation for the commercial excluding energy sector were much more stable when estimated over different sample periods in the case where a labour market gap variable was used (as opposed to an output gap variable). For instance, the coefficient on the relative energy price variable was positive when estimated over the 1956-73 period in the case of the equation using an output gap variable; on the other hand, the coefficient of this variable was virtually unchanged when estimated over the same

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9. The average cost shares of labour, capital and energy in the manufacturing excluding energy sector were estimated to be 63%, 30% and 7% respectively. The respective average cost shares of labour, capital and energy for the commercial excluding energy sector were estimated to be 54%, 41% and 5%.

period for the equation using the labour market gap variable. This suggests that greater confidence should be given to the equation using the labour market gap variable; perhaps one reason for this finding is that this measure of the gap variable does not directly depend on actual output.

Next, an equation was estimated in which additional time trend variables were introduced, allowing for shifts in the rate of technical progress starting in 1974 and 1979

$$\log(Y/L) = a + b*\log(K/L) + c*\log(PE/PY) + d*\log(GAP) + e*T + f*T1 + g*T2. \quad (4)$$

The results were consistent with the hypothesis of declines in the rate of technical progress starting in both 1974 and in 1979 (with the exception of the T1 variable for the commercial excluding energy sector, for which the coefficient was statistically insignificant). In the case of the equation for the commercial excluding energy sector using the labour market gap variable, the coefficient of the relative energy price variable remained negative, though statistically insignificant; the coefficients of the capital-labour ratio and the labour market gap variables were also insignificant. For the commercial excluding energy equation using an output gap variable and the manufacturing equations, the coefficient on the relative energy price variable became positive, an implausible result. In the light of these results, there is some difficulty in distinguishing empirically between the hypothesis that increases in the relative price of energy would be a partial explanation for the slowdown in labour productivity growth and the alternative hypothesis that there were simply inexplicable declines in the rate of technical progress in the mid-1970s and a further decline in the late 1970s.

An equation was also estimated in which the real energy input-labour ratio replaced the relative energy price variable

$$\log(Y/L) = a + b*\log(K/L) + c*\log(E/L) + d*\log(GAP) + e*T. \quad (5)$$

The coefficient on the capital-labour ratio was much higher than would have been expected on the basis of cost share considerations, while the estimated rate of technical progress was much lower than what had been obtained in most of the above regressions.

The model shown by equation (3) with a labour market gap estimated for the commercial excluding energy sector is illustrated in Figure 12. The solid line in this graph displays actual values of labour productivity in this sector over the 1956-83 period. The simulated values using equation (3) are shown as line LAC910. Finally, setting the labour market gap measure to its average value over the 1956-83 period and employing equation (3), one obtains line LAC85. Given the model being used, this implies that LAC85 would be below (above) LAC910 during periods of high

(low) capacity utilization. The model is able to explain just over 90% of the slowdown in labour productivity growth between the 1956-74 and 1975-81 periods and about 40% of the actual slowdown is attributable to low rates of capacity utilization (Table 8). The rise in the relative price of energy accounts for nearly half of the slowdown, while a decline in the rate of growth of the capital-labour ratio accounts for about 4% of the fall in labour productivity growth. A similar kind of exercise was carried out for the manufacturing sector using the version of equation (3) with a constraint on the coefficient of the capital-labour ratio (Figure 13). Though the weight given to low rates of capacity utilization is about the same as for the commercial sector, the model is much less successful in explaining the overall slowdown in labour productivity growth between the 1956-74 and 1975-81 periods (Table 8).

While the model used above is quite crude, its results are in accord with a number of other studies that give an important role to low rates of capacity utilization and the energy price shock as explanations for the productivity slowdown. Other important factors that may have played a role include special structural characteristics of energy-related industries and higher inflation rates, as discussed in Stuber (1981). With regard to the use of cyclically weak demand as an explanation of the slowdown, one must note that there is reason to be skeptical about the quality of reported aggregate rates of capacity utilization in recent years. Increased difficulties in measuring the capital stock, which is an important input into the Bank of Canada measure of capacity utilization, may have led, for instance, to an understatement of aggregate operating rates. As well, if capacity utilization remained at a low level for a sustained period, one might ask why firms would not adjust factor inputs (and operating rates) so as to raise productivity levels back to pre-shock levels.

One other area of interest, with respect to the cyclical behaviour of labour productivity, concerns the distinction between production and overhead labour. As an example, recent data for hourly paid and salaried employees in the manufacturing sector are examined (Figure 14).[10] As might be expected, the employment corrections during recessions for hourly paid workers are much larger than for salaried workers. Further, hourly paid workers also experience reductions in average weekly hours during recessions (Figure 15). The employment and labour productivity data (Figure 16) indicate that increases in output during the early stages of an expansion are met mainly through a rise in productivity and to a lesser extent by an increase in average hours worked. In the last major expansion from 1975 to 1979, major increases in the level of the labour input took place only in a later stage of the recovery.

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10. Data on employment and average hours worked are taken from Statistics Canada, Employment, Earnings and Hours (72-002). Employment of hourly paid workers refers to the number of wage-earners (hours reported). Output is measured as in footnote 8. The employment data were seasonally adjusted at the Bank of Canada.

Table 1

Average Annual Changes (%) in Aggregate Labour Productivity and Output Over Various Phases of Recent Cycles

	Peak to peak							
	1953Q2-1956Q4	1956Q4-1960Q1	1960Q1-1966Q1	1966Q1-1969Q4	1969Q4-1974Q1	1974Q1-1979Q4	1979Q4-1981Q2	1981Q2-1984Q2
Real GNE per employee	3.0	1.3	2.5	2.2	2.5	-0.1	0.2	0.8
Real GNE	5.2	2.8	5.5	4.6	5.8	2.7	3.0	0.5
Real gross domestic product per employee	3.1	0.8	2.6	2.2	2.5	0.1	0.6	0.5
Real gross domestic product	5.3	2.3	5.5	4.4	5.8	2.9	2.9	0.2
Commercial (excluding agriculture, fishing and trapping)								
Output per employee	N/A	N/A	N/A	2.3	2.8	0.8	-0.1	N/A
Output	N/A	N/A	N/A	4.8	6.6	3.1	3.0	-0.1
Goods-producing (excluding agriculture), transportation, storage, communications and trade								
Output per employee	3.7	1.7	3.6	3.0	3.3	0.3	0.8	0.7
Output	6.3	2.2	6.2	4.6	6.6	2.4	1.9	1.1

Source: Statistics Canada data

Table 2

Average Annual Changes (%) in Aggregate Labour Productivity and Output Over Various Phases of Recent Cycles

	Peak to trough							
	1953Q2-1954Q2	1956Q4-1957Q4	1960Q1-1961Q1	1966Q1-1968Q1	1969Q4-1970Q4	1974Q1-1975Q1	1979Q4-1980Q2	1981Q2-1982Q4
Real GNE per employee	-2.1	-1.6	-1.6	1.3	-0.7	-1.9	-1.7	-1.2
Real GNE	-2.6	-0.3	-1.1	3.5	0.9	-0.4	-0.6	-4.6
Real gross domestic product per employee	-2.9	-3.7	-1.3	1.5	0.2	-2.1	-2.1	-1.3
Real gross domestic product	-3.6	-2.4	-0.9	3.7	1.8	-0.6	-1.0	-4.7
Commercial (excluding agriculture, fishing and trapping)								
Output per employee	N/A	N/A	N/A	2.0	2.7	-3.0	-1.9	-0.1
Output	N/A	N/A	N/A	3.7	1.5	-1.7	-2.3	-6.4
Goods-producing (excluding agriculture), transportation, storage, communications and trade								
Output per employee	-1.7	-4.0	0.5	2.2	0.6	-3.4	-2.8	-2.8
Output	-3.6	-3.4	-0.9	3.3	1.1	-4.1	-4.3	-9.3

Source: Statistics Canada data

Table 3

Average Annual Changes (%) in Aggregate Labour Productivity and Output Over Various Phases of Recent Cycles

	Trough to peak							
	1954Q2-1956Q4	1957Q4-1960Q1	1961Q1-1966Q1	1968Q1-1969Q4	1970Q4-1974Q1	1975Q1-1979Q4	1980Q2-1981Q2	1982Q4-1984Q2
Real GNE per employee	5.1	2.6	3.3	3.2	3.4	0.9	1.3	2.8
Real GNE	8.4	5.4	6.8	5.9	7.2	3.7	5.0	5.5
Real gross domestic product per employee	5.6	2.8	3.4	3.1	3.3	1.0	1.3	2.3
Real gross domestic product	8.9	4.5	6.8	5.8	6.9	3.8	4.9	5.0
Commercial (excluding agriculture, fishing and trapping)								
Output per employee	N/A	N/A	N/A	2.8	2.8	2.1	0.8	N/A
Output	N/A	N/A	N/A	6.2	8.0	4.3	5.7	6.1
Goods-producing (excluding agriculture), transportation, storage, communications and trade								
Output per employee	5.9	4.3	4.1	3.9	4.1	1.6	3.1	4.2
Output	10.4	4.7	7.7	6.1	8.2	4.1	5.6	7.0

Source: Statistics Canada data

Table 4

Average Annual Changes (%) in Labour Productivity and Output Over Various Phases of Recent Cycles

	Peak to peak					% share
	1966Q1-1969Q4	1969Q4-1974Q1	1974Q1-1979Q4	1979Q4-1981Q2	1981Q2-1984Q2	of aggregate output in 1981
Mining:						3.3
Output per employee	4.5	5.0	-4.7	-11.3	8.6	
Output per man-hour	5.4	5.2	-4.9	-10.1	N/A	
Output	5.1	6.7	-1.0	-3.7	0.8	
Manufacturing:						26.3
Output per employee	3.5	4.3	1.4	0.2	4.7	
Output per man-hour	4.5	4.4	1.7	-0.2	N/A	
Output	4.6	6.4	1.8	1.0	-1.1	
Construction:						7.5
Output per employee	0.8	1.4	0.9	0.2	1.5	
Output per man-hour	2.8	1.1	0.8	1.6	N/A	
Output	0.6	4.9	1.6	2.7	-5.4	
Transportation and other utilities:						17.0
Output per employee	5.5	4.2	2.9	1.5	2.9	
Output	7.0	7.2	4.7	3.8	0.6	
Trade:						15.3
Output per employee	-0.2	3.4	0.1	-0.5	1.0	
Output	3.8	8.2	2.8	2.9	-0.3	
Finance, insurance and real estate:						16.1
Output per employee	-0.6	-0.6	0.3	2.1	0.3	
Output	5.3	5.6	4.7	4.7	1.3	
Other commercial services:						13.7
Output per employee	1.3	0.4	0.2	0.2	-0.3	
Output	7.1	7.1	5.8	6.3	2.0	
Commercial (excluding agriculture, fishing and trapping):						100[1]
Output per employee	2.3	2.8	0.8	-0.1	N/A	
Output	4.8	6.6	3.1	3.0	-0.1	

Source: Statistics Canada

1. This sector also includes forestry, which accounted for about 0.8 per cent of aggregate output in 1981.

Table 5

Average Annual Changes (%) in Labour Productivity and Output Over Various Phases of Recent Cycles

	Peak to trough				
	1966Q1-1968Q1	1969Q4-1970Q4	1974Q1-1975Q1	1979Q4-1980Q2	1981Q2-1982Q4
Mining:					
Output per employee	5.3	8.0	-13.7	-9.1	4.9
Output per man-hour	5.8	8.0	-12.8	-8.5	7.5
Output	6.3	13.8	-11.6	2.5	-10.5
Manufacturing:					
Output per employee	2.4	0.5	-4.6	-4.3	-2.4
Output per man-hour	3.6	0.5	-2.2	-3.2	0.1
Output	2.6	-3.0	-8.3	-9.6	-13.5
Construction:					
Output per employee	1.2	7.8	-2.8	3.4	5.1
Output per man-hour	2.0	8.2	-0.7	7.1	5.1
Output	-1.2	1.7	-2.7	-9.3	-9.6
Transportation and other utilities:					
Output per employee	4.6	5.1	-1.0	-3.5	-1.7
Output	6.5	4.9	1.9	0.6	-5.5
Trade:					
Output per employee	0.1	1.8	-4.2	-0.4	-2.9
Output	3.2	1.6	-1.0	-0.8	-7.3
Finance, insurance and real estate:					
Output per employee	-1.3	2.3	-1.6	0.5	1.1
Output	4.5	2.5	4.3	3.4	0.8
Other commercial services:					
Output per employee	1.1	1.0	0.4	-1.5	0.6
Output	6.7	2.3	6.2	2.3	0.3
Commercial (excluding agriculture, fishing and trapping)					
Output per employee	2.0	2.7	-3.0	-1.9	-0.1
Output	3.7	1.5	-1.7	-2.3	-6.4

Source: Statistics Canada

Table 6

Average Annual Changes (%) in Labour Productivity and Output Over Various Phases of Recent Cycles

	Trough to peak				
	1968Q1-1969Q4	1970Q4-1974Q1	1975Q1-1979Q4	1980Q2-1981Q2	1982Q4-1984Q2
Mining:					
Output per employee	3.5	4.1	-2.7	-12.3	12.3
Output per man-hour	4.9	4.4	-3.2	-10.9	N/A
Output	3.7	4.5	1.3	-6.8	11.8
Manufacturing:					
Output per employee	4.7	5.4	2.6	2.6	11.7
Output per man-hour	5.6	5.6	2.5	1.3	N/A
Output	7.0	9.3	3.9	6.3	10.8
Construction:					
Output per employee	0.3	-0.3	1.7	-1.4	-2.2
Output per man-hour	3.8	-0.8	1.1	-1.2	N/A
Output	2.7	6.5	2.5	8.5	-1.2
Transportation and other utilities:					
Output per employee	6.5	4.5	3.7	4.0	7.5
Output	7.6	7.9	5.0	5.3	6.5
Trade:					
Output per employee	-0.6	3.9	1.0	-0.5	4.8
Output	4.5	10.2	3.6	4.7	6.7
Finance, insurance and real estate:					
Output per employee	0.3	-1.5	0.7	3.0	-0.5
Output	6.2	6.5	4.8	5.9	1.7
Other commercial services:					
Output per employee	1.7	0.3	0.2	1.0	-1.2
Output	7.7	8.6	5.7	8.4	3.6
Commercial (excluding agriculture, fishing and trapping):					
Output per employee	2.8	2.8	2.1	0.8	N/A
Output	6.2	8.0	4.3	5.7	6.1

Source: Statistics Canada

Table 7

Estimation of Results for Labour Productivity Equations (t-statistic in brackets)

(1) log (Y/L) = a + b*log(GAP) + c*T

Coefficients	Commercial excluding energy		Manufacturing excluding energy
	Output gap	Labour market gap	Output gap
a	.510 (19.7)	.446 (14.8)	.349 (9.9)
b	.445 (6.5)	1.743 (5.7)	.467 (4.9)
c	.028 (44.3)	.028 (41.0)	.033 (42.0)
$\bar{R}^2$	.988	.986	.985
Standard error of regression	.024	.027	.033
D.W.	.59	.75	.41

Estimation period: 1956-1983 (annual)

(2) log(Y/L) = a + b*log(GAP) + c*T + d*T1 + e*T2

Coefficients	Commercial excluding energy		Manufacturing excluding energy
	Output gap	Labour market gap	Output gap
a	.306 (13.6)	.283 (13.6)	.169 (4.2)
b	.089 (2.0)	.087 (0.4)	.128 (1.7)
c	.032 (66.1)	.032 (62.4)	.037 (41.1)
d	-.015 (-7.3)	-.016 (-7.3)	-.005 (-1.4)
e	-.005 (-1.4)	-.006 (-1.7)	-.025 (-3.7)
$\bar{R}^2$	.998	.997	.995
Standard error of regression	.010	.011	.020
D.W.	2.00	2.11	1.45

Estimation period: 1956-1983 (annual)

(3) log (Y/L) = a + b*log(K/L) + c*log(PE/PY) + d*log(GAP) + e*T

Coefficients	Commercial excluding energy		Manufacturing excluding energy	
	Output gap	Labour market gap	Output gap no constraint	Output gap constraint on b
a	.454 (31.8)	.393 (24.5)	-.019 (-0.5)	.149 (3.6)
b	.504 (4.4)	.397 (2.4)	.945 (9.3)	.327
c	-.074 (-2.6)	-.109 (-2.7)	-.016 (-0.7)	-.077 (-2.3)
d	.426 (4.8)	1.295 (2.5)	1.063 (10.5)	.549 (6.3)
e	.011 (2.3)	.014 (2.2)	.001 (0.2)	.023 (26.3)
$\bar{R}^2$	.998	.997	.997	.993
Standard error of regression	.009	.012	.014	.022
D.W.	1.00	1.31	1.10	.51

Estimation period: 1956-1983 (annual)

Table 7 (continued)

(4) log(Y/L) = a + b*log(K/L) + c*log(PE/PY) + d*log(GAP) + e*T + f*T1 + g*T2

Coefficients	Commercial excluding energy		Manufacturing excluding energy
	Output gap	Labour market gap	Output gap
a	.369 (14.7)	.355 (9.0)	.010 (0.5)
b	.463 (5.7)	.254 (1.5)	.698 (10.8)
c	.035 (0.9)	-.072 (-1.4)	.069 (2.3)
d	.388 (6.0)	.735 (1.4)	.798 (12.2)
e	.013 (4.2)	.021 (3.1)	.011 (4.2)
f	-.010 (-2.8)	-.004 (-0.7)	-.007 (-2.1)
g	-.005 (-2.0)	-.008 (-2.2)	-.013 (-4.2)
$\bar{R}^2$	.999	.998	.999
Standard error of regression	.007	.010	.008
D.W.	1.99	1.97	1.88

Estimation period: 1956-1983 (annual)

(5) log(Y/L) = a + b*log(K/L) + c*log(E/L) + d*log(GAP) + e*T

Coefficients	Commercial excluding energy		Manufacturing excluding energy
	Output gap	Labour market gap	Output gap
a	.149 (0.3)	-.235 (-0.5)	-.580 (-1.1)
b	.632 (4.8)	.521 (3.7)	.923 (8.5)
c	.083 (0.7)	.169 (1.2)	.130 (1.1)
d	.536 (5.0)	1.887 (3.9)	.995 (8.9)
e	.002 (0.5)	.003 (0.7)	-.003 (-0.6)
$\bar{R}^2$	.995	.994	.996
Standard error of regression	.011	.013	.012
D.W.	0.91	1.27	0.90

Estimation period: 1961-1980 (annual)

Table 8

Estimates of Contributions to Productivity Slowdown Using Equation (3) (%)

	Commercial excluding energy[1]	Manufacturing excluding energy[2]
Change in average annual rate change of labour productivity between 1956-74 and 1975-81	-1.58	-2.14
Proportion of change in labour productivity growth between 1956-74 and 1975-81 explained by model	91.4	63.6
Attributable to:		
Cyclical factors	40.1	42.1
Energy price shock	47.5	21.0
Capital-labour ratio	3.8	0.5

1. Equation with labour market gap.
2. Equation with constraint on b.

FIGURE 1A

REAL GNE PER EMPLOYEE AND REAL GNE

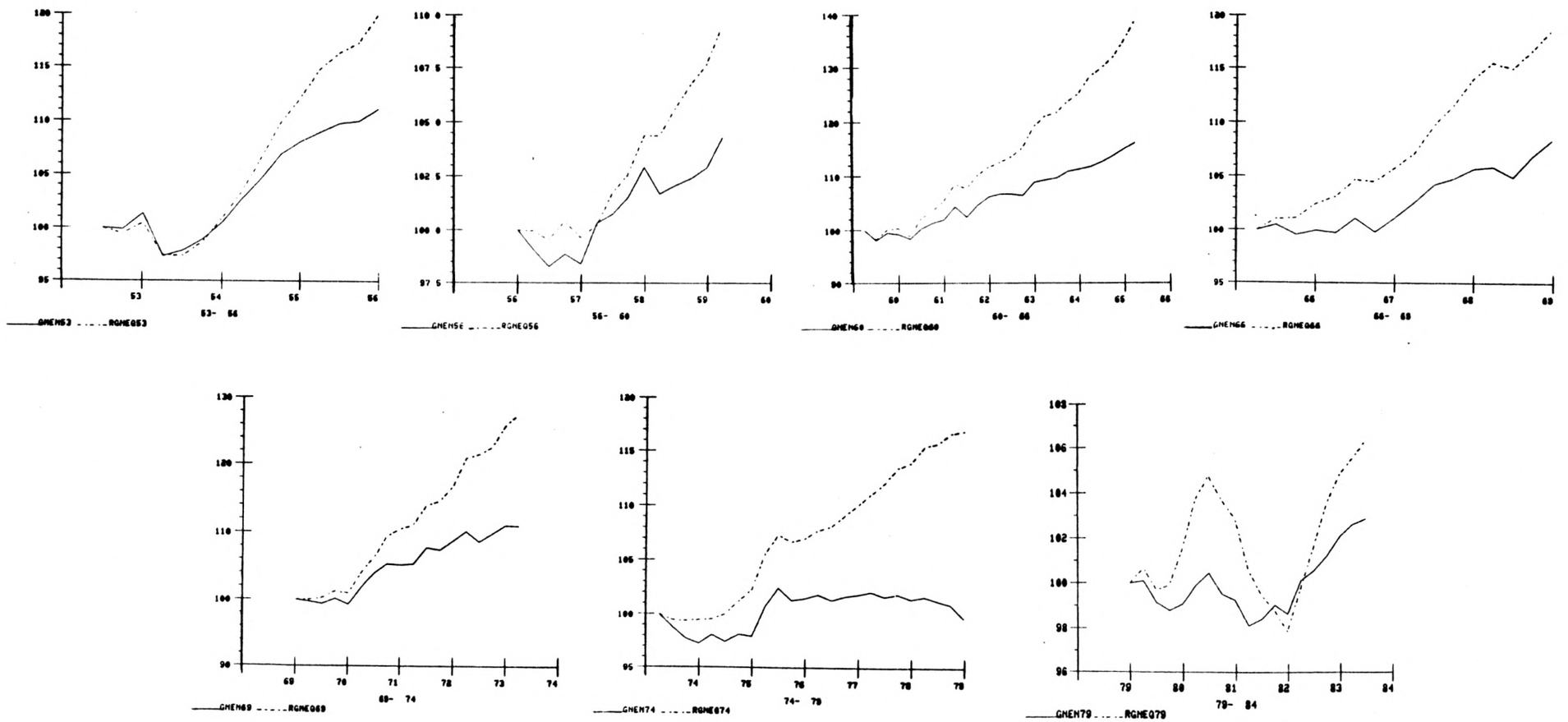


FIGURE 1B

OUTPUT PER EMPLOYEE AND OUTPUT -
GOODS PRODUCING (EXCLUDING AGRICULTURE), TRANSPORTATION, STORAGE,
COMMUNICATIONS AND TRADE

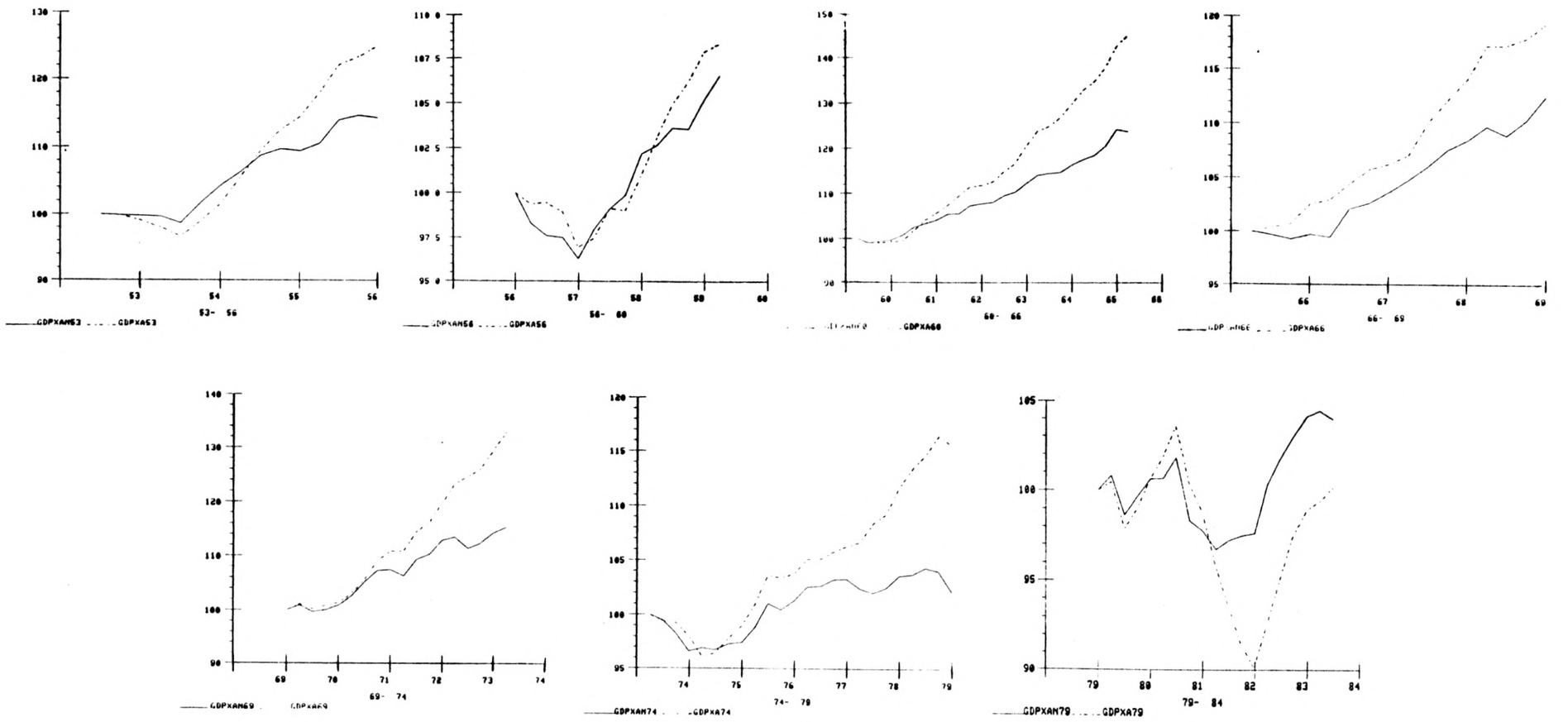


FIGURE 1C

OUTPUT PER EMPLOYEE AND OUTPUT -
COMMERCIAL SECTOR (EXCLUDING
AGRICULTURE, FISHING AND TRAPPING)

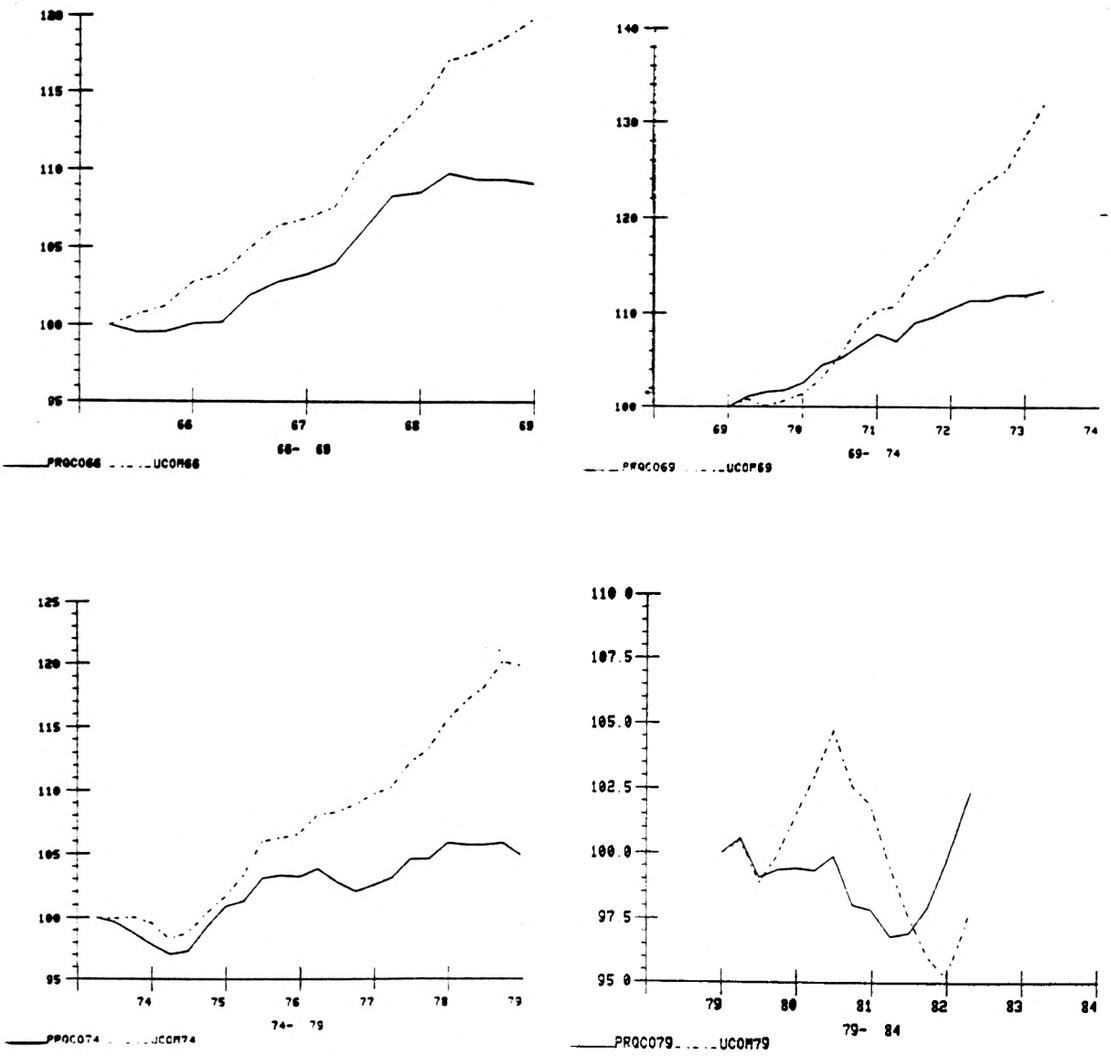
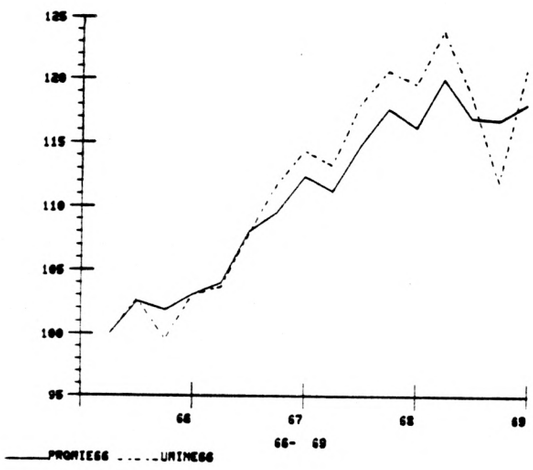
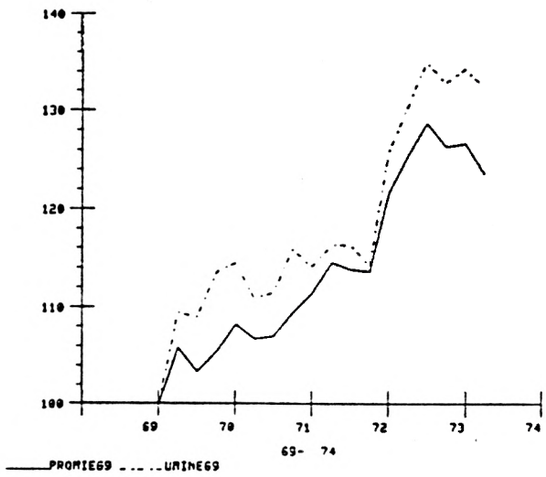
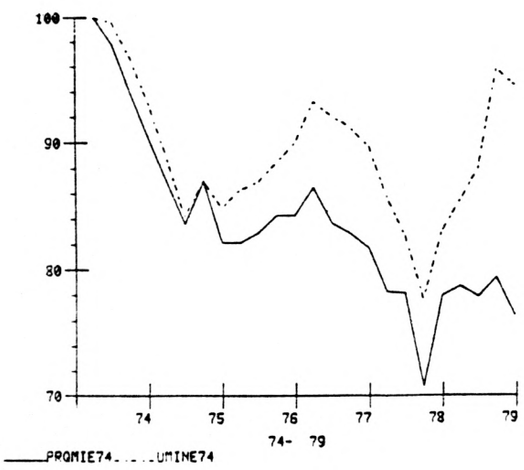


FIGURE 2

OUTPUT PER EMPLOYEE AND OUTPUT MINING SECTOR







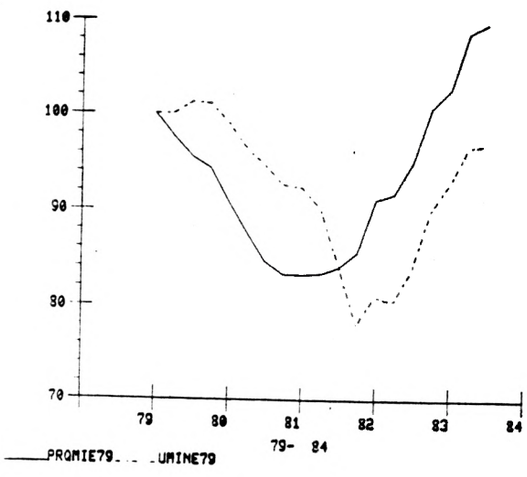


FIGURE 3

OUTPUT PER MAN-HOUR AND OUTPUT - MINING SECTOR

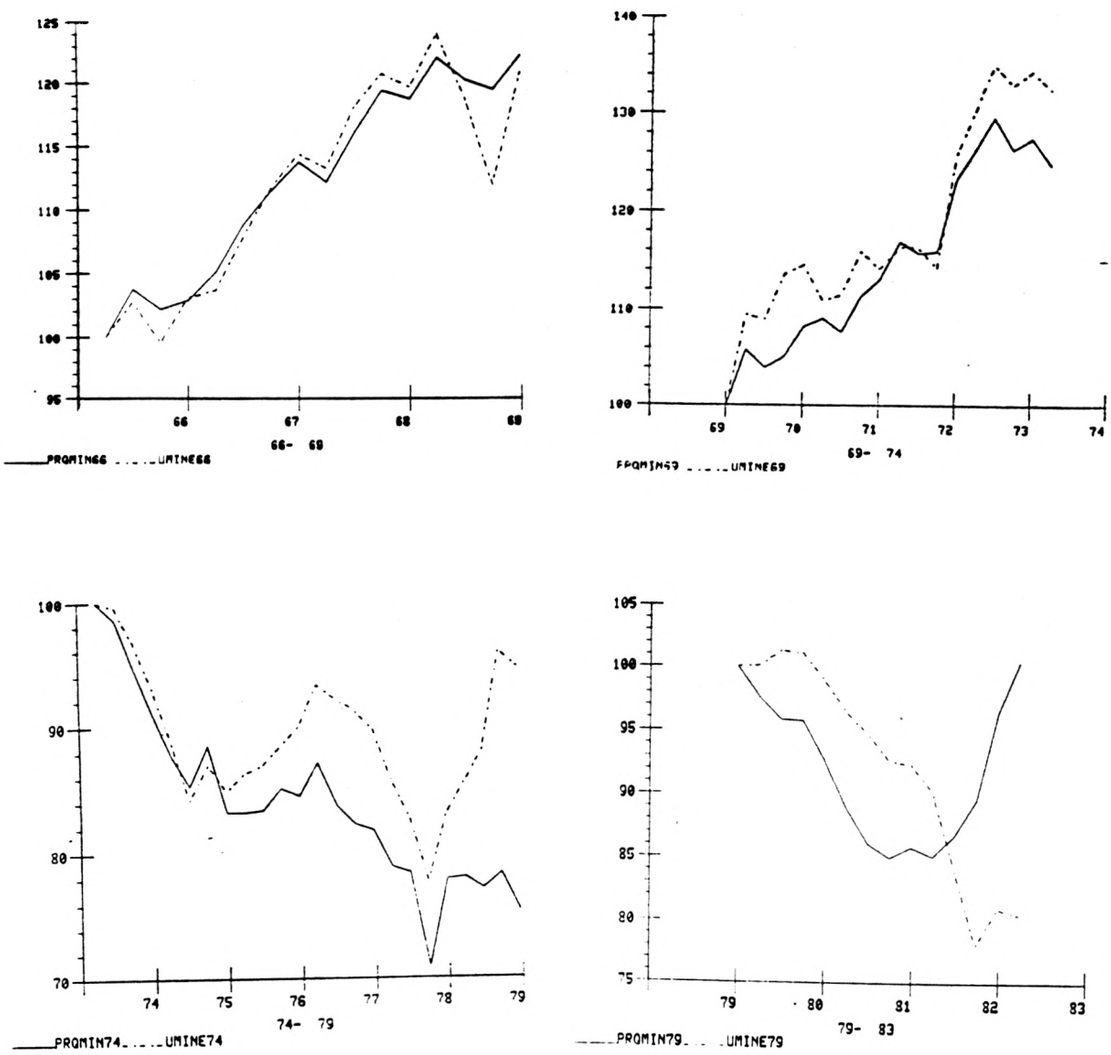


FIGURE 4

OUTPUT PER EMPLOYEE AND OUTPUT -
MANUFACTURING SECTOR

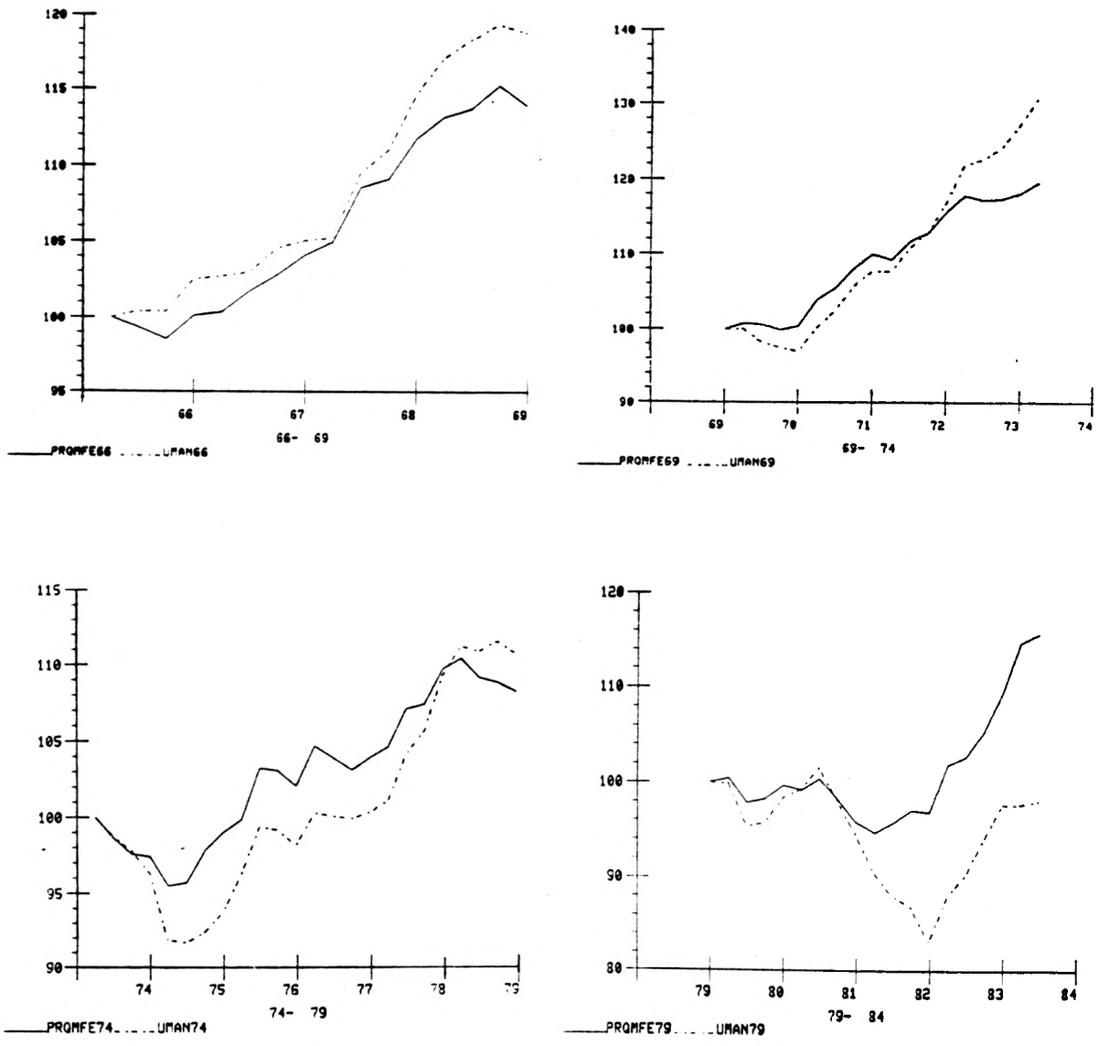


FIGURE 5

OUTPUT PER MAN-HOUR AND OUTPUT -
MANUFACTURING SECTOR

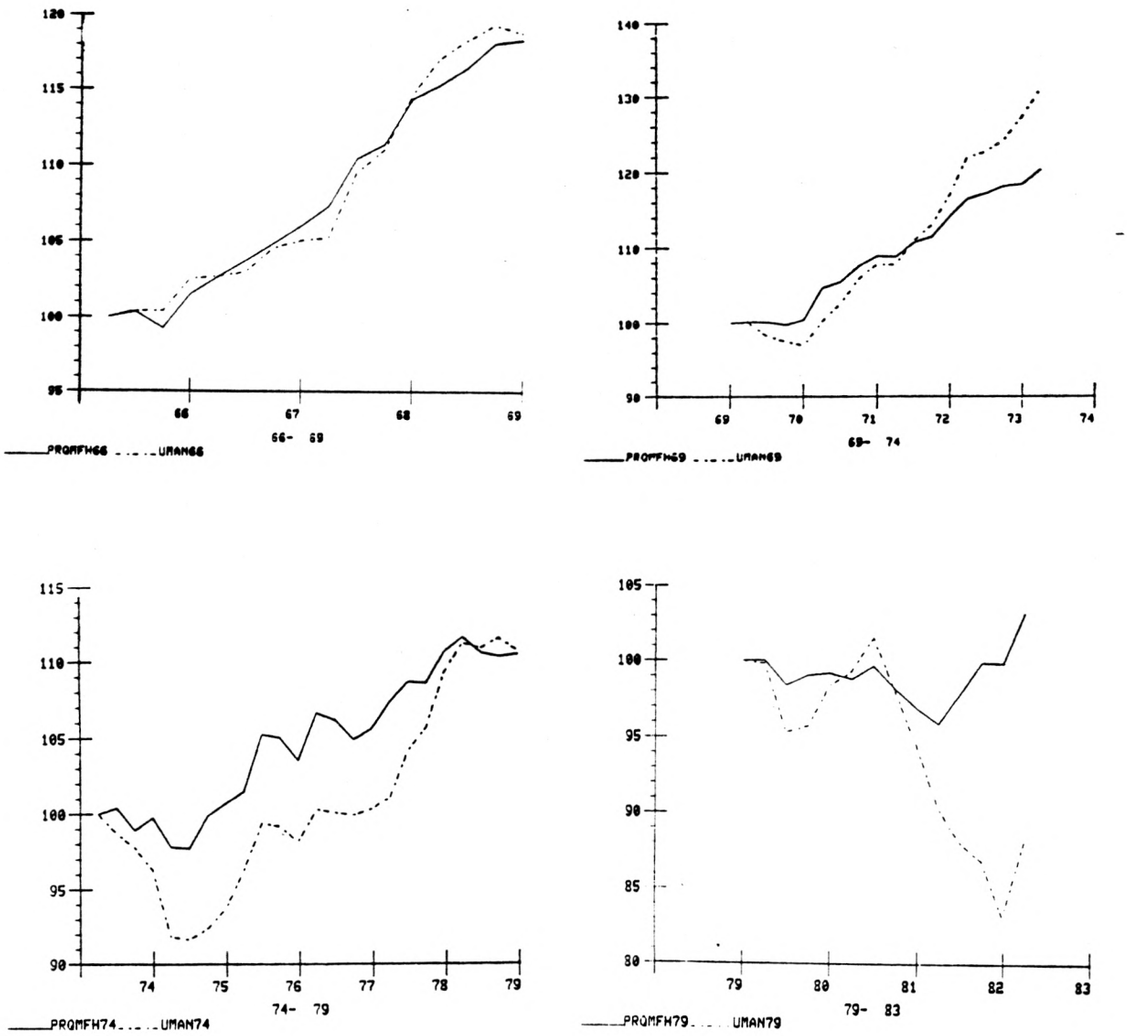


FIGURE 6

OUTPUT PER EMPLOYEE AND OUTPUT -
CONSTRUCTION SECTOR

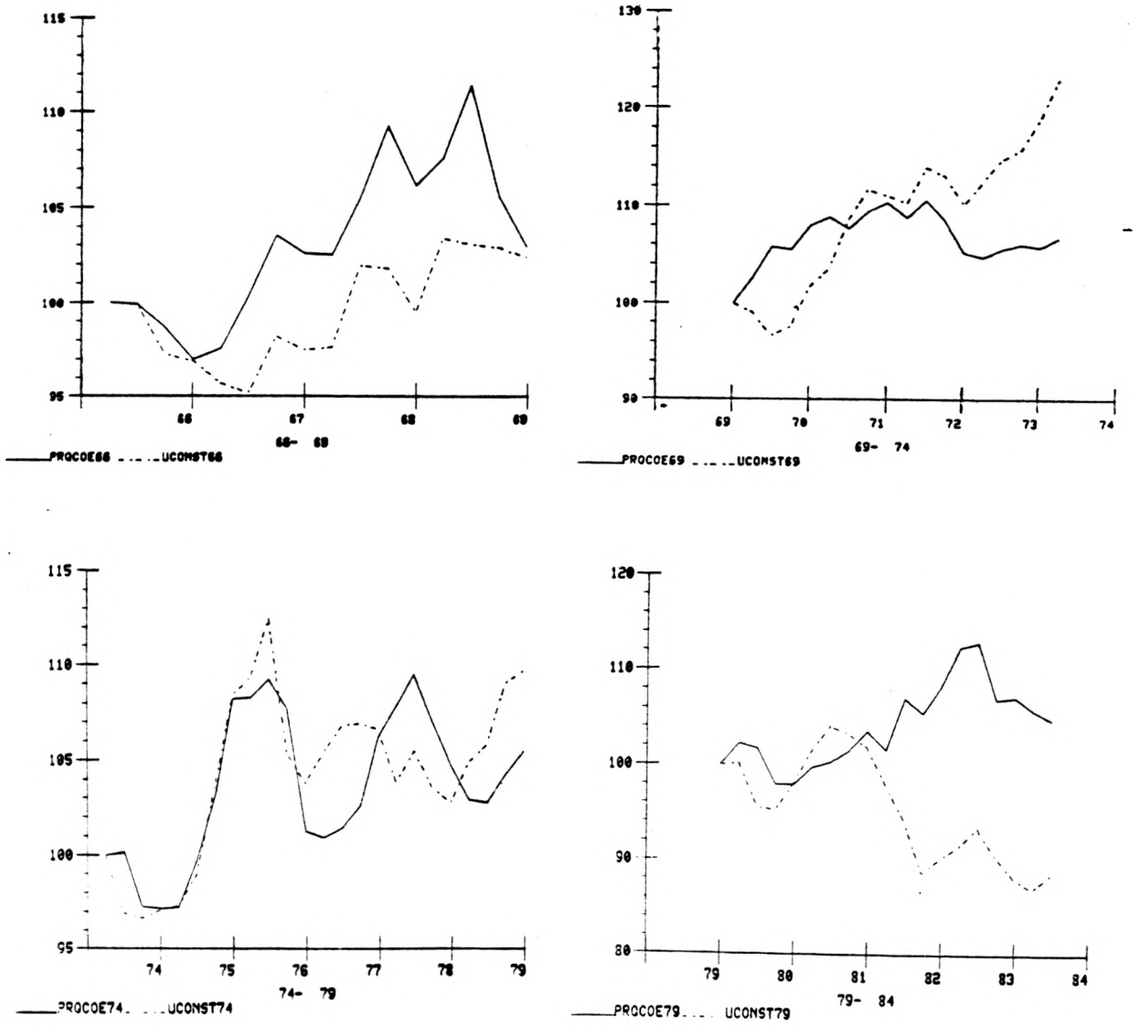


FIGURE 7

OUTPUT PER MAN-HOUR AND OUTPUT -
CONSTRUCTION SECTOR

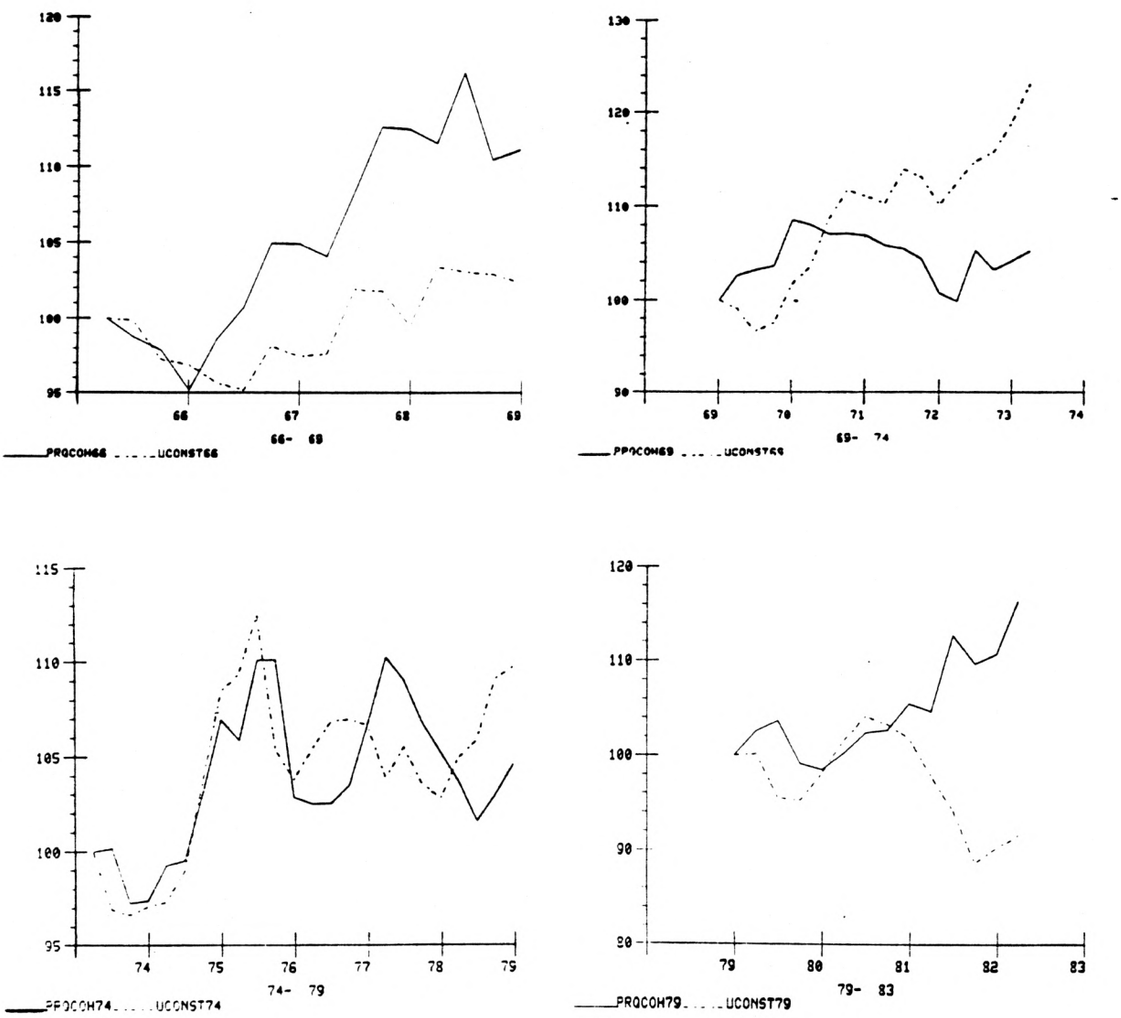


FIGURE 8

OUTPUT PER EMPLOYEE AND OUTPUT -
TRANSPORTATION, COMMUNICATIONS AND
OTHER UTILITIES SECTOR

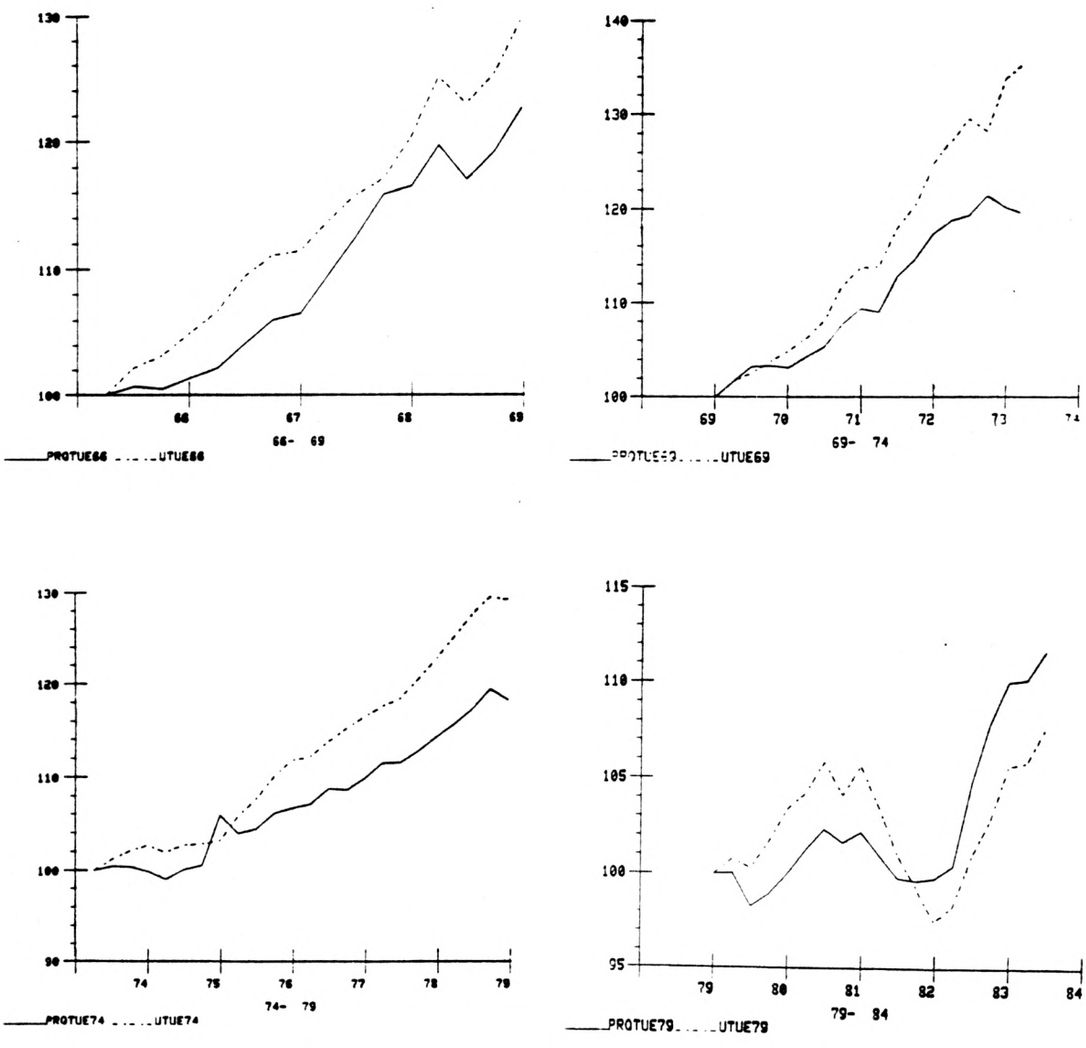


FIGURE 9

OUTPUT PER EMPLOYEE AND OUTPUT -
TRADE SECTOR

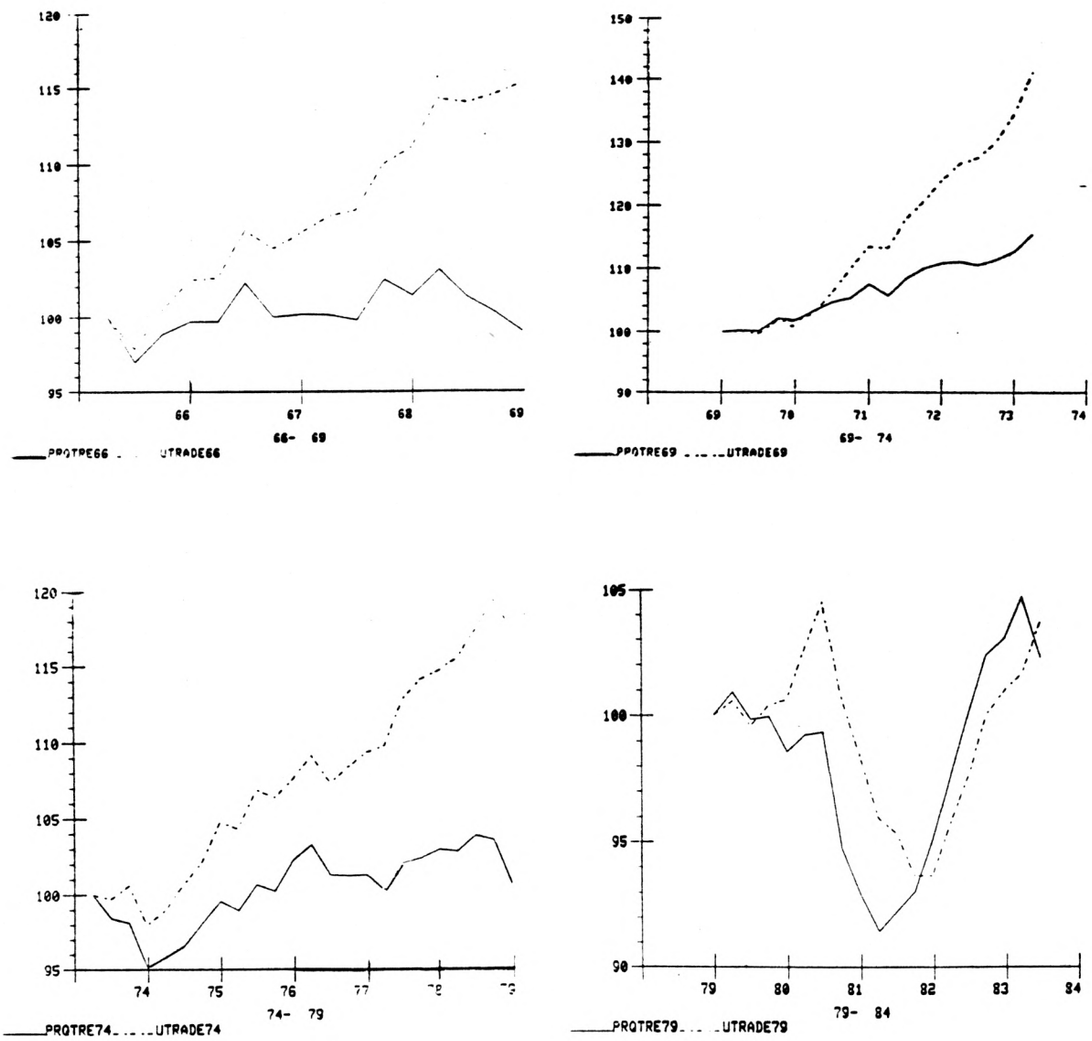


FIGURE 10

OUTPUT PER EMPLOYEE AND OUTPUT -
FINANCE, INSURANCE AND REAL ESTATE SECTOR

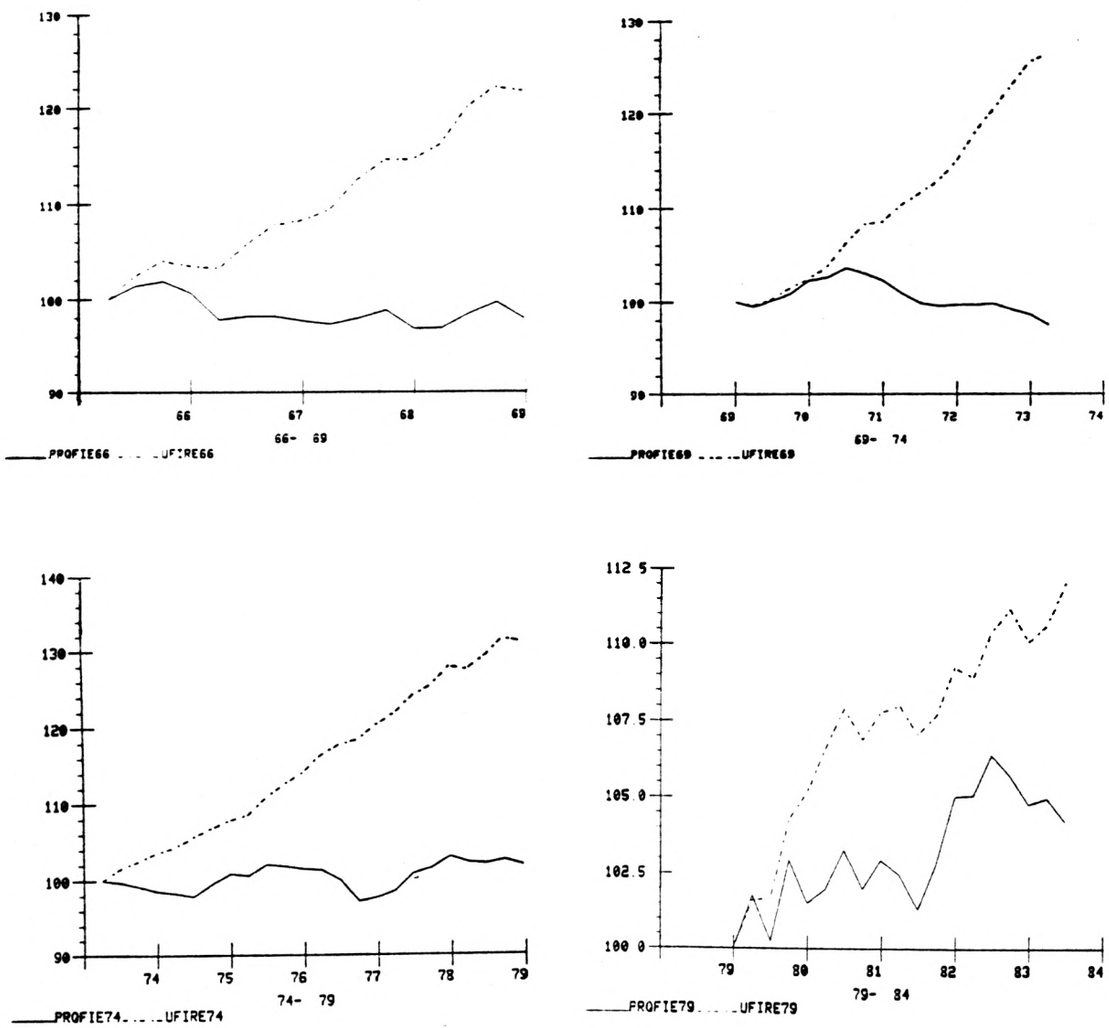


FIGURE 11

OUTPUT PER EMPLOYEE AND OUTPUT -
OTHER COMMERCIAL SERVICES SECTOR

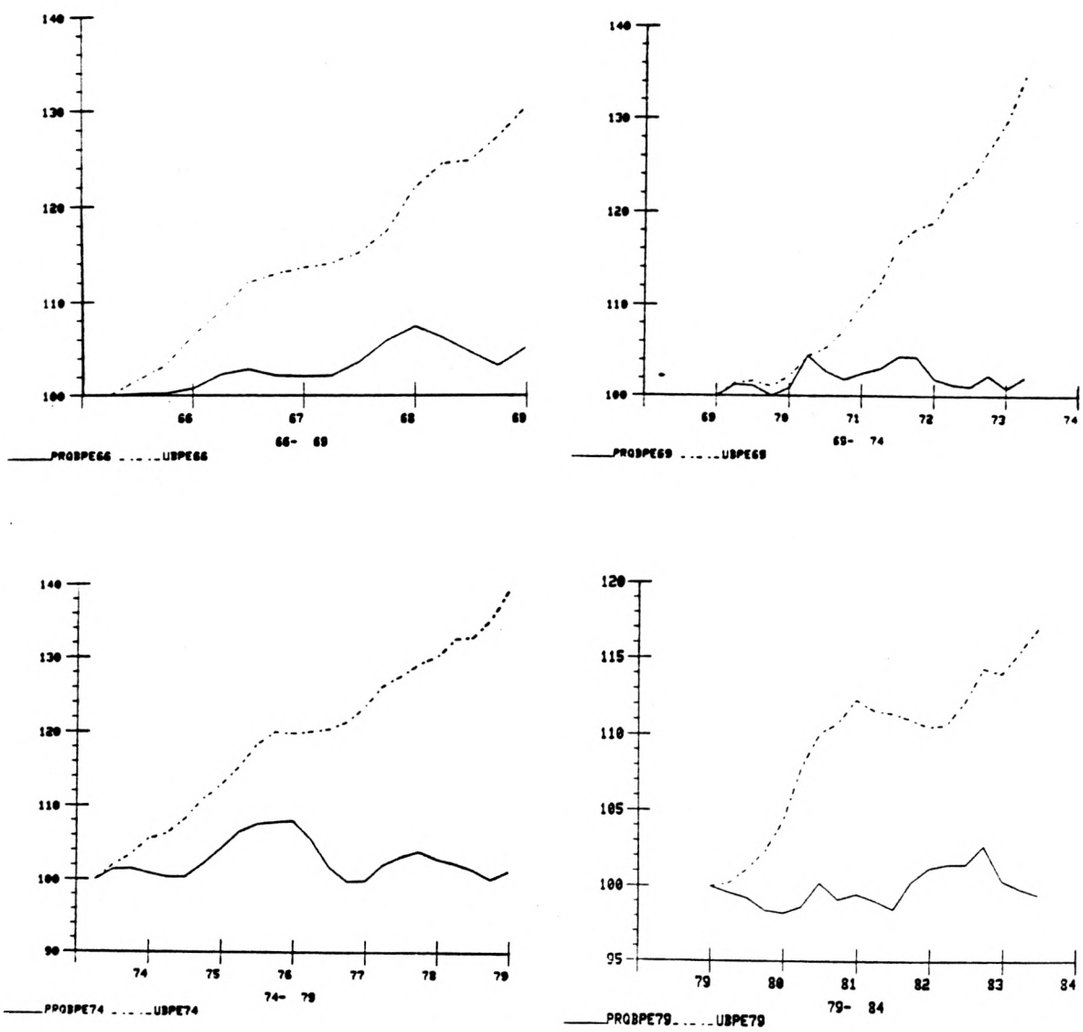
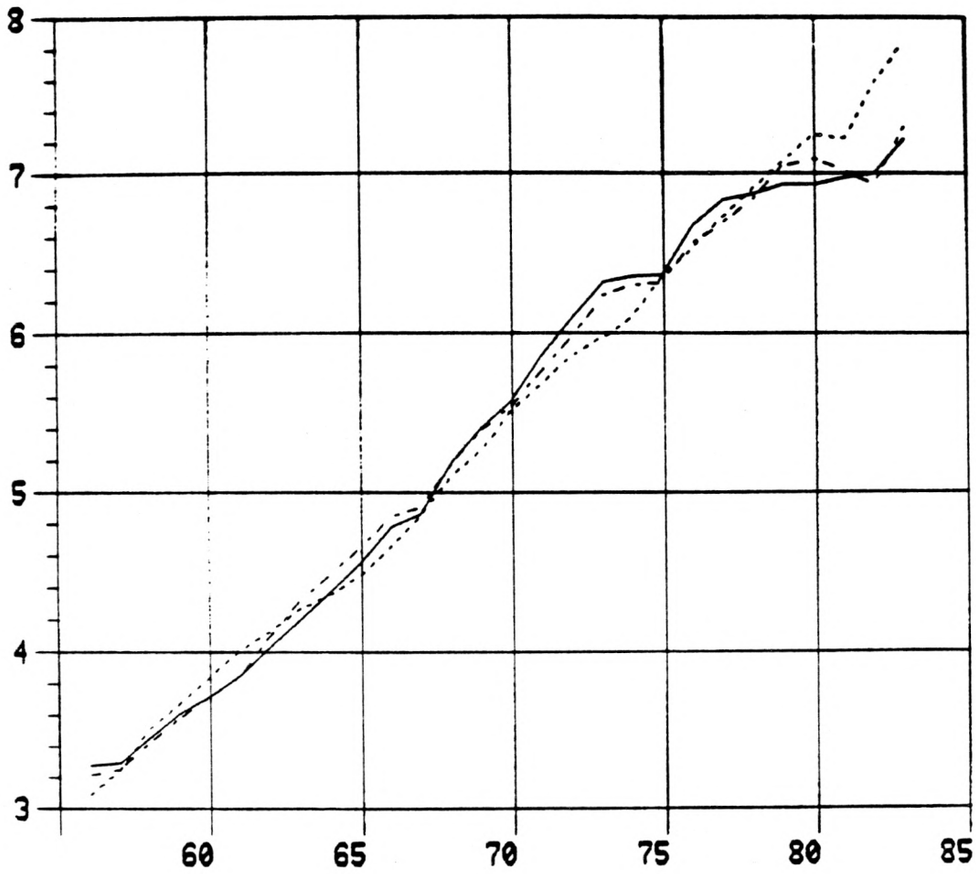


FIGURE 12

Labour Productivity - Commercial



1956 - 1983

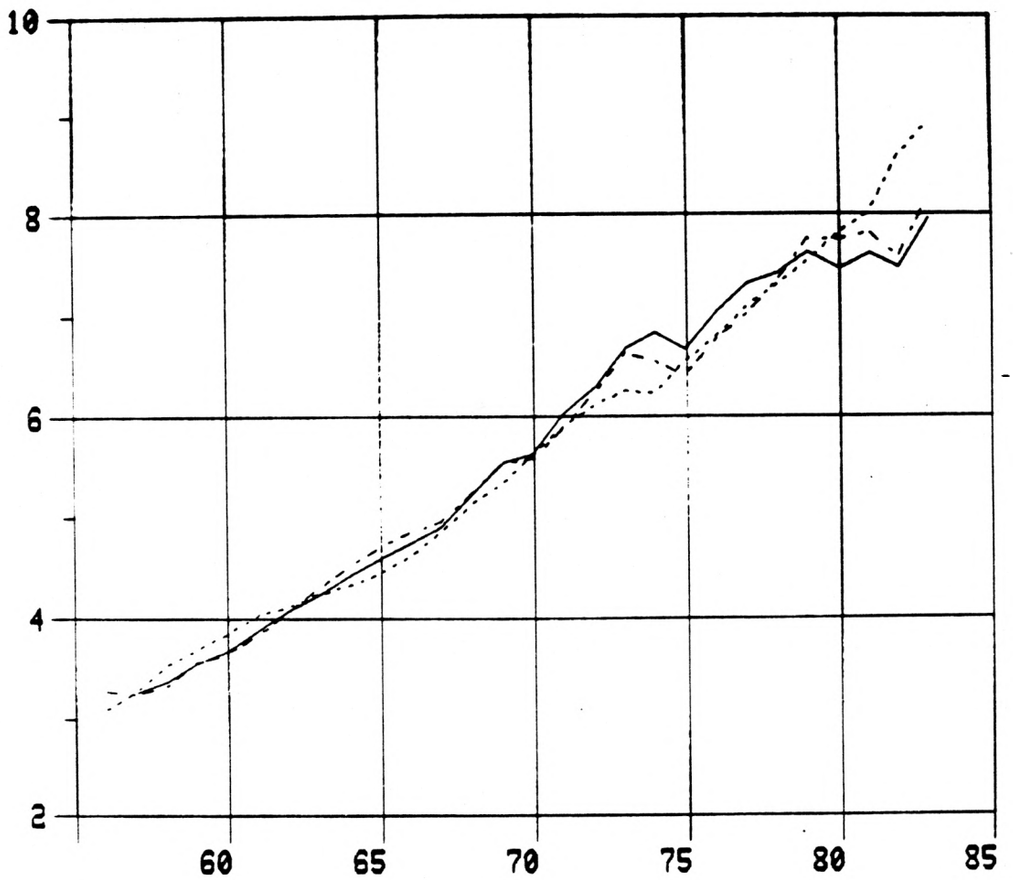
LPCOM — Actual

LPC80 — Model

LPC81 — Cyclically Neutral

FIGURE 13

Labour Productivity - Manufacturing



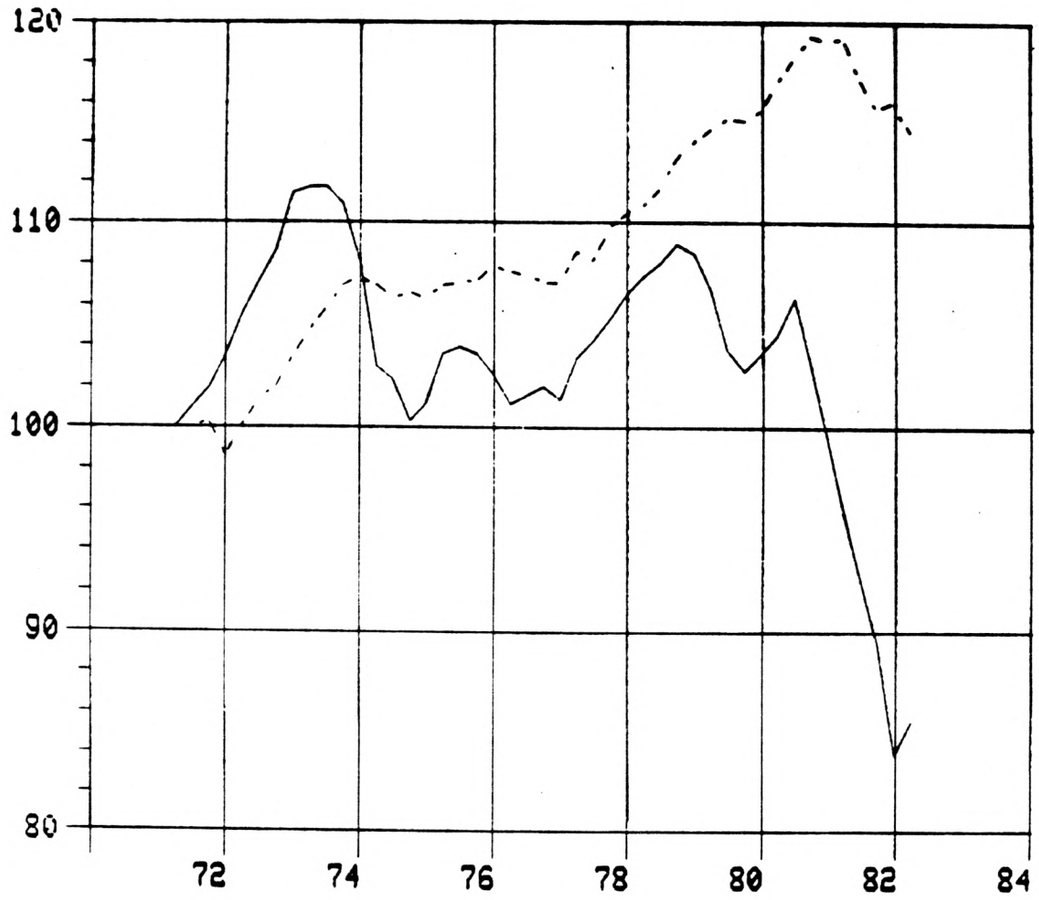
1956 - 1983

_____ LPMFG _ _ _ _ _ LPM810 _____ LPM811

Actual Model Cyclically Neutral

Figure 14

Employment - Manufacturing



WEQMANI ---- SEQMANI

Hourly Paid Salaried

Figure 15

Average Hours Per Week - Manufacturing

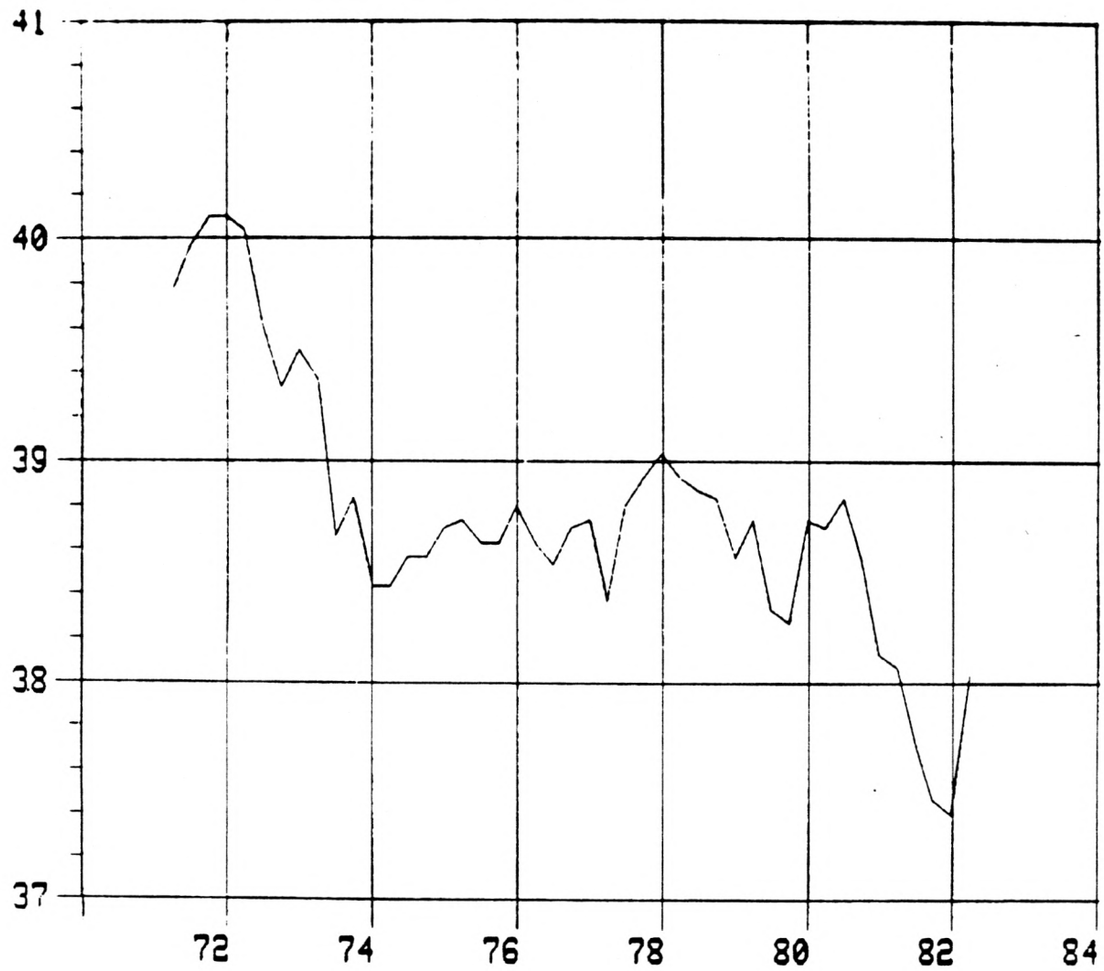
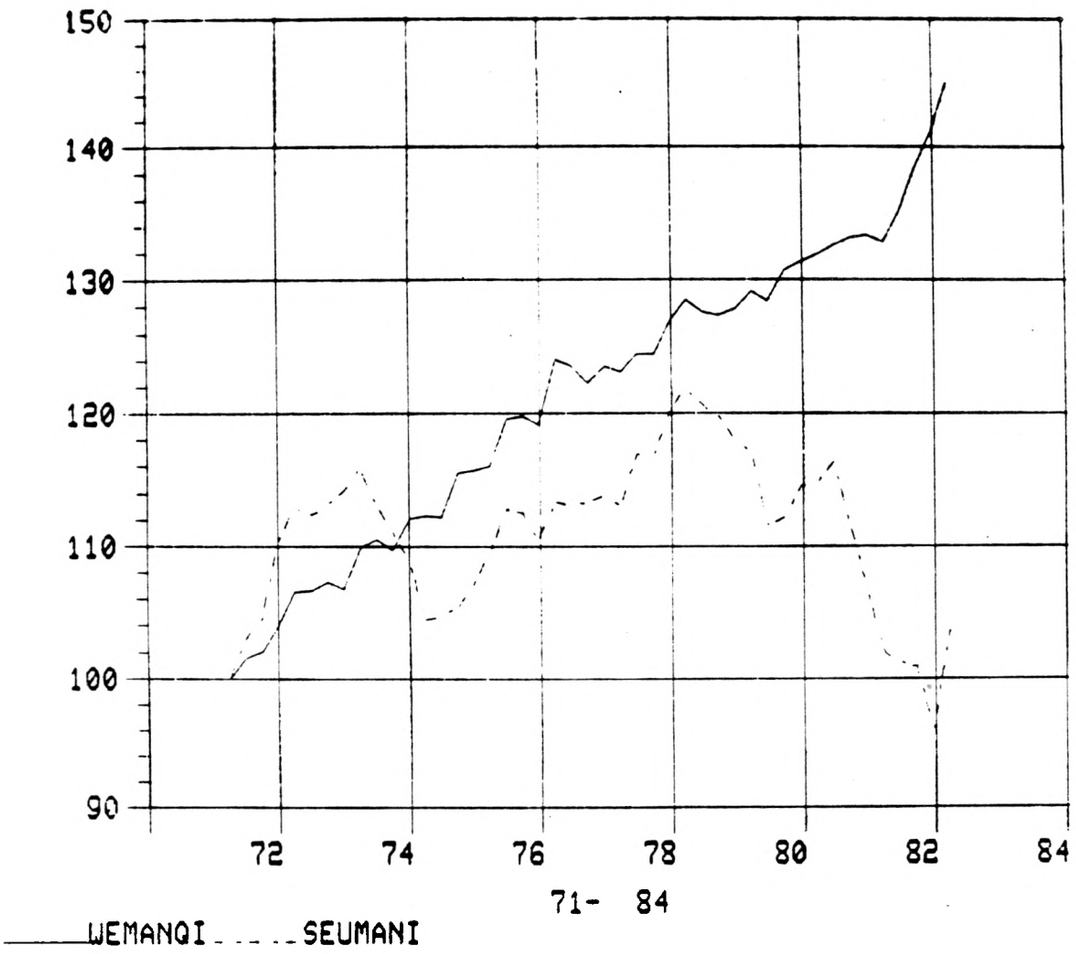


FIGURE 16

LABOUR PRODUCTIVITY - MANUFACTURING



WEMANQI - Output Per Production Worker Man-hour
SEUMANI - Output Per Salaried Employee

DATA APPENDIX

Mnemonics

UQMFTFS = Output - Manufacturing excluding energy
UQCØTFS = Output - Commercial excluding energy
MNEMH = Man-hours - Manufacturing excluding energy
MHCØNE = Man-hours - Commercial excluding energy
KMFNE = Capital stock - Manufacturing excluding energy
KCØNE = Capital stock - Commercial excluding energy
UEGYMFG = Real energy input - Manufacturing excluding energy
UEGYCØM = Real energy input - Commercial excluding energy
CUMXE = Capacity utilization rate - Manufacturing excluding energy
CUCØXE = Capacity utilization rate - Commercial excluding energy
PEGYMFG = Energy price - Manufacturing excluding energy
PEGYCØM = Energy price - Commercial excluding energy
PQMFTFS = Output price - Manufacturing excluding energy
PQCØTFS = Output price - Commercial excluding energy
RNUA = National unemployment rate
RNUTØA = Unemployment rate at trend output

DATA APPENDIX

	UQMFTFS	UQCOTFS	MNEMH	MHCONE
56	10530120	37000320	2843231	10112726
57	10504670	37256950	2817019	10139148
58	10306625	37662465	2673027	9769468
59	11056205	39680795	2721450	9930192
60	11245520	40477590	2674703	9835131
61	11693282	41407195	2639660	9745009
62	12666014	44011085	2740751	9981155
63	13244749	46010745	2819530	10131239
64	14412537	49080944	2961143	10432815
65	15803916	52947574	3113638	10791443
66	16795461	56240276	3237843	11028554
67	17022154	56949712	3229002	11170471
68	18057810	59726327	3209620	11041117
69	19424073	62781486	3260120	11283347
70	18961614	63079438	3168734	11164944
71	19900729	66734892	3130594	11271632
72	21508440	70649349	3229992	11559727
73	23796419	77014979	3359493	12137550
74	24404409	79764260	3404107	12671001
75	22820815	80097724	3287262	12665539
76	24636715	85204564	3305332	12789215
77	25475475	86845403	3236926	12860784
78	26936613	90648679	3347261	13252077
79	27858567	94700032	3444113	13754805
80	26804756	96236808	3418314	13932501
81	27099260	99282650	3381954	14228891
82	24004630	93583230	3076938	13407094
83	25471100	96295055	3066178	13386793

	KMFNE	KCONE	UEGYMFG	UEGYCOM
56	12980.10	33949.90		
57	14101.10	36478.40		
58	14860.00	38422.60		
59	15305.40	39963.59		
60	15805.60	41647.59		
61	16255.00	43183.79	702318.5	1568710
62	16690.40	44714.69	724642.5	1603453
63	17216.10	46468.19	764981.5	1740064
64	18000.10	48786.79	826094.2	1897847
65	19205.80	51880.49	927616.5	2073771
66	20806.40	55815.09	1000858	2219470
67	22341.90	59903.29	974100.3	2208406
68	23375.40	63257.99	1030647	2306457
69	24311.20	66344.68	1062688	2459044
70	25353.30	69625.58	1113227	2587597
71	26752.90	72932.09	1147107	2717866
72	27631.50	76381.09	1250647	2926498
73	28589.20	80593.79	1349492	3135316
74	29943.90	85859.39	1443586	3285985
75	31421.70	91685.29	1364868	3237058
76	32669.40	97442.48	1427813	3348509
77	33755.80	102706.9	1474641	3525832
78	34667.30	107308.0	1608449	3752600
79	35539.00	112150.3	1707732	4060228
80	36788.90	117888.9	1735111	4165796
81	38475.30	124165.2		
82	39833.90	129459.4		
83	40255.20	132563.6		

DATA APPENDIX

	CUMXE	CUCOXE	PEGYMFG	PEGYCOM
56	95.20000	93.20000	.843340	.887790
57	87.00000	86.30000	.855210	.900280
58	80.40000	81.80000	.837010	.881120
59	83.00000	82.10000	.832700	.876590
60	81.30000	80.50000	.823200	.866590
61	81.58320	79.42378	.816615	.859655
62	86.39614	84.30603	.807335	.852826
63	89.38041	87.36590	.813922	.855760
64	93.50811	92.22138	.799199	.846480
65	95.60646	94.74681	.782132	.827960
66	94.91791	94.23577	.803054	.834957
67	90.46142	89.61771	.859262	.875734
68	90.57347	89.91573	.872154	.889695
69	92.72493	91.03937	.898197	.901516
70	86.73476	86.78257	.928882	.932824
71	87.15651	87.75109	1.000000	1.000000
72	90.19356	89.40373	1.024233	1.020836
73	95.57770	93.53954	1.090301	1.108971
74	94.31074	92.08218	1.497196	1.509725
75	84.69103	84.28179	1.868303	1.842344
76	87.07449	86.01944	2.176813	2.113607
77	86.48959	84.14780	2.487995	2.446532
78	88.61536	83.35242	2.816653	2.782892
79	91.83163	85.72640	3.092859	3.054445
80	86.39557	81.67171	3.517221	3.537686
81	84.01211	80.13367	4.573730	4.600370
82	72.59117	69.43025	5.480090	5.512010
83	76.65387	72.12818	5.906220	5.940610

	PQMFTFS	PQCOTFS	RNUA	RNUTOA
56	.764090	.702050	2.967272	4.500000
57	.779370	.722530	4.240316	4.500000
58	.782490	.730470	6.350278	4.500000
59	.790320	.726610	5.242434	4.500000
60	.791110	.731890	6.331585	4.500000
61	.794269	.727971	6.355053	4.500000
62	.807183	.738965	5.322478	4.689994
63	.831090	.757706	4.987451	4.680545
64	.845687	.769983	4.288370	4.656296
65	.834925	.769232	3.578759	4.610061
66	.873595	.824817	3.333693	4.529501
67	.898228	.855453	3.824300	4.445142
68	.917722	.881732	4.477953	4.571297
69	.943080	.921756	4.417923	5.143793
70	.959464	.961995	5.711437	4.994424
71	1.000000	1.000000	6.189765	6.379023
72	1.038402	1.049852	6.233341	7.083247
73	1.107371	1.149549	5.541456	7.091821
74	1.289084	1.331653	5.334480	6.931091
75	1.460600	1.495370	6.923292	6.778566
76	1.542398	1.615118	7.124775	6.531131
77	1.638029	1.726046	8.098962	6.456296
78	1.776717	1.867774	8.338363	6.555951
79	2.000026	2.065582	7.419053	6.282574
80	2.251378	2.288443	7.459192	6.277950
81	2.436000	2.489560	7.543269	6.167095
82	2.562700	2.660340	11.05587	6.117747
83	2.644670	2.791800	11.86710	6.445000

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