ANALISIS JILID 2, BIL. 1.

THE CYCLICAL BEHAVIOUR OF LABOUR PRODUCTIVITY IN THE CANADIAN MANUFACTURING INDUSTRY

Jessica Lee K.G.
School of Economics and Public Administration, UUM

1. Introduction

With the growth in Canadian industrial sector in relation to the rest of the economy, changes in output per man-hour in manufacturing necessarily become progressively more important in influencing both the standard of living and the balance of payments of the Canadian economy.

An attempt is thus made to investigate empirically the importance of gross stock, unemployment rate and hours of work on the output per man-hour (measuring of labour productivity) in the Canadian manufacturing industry over the period 1946-1983. The productivity concept, meaning and measurements are discussed in part 2. Oi's theory is discussed in part 3. A specification of a regression model of the labour productivity and data are discussed in part 4. Empirical rersults and analysis of the results are discussed in part 5 and followed by Implications and conclusions in part 6.

2. Theory Of Productivity

Productivity is an important element in economic growth. It is a relationship between the output and input of the production process measured in physical terms: often expressed in ratios. Therefore when the output is related only to one class of input, it indicates the amount of capacity achieved as the result of efficient use of that particular input or as a result of the substitution of one type of resource for another. Productivity has been the most important element of economic growth of the nation since the 1930s. The increase in the standard of living and in real product per capita has been traceable to improvements in productivity efficiency; It also measure the creativity of our society. A more fundamental approach can be seem in the changing values of society and the influence of large institutions on the society.

Though behaviour over time can baffle even experts, productivity is a seemingly straighforward concept: real output per worker hour. Brides labour, productivity can also arise from non-labour factors, notably technology and tangible capital. In the short run, changes in productivity are dominated by cyclical influence. In the long run, the cyclical bounding dwindles in importance, but it does not fade out altogether because the economy's short run fluctuations influence basic factors of growth such as capital formation. Although productivity growth over a span of years is affected by a great many interacting factors, most of the change can be explained in terms of level of skills, experience and education of the labour force.

Increased productivity is one of the keys to economic progress. It allows the nation to raise its standard of living, to support such social goals as education and health care and also to contribute to other aspects of the general welfare. Productivity is an essential underpinning of the nations security. Increased productivity allows these "non-economic" objectives to be achieved without absolute reduction of workers's living standard. Moreover, productivity growth offers intangible reward through its contributions to national morable. A nation whose productivity is declining is likely to be beset by doubts and a decline in self-confidence as well as in material well being. In addition to this, productivity is also a potent counter-inflationary force. Hence increased productivity offset to a greater degree, the effect of rising factor prices on the unit costs which are the main elements in product prices. Productivity also plays a critical role in the economic development that eventually leads to downturns and subsequent recoveries of the economy. Thus cyclical movements of productivity are related to changes in costs, profits, ouputs and the other key aspects of economic activity.

In practice, measuring changes in productivity is not so simple. For example attaching a machine to an outfit does not measure productivity directly anymore than to a man finding out how much energy he is putting into the job. So we measure productivity only indirectly by looking at the chance in relation to the input labour plus the material (Kendrick, 1962). Changes in total productivity indicate primarily advances or changes in the technology of production, whether they are result of change in the plant lay-out, or improved equipment or new plant. Over the short run, changes in the rate of utilization of capacity would be important.

As we know, when industrial operations fall from 90 to 70 percent, this is often accompanied by a decline in output relative to inputs, because certain overhead costs are cut back proportionately with output. But if one look at trends over a long period of time, particularly of high level activity, the major source of increase in productivity is the improvement in technology. This technology advance, is a result of investment designed to increase knowledge and know-how in respect to the production processes (Kendrick, 1962).

There are two types of productivity measures which are commonly used i.e labour productivity and total factor of multifactor productivity. Labour productivity commonly measures output per man-hour in a plant, industry or some national aggregate such as the private sector. Total factor productivity includes not only labour input but also the services of plant and equipment, sometimes energy and materials. Each type of measure has its advantages and its limitations. In each case, the output measure includes the effects of technological changes; the improved quality of capital goods; the increasing skill and education of the labour force; and many other sources of productivity efficiency not purchased directly. The method of total factor productivity is appropriate when assessing the structure of production and changes in costs and prices, especially when all purchased inputs are included in the analysis. It also provides framework for analysis of substitution among factors of production. Even capital-labour substitution depends on the quantities of energy and materials involved in the production process. Labour productivity on the other hand, better can be seen as a more significant determinant of the nation's standard of living. In this paper, only the labour productivity measure method will be discussed. Ratios of output to each of the categories of inputs are called "partial productivity" which measures output per man-hour. Partial productivity ratios reflect changes in input mix resulting from factor substitutions, as well as technological advance and other forces impinging on productive efficiency. This ratio is useful in showing savings achieved over time in each major class of input per unit of output (more clearly when the ratios are inverted). The ratio does not indicate the productivity of the individual factor nor productivity efficiency generally, since factor substitutions are involved. The substitutions occur because of changes in relative factor prices and in the composition of output because of the nature of technology changes. In general, capital has grown faster than labour in the Canadian economy and in practically all industries, which is associated with the fact that the prices of labour has generally risen significantly more than the price of capital. Output per man-hour may increase as a result of the substitution of capital for labour or increased efficiency of production generally.

Output-labour ratios were more appropriate measure of changing efficiency when capital was quantitatively less important than it has since become. In other words, labour is quantitatively the largest input, so changes in labour productivity over time are likely to reflect the movements of a properly defined measure of productivity. In this sense, labour productivity will therefore be a better measure of total productivity.

3. Comparison With An Earlier Studies

Oi (1962) suggests that output per employee (QE) will fall whenever there is unexpected decline in demand during the recessionary period. This is because firm's total product demand has decreased and consequently the value of marginal product (VMP) will also decline. This may not affect the number of employee (E) but if E were to fall, the amount of decline will not be large since hoarding occurs. This implies that firms do not lay off their employees even if VMP were to fall below the wage rate because they belief that recessionary period will not continue forever and also they need not have to pay for both the training and hiring costs when the employees were back at work again. On the other hand, he would predict firms' total product during boom period will increased and therefore he concludes the QE will also rise. Firms will begin to hire the workers again only after there is a sign of improvement in demand and the hoarded workers are being fully utilized.

For the output per man-hour (QMH) case, Oi predict that QMH will probably increase during the recessionary period. Total product demand will decrease as explained in last paragraph. Since each hours of work (H) is more productive, firms have to reduce the hours of work for each employee so they are able to hoard employees and adjust the output level to a lower demand and sales volume. As we know, output (O) is a function of number of persons employed and hours of work (H), then the equation can be shown as below:

$$O = f(E, H)$$

If E is unaffected or there is a slight fall in E, output will decrease since H falls. In other words, if the rate of decrease in hours of work is larger than the rate of decrease in the output, then QMH will increase. QMH ratio might fall when the economy is at the expansionary period, as the increase in H is larger than rise in the output.

4. Model Formulation

In this section, we will deal with the models underlying the analysis. We will look at the two basic relationships which could address the issue of the cyclical behaviour of labour productivity in the Canadian manufacturing industry. Equation for the output per person will be outlined first while the output per man-hour will be analysed later. The purpose of running the two regressions is to see whether output per person or output per-man hour is an appropriate measure of labour productivity in the Canadian manufacturing industries. Furthermore, we could see whether Oi's theory is refutable.

We could specify the function in the following manner:

$$QE = f(H, UR, GS, T, TSQ) \quad \text{.....................} \quad (1)$$

$$QMH = f(UR, GS, T, TSQ) \quad \text{.....................} \quad (2)$$

where

QE = Index of output per person in manufacturing industries.

QMH = Index of output per man-hour in manufacturing industries.

H = Index of hours of work measured by the total man-hours divided by the number of person employed in manufacturing industries.

UR = unemployment rate in percentage by the sum of unemployment rate for the month of January to December divided by 12 and is used to capture the cycle.

GS = mid-year gross stock of manufacturing industries (In millions of constant 1971 dollars)

T,TSQ = time trend and time square-trend respectively which are used to capture the linear and non-linear technological advances.

In this regression, we will be using yearly time-series data for Canada and the period covered is from 1946 to 1983. All the data are obtained from Statistics Canada and CANSIM data tape. We only concentrate on the manufacturing industries since in this sector, the training and hiring costs are high. Only then our aim of testing the Oi's theory could be made with greater accuracy.

For comparisons, we also run the regression equations in logarithmic form. The functions are outlined as shown below:

$$\ln QE = \alpha_0 + \alpha_1 \ln H + \alpha_2 \ln UR + \alpha_3 \ln GS + \alpha_4 T + \alpha_5 TSQ \quad \text{.............. (3)}$$

$$\ln QMH = \beta_0 + \beta_1 \ln UR + \beta_2 \ln GS + \beta_3 T + \beta_4 TSQ \quad \text{............. (4)}$$

where

α_0, β_0 = constants

α's , β's = coefficients of the independent variables.

5. Empirical Results

The output per person equation, specified as in equation (1) was estimated using ordinary least squares and the estimated parameters are presented in Table 1. Since the Durbin-Watson statistic shows that there is first order positive serial correlation in the model, we therefore use the Cochrane-Orcutt iterative technique to adjust for the first order autocorrelation.

The estimated parameters for the equation in column 1 of Table 1 have correct sign except the GS variable. The negative coefficient on GS might be due to factor substitutions or multicollinearity problem. Since capital has grown faster than labour in the Canadian economy, practically in almost all the industries, therefore substitutions between labour and capital will occur. This will result in changes of relative factor prices and alsō the composition of output as well due to the nature of technological changes. The high correlation matrix between GS variable and dependent variable (0.9833) might give rise to multicollinearity problem.

TABLE 1
Output Per Person Equation

	OLS (AR 1)	OLS (AR 1)
C	−26.207 (0.71)	−109.233* (−1.71)
H	–	1.2597* (2.19)
UR	−0.924* (−2.29)	−0.781* −2.01)
GS	−0.0006 (− 0.59)	0.0001 (0.09)
T	3.857* (3.33)	3.197* (3.04)
TSQ	0.005 (0.03)	−0.003 (−0.09)
R^2	0.878	0.906
D.W−Stat	1.679	1.739
F−Stat	57.838	57.656

NOTE: numbers in parentheses are t−ratios
* indicates significances at the 95% level
OLS : Ordinary least square estimate
AR 1 : Cochrane-Orcutt procedure

The negative coefficient on the unemployment rate implies that as number of unemployed in the manufacturing industries increases, there will be less workers to contribute to the production process. This will give rise to a lower output per person. The positive coefficient on the T variable implies that output per person will increase if the workers are skilled, experienced and well-educated.

The inclusion of H variable yields significant results for all the independent variables and all have correct signs. These can be seen in column 2 of Table 1. The positive coefficient of H shows that as workers spent more hours working, the firms' production will simultaneously increase. In other words, output per person which measures the labour productivity will also increase. Therefore this output per person regression equation with the inclusion of H variable is more preferable measure of labour productivity than the former regression equation.

Summary statistics and coefficients of the independent variables for the adjusted regressions when output per man-hour is used as the dependent variable, are presented in column 1 of Table 2. The results are similar to that of Table 1 but the gross stock variable appears to be insignificant, while the rest of the variables are significant at the 95% confidence level. The negative sign on UR which is significant, might be due to not only hoarding of employee but also hours of work (H). There is also evidence of an upward trend or monotonic relationship in technological advances as seen by the positive sign in both the T and TSQ variables.

TABLE 2
Output Per Man-Hour Equation

	OLS (AR 1)	OLS (AR 1)
C	−22.021	−1.859*
	(1.62)	(−1.72)
UR	−0.8707*	−0.046*
	−2.37)	(−2.15)
GS	−0.0001	0.521*
	(−0.05)	(3.81)
T	3.066*	7380.14
	(−3.02)	(0.73)
TSQ	0.005	−3689.93
	(0.17)	−0.73)
R^2	0.916	0.974
D.W−Stat	1.715	1.389
F−Start	87.592	302.955

NOTE: numbers in parentheses are t−ratios
* indicates significance at the 95% level
OLS : Ordinary least square estimates
AR 1 : Cochrance-Orcutt procedure

When we look at the correlation matrix between the gross stock and the dependent variables (QE, QMH), there is a very high correlation matrix between these two variables. The correlation matrix are 0.9833 and 0.9893 respectively. Probably as a result of serious multicollinearity problems, the gross stock variable is insignificant at 95% confidence level. The high values of both the F – statistic and R – square in Tables 1 and 2 show that the explanatory variables except GS have a very strong joint influence upon the dependent variable.

The output per person and output per man-hour regressions, as formulated in equation (3) and (4) simultaneously, are estimated in logarithmic form. Since the regression being estimated demonstrate positive autocorrelation as shown by the Durbin-Watson statistic, we also used the Cochrane-Orcutt procedure to adjust for first order serial correlation.

The results are shown in Table 3 and column 2 of Table 2. All the coeficients have the correct sign and are sifnificant at 95% confidence level. In other words, the results obtained in logarithmic form for both QE and QMH are quite encouraging compared to the previous level regression as formulated in equations (1) and (2). Overall, we can see that the logarithmic regression is more preferable than the level form in explaining the cyclical behaviour of labour productivity in the Canadian manufacturing industry. Moreover, all the F – statistics (and the associated R – squares) in Table 2 and 3 show that these equations are very significant, that is, the independent variable can explain a lot of the dependent variable.

6. Conclusion

Because productivity is critical to the nations international competitiveness, rate of inflation and standard of living, it has been a major concern not only of analysts but also of public and private policymakers. Indeed in one way or another, productivity appears in all aspect of economic problems. Despite its importance and the wide attention paid to it, productivity is a subject surrounded by considerable confusion.

From the analysis of the data we conclude that output per man-hour and output per employee are varying in the same direction (although with different magnitude) between the period 1946 to 1983. We also found that increase in gross stock does result in the decline in labour productivity. These were shown in both Table 1 and Table 2 where the regression estimates are formulated as in equation (1) and (2). The results in logarithmic form on the other hand support Oi's theory. Since not much study is being done in this area, we therefore need to do further research to deal with this issue before a concrete solution can be reached. Furthermore according to Oi's theory, QMH will rise during the recession. In our

TABLE 3
Output Per Person Equation

	OLS (AR 1)	OLS (AR 1)
C	−0.575 (−0.42)	−10.552* (− 3.16)
LH	–	1.729* 2.94)
LUR	−0.051* (−2.10)	−0.041* (−1.83)
LGS	−0.372* (−2.14)	0.602* (4.45)
T	9681.50 (0.87)	6254.99 (0.61)
TSQ	−4840.56 (−0.87)	−3127.38 (−0.61)
R^2	0.959	0.974
D.W−Stat	1.494	1.437
F−Start	185.090	222.919

NOTE: numbers in parentheses are t−ratios
* indicates significance at the 95% level
OLS : Ordinary least square estimates
AR 1 : Cochrane-Orcutt procedure

results, QE is moving in the right direction while QMH is not, which contradicts the Ŏi's theory. We could therefore predict that hoarding of H migh occur too. The inconsistency may give us a conclusion that Oi's theory is refutable. Nevertherless, given the formidable theoritical and empirical problems which beset work in this area, it seems reasonable to regard these findings as exploratory rather than definitive in nature. More work at untangling the important relationship between labour productivity in manufacturing industry is called for. Hopefully the research done by Oi will serve to stimulate such efforts.

REFERENCES

Brakel, L., "A comparison of productivity and recent productivity trends in various countries" *Restat 44,* May 1962, pp 123 – 123.

Committee for Economic Development, "Productivity Policy: Key to the Nation's Economic Future" April 1983.

Feldstein, M.S., "Specification of the labour input in the Aggregate production function," *Review of Economic Studies,* Volume 34, pp 375 – 386.

Kendrick, J. W., *What is productivity? Solving problems of productivity in a free society.* University of Wisconsin, June 1962, pp 7 – 9.

Kendrick, J. W., *"Post War Productivity Trends in the United States",* Columbia New York: Columbia University Press, 1973.

Kendrick, J. W. and Grossman, E., "Productivity in the United States Trends and Cycles", Baltimore: John Hopkins University Press, 1980.

Levithan, S. and Werneke, D., *"Productivity: Problems, Prospects and Policies".* Baltimore: John Hopkins University Press, 1984.

Naizels, A. "Comparative productivity in manufacturing industry: A case study of Australia and Canada", *Economic Review,* Volome 34, April 1985, pp 67 – 87.

Naizels, A., "Trends in production and labour productivity in Australian manufacturing industries, *Economic Review,* Volume 33, August 57, pp 162 – 181.

Oi, W. Y., "Labour as a Quase-fixed factor". *Journal of Political Economy,* Volume 70, December 1962, pp 538 – 555.

Stigler, G. J., *Economic problems in measuring changes in Productivity: Studies in income and wealth.* Volume 25, Princeton University Press, 1962.

Soderstorm, Hans, Tson., "Cyclical fluctuations in labour productivity and capacity utilization reconsidered", *Swedish Journal Economic,* June 1972., Volume 74 (2) pp 220 – 223.