Volume Title: The Theory and Empirical Analysis of Production

Volume Author/Editor: Murray Brown, editor

Volume Publisher: NBER

Volume ISBN: 0-870-14486-3

Volume URL: http://www.nber.org/books/brow67-1

Conference Date:

Publication Date: 1967

Chapter Title: Postwar Production Relationships in Canada

Chapter Author(s): N. H. Lithwick, George Post, T. K. Rymes

Chapter URL: http://www.nber.org/chapters/c1479

Chapter pages in book: (p. 139 - 273)

POSTWAR PRODUCTION RELATIONSHIPS IN CANADA

N. H. LITHWICK
CARLETON UNIVERSITY

GEORGE POST
BANK OF CANADA

T. K. RYMES
CARLETON UNIVERSITY

Preface

ON May 25, 1966, the Dominion Bureau of Statistics published substantial revisions in its indexes of constant-dollar gross domestic product at factor cost by industry (DBS 61-005, *Annual Supplement to the Monthly Index of Industrial Production*). Time limitations prevented the recalculation of our data to include these revisions. Readers are warned that for a number of major groups in manufacturing, the findings on the investment-output relationship and total factor productivity increase presented in the text of this paper require substantial revision. At the time of publication we were able to include the revised series in several of our key tables. These are presented at the end of our Statistical Appendix, and a brief analysis of the effects these revisions have on our results is carried out. Reworking of our material with the revised data is continuing, and copies of the revised tables will be obtainable from the authors upon request toward the end of 1966.

Introduction

This study attempts to examine postwar production relationships in Canadian manufacturing from several perspectives, reflecting our view that no single approach can adequately explain the complexities involved.

Our initial task has been to try to determine the nature of the capital formation process in manufacturing. This was followed by a calculation of the contributions of labor, capital, and technical change to the growth of manufacturing output. Finally, an attempt was made to set these findings for manufacturing into a longer-run, economy-wide context by reference to several relevant studies.

The analysis of investment behavior employed three models. The first model related net investment directly to net capital stock, whereas the second used the net stock to estimate a capacity series, and the gap between capacity and expected output then was introduced to explain gross investment. The second equation resulted in a generally better fit, but the possibility of trends in investment renders these findings somewhat less significant. Estimates of the adjustment coefficients in these models reveal that it takes several years to arrive at the desired capital output relationship through adjustments in the stock of capital. The final function involved an attempt to estimate whether technological advance had in part been embodied in new capital. Our findings for Canadian manufacturing lend no support to the embodiment hypothesis.

Our second section was devoted to estimating the contribution of measured factor inputs and their productivity advance to the growth of output in the thirteen major groups in manufacturing. In conducting the analysis, we introduced a number of different assumptions about our variables, including such things as the lives of the capital goods, various labor measures, different allocations of the income of incorporated enterprises and different measures of output. The results suggest such great variability in the growth rate of "total factor productivity" under the various assumptions that we conclude that much more refined concepts and more reliable data are required to enable us to choose the most accurate variables from the bewildering variety we have found necessary to consider. The final part of this section contains an attempt to check on the growth rate of total factor productivity by inverting the usual procedure which uses deflated "real" values and replacing it with a model using factor and product prices. While our results were not entirely satisfactory, the technique developed should be considered as a necessary check on the more customary procedure.

The final section surveys several Cobb-Douglas type functions which have been applied to the total economy as well as the major sectors. They suggest that while manufacturing's growth performance was not spectacular in the postwar period, it did contribute substantially to the growth of aggregate productivity. Also, the higher growth rate of aggregate output and productivity in Canada as compared to the United States is not the result of faster growth in any single industry, but rather reflects the very sharp decline of agriculture in Canada in the postwar period. This interindustry shift from an industry with low productivity levels to more efficient ones, has been a once-and-for-all event, however, suggesting that the past growth rate in aggregate productivity will not be easily attained in the future.

We have presented a rather lengthy statistical appendix, which includes most of the data developed for this study. Finally, a technical appendix has been added, which gives the theoretical arguments that underlie the procedures we have followed.

1. Capital Inputs and Investment Decisions

In this section of the paper we analyze the investment expenditures by Canadian manufacturing establishments in the postwar period. We are interested in the investment process because it is the means by which businessmen adjust the existing capital stock to attain the optimum stock. By analyzing investment expenditures we attempt to make inferences about what capital stock the business planners regard as the equilibrium stock at any given time. We do not know actual retirements and use the perpetual inventory estimates of stock in our calculations. This procedure does not, of course, give us an independent estimate of the size of the stock, but we can derive a view about the desired relationship between actual output and actual stock as measured by the perpetual inventory method.

We must recognize at once that in planning production over any immediate period like a month or a quarter the businessman has very limited scope for adjusting his capital stock. For a major change of the capital stock, it is only in the longer time context of a year or two years that redundant assets can be sold or scrapped and new assets can be ordered, constructed, installed, and started up. Hence the relationship between output and capital input during any particular year is determined by historical factors and may not correspond closely to the relationship that would represent an optimum in the light of relative factor prices from the planner's point of view. This result is particularly to be expected where output is subject to large variations that are inherently difficult to forecast.

The relationship which, in a sense, is under the control of the business planner is the one between expected output and the capital stock in some future period. The expected volume of output is the sum of expected sales plus desired inventory changes; therefore, its actual realization is influenced by price policies, advertising expenditures, and actual inventory buildups. Nevertheless, for most manufacturing firms and industries it appears that the principal determinant of output variation is the fluctuation of the level of aggregate demand and variations in the elasticity of demand for the product through changes in substitute products—both elements which are largely beyond the control of the planner. The desired capital stock at some future time is within the control of the planner subject to financial and physical constraints as to how rapidly the existing stock can be reduced or augmented. These constraints impose themselves on planners as sharply rising marginal costs so that at any specific time there is an optimum rate at which to change the capital stock. This optimum rate is achieved when the increment to expected profit from having a more rapid adjustment of the capital stock is equal to the marginal cost of hastening the adjustment.[1]

Many economists have attempted to find empirical evidence of the influence of the availability of investment goods and financial resources on investment expenditures. These investigations have been hampered by lack of relevant data on the marginal costs of funds and assets to individual firms. In this study we have not attempted to include considerations of the supply of investment goods in our investigation, nor have we been able to include the impact of new products and new processes which render existing equipment obsolete and require an enlargement of the physical capital stock.

We have used two simple models of the investment expenditure process in our attempt to derive inferences about the desired capital stock in the postwar period. One model uses net capital expenditures as the dependent variable, and the other model uses gross expenditures. The net investment figure is arrived at by deducting from gross capital

[1] An interesting analysis of the determinants of the speed of the capital stock adjustment process is given by R. Eisner and R. Strotz, "Determinants of Business Investment," in *Impacts of Monetary Policy,* a series of research studies prepared for the Commission on Money and Credit, Princeton, N.J., 1963, pp. 64–87.

expenditures the estimated annual depreciation charge used in calculating the net capital stock estimates.

We suppose that

$$I_{nt} = \alpha(N_t^* - N_{t-1}) \tag{1}$$

where I_{nt} is net investment, N_t^* is the net capital stock that would be optimal at the end of period t, N_{t-1} is the actual capital stock at the beginning of period t, and α is the adjustment coefficient. The capital stock data used are perpetual inventory estimates prepared by the DBS using the Set I assumptions about asset lives.[2] All these data are expressed in 1949 dollars. The desired capital stock N_t^* is assumed to depend on the quantity of output that is expected in future periods. The equation is

$$N_t^* = f(O_{t+1}^*, O_{t+2}^*, \cdots, O_{t+n}^*) \tag{2}$$

where O_{t+1}^* is the level of output that it is anticipated can be profitably sold in period $t + 1$. This level of anticipated profitable output depends, of course, on the level and elasticity of demand at expected prices and the expected prices for material and labor inputs, as well as on the current costs of financing and capital goods. If the desired stock can be attained in a single period, then the desired stock this period will be influenced only by expected output next period. To the extent that capital stock changes this year are part of a long-term adjustment that cannot be completed in a single period, then the output expected two or more periods in the future will influence the stock that is currently desired. Because we believe that O_{t+1}^*, O_{t+2}^*, and so on will be formulated on the basis of the currently available information they will be strongly correlated. Hence we assume

$$N_t^* = \beta O_{t+1}^* \tag{2a}$$

where β is the optimal capital-output ratio.

A more realistic and detailed model of investment decisions might explicitly recognize that O_{t+1}^* is subject to uncertainty, and attempt to take its distribution into account perhaps by introducing an expected loss function that would weight the costs of too large a stock against those of too small a stock.

The difficult step for us, as for the business planner, is to relate ex-

[2] The basic data underlying this paper are described in the attached Statistical Appendix. The alternative life assumptions used in the estimation of the capital stock are given in Table SA-9.

pected output to currently available information. We suppose that this estimate will be based primarily on the past performance of the output series itself.

$$O_{t+1}^* = g(O_{t-1}, O_{t-2}, \cdots, O_{t-m}) \tag{3}$$

Ideally we should like to make expected output depend upon the whole history of past output and in particular to take account of past discrepancies between expected and actual levels of output. We are restrained here by the relatively few observations available in the postwar period and by the fact that the level of sales in one year is related to the level in earlier years.

We have assumed the simple relationship

$$O_{t+1}^* = a + bO_{t-1} + c\Delta O_t \tag{3a}$$

The inclusion of ΔO_t assumes that the planner has some knowledge of the level of actual output during the current year, but this does not seem unlikely given knowledge of advance orders and market data.

In our analysis we have explored two different measures of output; the gross value of shipments by manufacturing establishments in 1949 dollars and the gross domestic product originating in these manufacturing industries in 1949 dollars. The two concepts gave broadly similar results when the relative magnitudes of the two series are taken into account. We shall report here only the results derived when O_t measured gross domestic product.

Substituting (3a) and (2a) into (1) we have

$$\begin{aligned} I_{nt} &= \alpha[\beta(a + bO_{t-1} + c\Delta O_t) - N_{t-1}] \\ &= A + BO_{t-1} + c\Delta O_t - \alpha N_{t-1} \end{aligned} \tag{4}$$

We anticipated that the sign of O_{t-1} and ΔO_t would be positive and the sign for N_{t-1} would be negative. For only one of the thirteen industries was the coefficient of ΔO_t significantly positive at the 95 per cent level. Hence this variable was deleted, and the regression coefficients re-estimated. The results of the regressions based on this simple capital stock adjustment model are presented in Table 1.

It may be noted from Table 1 that this very simple regression has the signs we anticipated for all industries except clothing and miscellaneous manufacturing.[8] In six of the thirteen regressions, however, R^2 adjusted

[8] There is reason to believe that underestimation of output in the clothing industry may account for the unexpected results there.

TABLE 1

Estimated Regression Coefficients (millions of 1949 dollars)

	O_{t-1}	N_{t-1}	Constant	$\bar{R}^2$	$\bar{S}$	Durbin-Watson Ratio	Mean Net Invest-ment	Stand. Devi-ation I_n
Food and beverages	0.520 (5.878)	-0.303 (-5.763)	-41.464	0.709	4.334	2.132	44.715	8.363
Tobacco, rubber, and leather products	0.135 (1.508)	-0.128 (-0.989)	-2.547	0.070	2.861	0.943	4,631	3.088
Textile products	0.078 (0.985)	-0.282 (-4.476)	78.344	0.657	4.675	1.244	6.369	8.311
Clothing	-0.101 (-4.474)	-0.081 (-0.850)	40.256	0.677	1.569	2.211	0.408	2.875
Wood products	0.157 (1.767)	-0.170 (-1.707)	7.821	0.011	4.726	2.085	10.285	4.945
Paper products	1.301 (3.244)	-0.380 (-3.269)	-191.144	0.377	29.276	1.136	55.085	38.605
Printing, publishing, and allied industries	0.184 (1.215)	-0.156 (-1.088)	1.672	0.000	4.585	2.263	10.285	4.512
Iron and steel products	0.265 (2.179)	-0.082 (-1.158)	-81.718	0.274	20.016	1.910	45.985	24.443
Transportation equipment	0.193 (4.264)	-0.123 (-2.816)	-28.317	0.539	10.797	2.098	19.439	16.549
Nonferrous metal products and electrical apparatus and supplies	0.584 (5.573)	-0.375 (-5.087)	-2.627	0.684	14.686	2.256	32.639	27.200
Nonmetallic minerals and products of petroleum and coal	1.351 (3.071)	-0.422 (-2.782)	-34.366	0.432	20.480	1.684	66.239	28.286
Chemical products	0.921 (1.390)	-0.424 (-1.369)	-8.775	0.000	30.871	1.371	40.331	30.784
Miscellaneous manufacturing	-0.011 (-0.226)	0.152 (0.990)	-6.073	0.268	1.173	2.262	2.315	1.427
Total manufacturing	0.565 (4.197)	-0.290 (-3.891)	-668.579	0.540	86.270	2.238	338.715	132.384

Note: The observations cover the period 1948 to 1960. The t-values of the estimated regression coefficients are given in parentheses. The 5 per cent significance level for t in a one-tailed test is 1.81. The 5 per cent significance for $\bar{R}^2$ is .340. The lower and upper 5 per cent significance points for the Durbin-Watson test for positive serial correlation with 15 observations are 0.95 and 1.54.

for degrees of freedom is not significantly different from zero. The coefficient of N_{t-1}, which is $-\alpha$, the adjustment coefficient, lies between .08 and .42 for those industries where the regression plane is significant. A value for α of 0.30 implies the actual capital stock will be 76 per cent adjusted to a once-and-for-all shift in the desired stock at the end of four years.

In an effort to explain a greater part of the variation of net investment, alternative hypotheses were specified. On the presumption that financial factors influence ideas about the desired capital stock, a corporate interest rate variable was introduced. Alternatively, an estimated rate of return to capital series was included. Both of these variables had significant coefficients with the expected signs for only a few industries and were deleted.

In an effort to discover the influence of technological change on the desired capital stock an explicit vintage variable, the average age of capital in the net stock, was included in equation (4). Again, the coefficient of this variable behaved erratically, and the variable was deleted. Equation (4) was also formulated into a Koyck-type distributed lag, but the estimated lag coefficient was greater than unity for some industries, and this equation was dropped.

Although the regression equation that has been fitted is a stochastic rather than an exact relation one may estimate a value for N_t^* for each year using the estimated values of the parameters in (4).[4] As an example we take the estimated equation for total manufacturing investment:

$$I_{nt} = -668.6 + 0.565\, O_{t-1} - 0.290\, N_{t-1}$$

From (2) and (3)

$$N_t^* = \beta(a + bO_{t-1})$$
$$= \beta a + \beta b O_{t-1}$$

Therefore from (4)

$$\beta a = \frac{A}{\alpha} = \frac{-668.6}{.290} = -2305.445$$

$$\beta b = \frac{B}{\alpha} = \frac{.565}{.290} = 1.948$$

so that $N_t^* = -2305.4 + 1.948\, O_{t-1}$.

[4] See B. G. Hickman, "On a New Method of Capacity Estimation," *Journal of the American Statistical Association,* June 1964, pp. 529–49, where the capacity of the existing capital stock is inferred by a similar procedure.

The values of N_t^* for total manufacturing for the period 1948 to 1960 are given in Table 2 and compared with the original series for N_t. This is obviously not an independent estimate of the net capital stock but is rather an inference about the discrepancies which existed over this period between actual and desired net capital stock drawn from the series of net investment and our hypotheses about the nature of the investment process.

There seems little doubt that the desired capital stock for total manufacturing is underestimated by this method for the years 1948–50. These were years when many types of consumer goods were in relatively short supply and when prices were rising rapidly. Business planners may have had relatively pessimistic expectations in these early years, but it is more likely that the actual volume of investment was constrained by the availability of capital goods. The desired capital stock for each industry may be calculated by a similar procedure. The average of the annual percentage differences for each industry is presented in Table 3. The mean discrepancies are large in those industries, like iron and steel and miscellaneous manufacturing, where the regressions are not a good fit to the observed investment series.

In the second set of regressions we used gross investment (I_{gt}) as the dependent variable. Instead of introducing the net stock of capital as an explanatory variable we used it to calculate an estimate of capacity and made investment depend on the difference between expected output and actual capacity.

$$I_{gt} = \delta(U_{t-1} - O_{t+1}^*) + EG_{t-1} \tag{5}$$

where U_{t-1} is capacity output at the middle of the preceding year, and G_{t-1} is gross capital stock at the beginning of the period. We shall refer to the difference U_{t-1} minus O_{t+1}^* as expected excess capacity. We suppose that replacement is a constant proportion, E, of the gross capital stock, G_t, regardless of age or technical change and wish to estimate this proportion directly. One reason for using this equation was to estimate the parameters of a regression equation that had already been fitted to data for U.S. manufacturing by Alice Bourneuf.[5]

In her article Bourneuf uses the direct estimates of capacity collected by the McGraw-Hill Company to derive the excess capacity variable.

[5] "Manufacturing Investment, Excess Capacity and the Rate of Growth of Output," *American Economic Review*, September 1964, pp. 607–25.

TABLE 2

Net Capital Stock, Total Manufacturing, 1948-60

	Desired Capital Stock N_t^*	Actual Capital Stock N_t	Percentage Difference $\frac{N_t^* - N_t}{N_t}$
1948	5,091.3	4,604.6	10.6
1949	5,416.6	4,818.6	12.4
1950	5,630.9	4,968.0	13.3
1951	6,123.0	5,317.1	15.2
1952	6,821.3	5,774.8	18.1
1953	7,099.1	6,187.4	14.7
1954	7,726.2	6,457.1	19.7
1955	7,448.4	6,782.3	9.8
1956	8,384.8	7,367.9	13.8
1957	9,210.2	7,937.3	16.0
1958	9,035.6	8,197.6	10.2
1959	8,860.9	8,460.8	4.7
1960	9,583.2	8,717.6	9.9
Mean percentage difference			13.0

Note: Method of calculating N_t^* is described in the text.

TABLE 3

Mean Percentage Difference Between Desired and Actual Stock, By Industries, 1948-60

	Per Cent
Food and beverages	11.4
Tobacco, rubber, and leather	18.2
Textile products	5.4
Clothing	4.6
Wood products	14.6
Paper products	9.3
Printing and publishing	26.2
Iron and steel	66.0
Transportation equipment	30.9
Nonferrous metals	6.5
Nonmetallic minerals	12.4
Chemical products	13.6
Miscellaneous manufacturing	-26.5
Total manufacturing	13.0

We have used the estimate of net capital stock to derive estimates of capacity output. This will make a comparison of the coefficients of the excess capacity variables based on the different sets of data of some interest to us.

For these regressions we derived an estimate of capacity output, U_t, by making very simple assumptions about the output-capital ratio at capacity. After examining the ratios of actual output to net capital stock for the postwar period, it was decided that this ratio appeared to be quite stable for seven industries and that 1955 or 1956 was a year that represented full capacity utilization.[6] The output-capital ratio for the chosen year was multiplied by the net stock value in each year to obtain a capacity series. For six industries[7] and total manufacturing there appeared to be a persistent trend in this ratio, and so a trend line was fitted to the output-capital ratios for the two years 1948 and 1956, and the values along this trend were used to transform the stock series into a capacity output series.[8]

$$U_t = k_t N_t \tag{6}$$

where k_t is the output-capital stock ratio. To make U_t comparable with O_t, net stock at midyear was used in this calculation.[9]

Substituting (3a) and (6) into (5) we have

$$\begin{aligned} I_{gt} &= \delta[k_{t-1}N_{t-1} - (a + bO_{t-1} + c\Delta O_t)] + EG_{t-1} \\ &= -\delta a + \delta k_{t-1}N_{t-1} - \delta bO_{t-1} - \delta c\Delta O_t + EG_{t-1} \end{aligned} \tag{7}$$

It is clear when the equation is specified this way that this model is basically the same as the stock adjustment hypothesis we postulated above. Because we wish to estimate depreciation directly, problems can be expected from the inclusion of both the net and the gross capital

[6] The 1955 ratio was used for the tobacco, rubber, and leather products major group and for the nonferrous metal products and electrical apparatus major group.

[7] These six industries were food and beverages, textiles, paper products, iron and steel, chemicals, and miscellaneous manufacturing. The trend through the ratios for 1947 and 1956 was used for the miscellaneous manufacturing industry.

[8] To the extent that capacity was not utilized to the same degree in 1948 as in 1956 this trend line will be biased. The trend for all industries except miscellaneous manufacturing was one of falling output per dollar of net capital stock. Looking at the components of the estimated stock, one notes for most industries that the amount of output for each dollar of machinery and equipment fell considerably over the 1948–56 period, while the output per dollar of building and construction rose slightly.

[9] The estimates of capacity output and excess capacity are presented in Table SA-1.

stock variables. Since both capital stock measures are accumulated totals of past capital expenditures with relatively long lives we can expect the levels of these two series to follow similar patterns.[10] We considered the inclusion of the average age variable to explain replacement demand, but found that it was also collinear with the net stock variable, and so decided to adopt Bourneuf's model, in which the net capital variable is incorporated in the excess capacity variable—the difference between capacity and actual output. This variable, $U_t - O_t$, is not collinear with G_{t-1}. We have, in effect, constrained the coefficient b in (3a) and (7) to equal 1.0. This implies that future output is expected to be equal to lagged output plus some fraction of the current change in output. The regression to be estimated becomes

$$(8) \qquad I_{gt} = D + EG_{t-1} + F(U_{t-1} - O_{t-1}) + H\Delta O_t$$

We expect F to be a negative coefficient ($F = \delta$) and E and H to be positive. The coefficients estimated for this equation are given in Table 4.

For nine of the thirteen industries and for total manufacturing F is significantly negative while E is significantly positive for ten industries and the total. E is, however, rather larger than expected in most equations.[11] The coefficient of ΔO_t is significantly positive for only four industries, although it has the wrong sign in only two cases.

When interpreting the coefficients of this second set of regressions the reader should recall that the k_t parameter was also estimated from these same data and hence used additional degrees of freedom.[12]

The coefficient of $(U_{t-1} - O_{t-1})$ for the total manufacturing regression implies that if the difference between capacity output and actual output falls by a million dollars gross investment would increase by \$664,000. This coefficient is over twice as large as that estimated by Bourneuf using the U.S. excess capacity series. This is to be expected since the direct estimate of excess capacity for the United States is larger

[10] Griliches has argued that both the net and gross measures should be included (see "Capital Stock in Investment Functions: Some Problems of Concept and Measurement," in C. Christ *et al.* (ed.), *Measurement in Economics, Studies in Mathematical Economics and Econometrics in Memory of Yehuda Grunfeld,* Stanford, 1963, pp. 115–37).

[11] In interpreting the coefficient E it should be noted that this is an estimate of replacement expenditures which corresponds to a straight-line depreciation procedure.

[12] The $\bar{R}^2$, $\bar{S}$, and t estimated in Table 4 have not been adjusted for the loss of degrees of freedom in estimating k_t.

TABLE 4

Estimated Regression Coefficients

	$(U_{t-1}-O_{t-1})$	G_{t-1}	ΔO_t	Constant	$\overline{R}^2$	$\overline{S}$	Durbin-Watson Ratio	Mean Gross Investment	Standard Deviation I_g
Food and beverages	−0.373 (−6.296)	0.024 (3.948)	0.018 (0.131)	61.146	0.883	3.755	2.139	91.215	11.443
Tobacco, rubber, and leather products	−0.278 (2.762)	0.066 (3.505)	0.144 (1.899)	−1.318	0.639	2.474	1.391	17.277	4.288
Textile products	−0.069 (−0.631)	−0.133 (−3.160)	−0.010 (−0.118)	108.562	0.483	5.332	1.314	28.777	7.721
Clothing	0.009 (0.296)	−0.118 (−4.785)	0.045 (1.062)	39.119	0.708	1.318	2.567	11.085	2.538
Wood products	−0.191 (−2.348)	0.066 (2.520)	0.154 (1.953)	−2.681	0.261	4.383	1.731	34.908	5.308
Paper products	−1.699 (−4.857)	0.157 (4.617)	0.405 (0.883)	−124.826	0.655	22.629	1.523	117.815	40.101
Printing, publishing, and allied industries	−0.206 (−1.137)	0.085 (1.649)	0.151 (0.689)	−7.941	−0.104	4.928	2.187	22.385	4.881
Iron and steel products	−0.427 (−5.157)	0.181 (8.019)	0.268 (4.026)	−101.912	0.829	12.666	1.171	100.600	31.894

(continued)

TABLE 4 *(concluded)*

	$(U_{t-1}-O_{t-1})$	G_{t-1}	ΔO_t	Constant	$\bar{R}^2$	$\bar{S}$	Durbin-Watson Ratio	Mean Gross Investment	Standard Deviation I_g
Transportation equipment	-0.196 (6.294)	0.214 (5.266)	0.147 (3.145)	-114.858	0.751	7.849	2.016	45.200	16.375
Nonferrous metal products and electrical apparatus and supplies	-0.547 (-6.020)	0.084 (5.085)	0.104 (0.770)	9.380	0.762	14.112	2.072	83.385	30.114
Nonmetallic minerals and products of petroleum and coal	-1.326 (-5.332)	0.173 (7.683)	0.924 (3.848)	-85.399	0.847	13.010	1.726	104.485	34.663
Chemical products	-2.751 (-3.728)	0.085 (2.756)	2.111 (1.925)	-26.667	0.499	22.533	1.363	72.377	33.122
Miscellaneous manufacturing	0.132 (1.532)	0.129 (5.405)	-0.074 (-0.982)	-5.228	0.687	1.247	2.235	8.685	2.319
Total manufacturing	-0.664 (-7.762)	0.148 (9.848)	0.364 (4.368)	-747.561	0.878	54.257	1.270	738.231	161.951

Note: All variables are measured in millions of 1949 dollars. The observations cover the period 1948 to 1960. t-values of the estimated regression coefficients are given in parentheses. The 5 per cent significance level for t in a one-tailed test is 1.83. The 5 per cent significance level for $\bar{R}^2$ is .416. The lower and upper 5 per cent significance points for the Durbin-Watson test for positive serial correlation with 15 observations are 0.82 and 1.75.

than the estimate we devised by assuming 100 per cent utilization of capacity in 1948 and 1956. If we had assumed, say, that only 95 per cent of total capacity was used in these years excess capacity in absolute terms would have been higher over the entire period; and the coefficient F, correspondingly lower.

What can we conclude from these two sets of simple regressions? We have very strong evidence that the existing net capital stock, as we have measured it, is significantly related to the investment expenditures over this period, as we expected it would be. In general the second equation explaining gross investment gave a better fit. This might suggest that our estimate of replacement investment is too mechanical and hence leaves the net investment series with relatively large variations to be explained. In total manufacturing, for example, mean net investment is less than one-half of mean gross investment, but the standard deviation of net investment is 82 per cent of the standard deviation of gross investment. On the other hand, the direct estimate of the depreciation appears too high, suggesting that there may be a trend component of investment that is contributing to the coefficient of G_{t-1}. When a trend variable was explicitly included in equation (8) the coefficient of G_{t-1} was reduced in all but four major groups and was estimated to be significant at the 95 per cent level in only two regressions.

INVESTMENT AND TECHNICAL CHANGE

In our investment regressions we measured the capital stock at its costs in 1949 dollars less accumulated straight-line depreciation. We made no attempt to adjust the stock for quality changes. The question naturally arises: Is there any way we can use these data to determine the extent to which technological change has operated to make new additions to the capital stock more productive than earlier additions? One technique that is possible is to relate output per unit of labor input to additions to the capital stock. This procedure assumes that some components of this partial productivity measure are systematically related to the size of the capital stock and to the replacement of old assets by new ones. That is

$$\frac{O_t}{L_t} = f(N_{t-1}, A_{t-1}) \tag{9}$$

where L_t is the number of workers employed in year t and A_{t-1} represents the average age of assets at the beginning of the period. Because age and net stock tend to be highly correlated it was decided to specify this relation in a first-difference form and to use gross investment and drop the age variable. To recognize that output per worker is subject to strong short-term cyclical variation as the level of production deviates from the optimum level of capacity utilization, the change in the level of output was included as an explanatory variable. The equation that was fitted to the data for each industry was

$$\Delta \frac{O_t}{L_t} = R + SI_{gt-1} + T\Delta O_t \tag{10}$$

Gross capital expenditures were used as the independent variable in this regression because both the net addition of assets and the replacement of old assets would be expected to embody technical change. The coefficients estimated in these regressions are summarized in Table 5.

It is surprising that there appears to be no significant relationship between investment this year and the change in output per employee next year. At the same time there is a significantly positive relationship between changes in output and output per worker in ten of the regressions. This implies that, in the short run at least, the business cycle, rather than improved capital equipment, tends to be the dominant influence on labor productivity measures.

In his recent study, Hickman has used a trend variable to measure the influence of steady technical progress on the capital-output ratio.[13] By introducing a time trend into our equation (2a) we can similarly hypothesize that the relation between desired stock and expected sales is

$$N_t^* = \beta O_{t+1}^* + Et$$

Hickman finds that for most of the industries he studied the coefficient of the trend was negative, indicating that technical progress was sufficiently rapid to reduce the equilibrium amount of capital per unit of output. When a time trend was added to the first regression equation summarized in Table 1 the coefficient of this trend variable was significantly different from zero at the 95 per cent level in only four cases when it

[13] Bert G. Hickman, *Investment Demand and U.S. Economic Growth,* Washington, D.C., 1965. The basic regression model used in this study is specified as a log-linear relation which is, in our notation,

$$\log N_t - \log N_{t-1} = \log a + b_1 \log O_t^* + b_2 \log P_t^* + b_3 t - b_4 \log N_{t-1}$$

and P_t^* refers to the "normal" level of relative prices.

TABLE 5

Estimated Regression Coefficients, Change in Output per Worker Employed

	I_{gt-1}	ΔO_t	Constant	$\bar{R}^2$	$\bar{S}$	Durbin-Watson Ratio	Mean Change Output per Worker	Standard Deviation of Change
Food and beverages	−0.192 (−0.092)	6.787 (3.341)	−62.290	0.422	73.824	1.745	77.541	101.065
Tobacco, rubber, and leather products	4.454 (0.913)	9.407 (6.795)	−16.339	0.773	64.763	2.648	92.344	141.386
Textile products	−1.749 (−0.369)	6.589 (3.667)	134.595	0.463	142.788	2.288	115.351	202.853
Clothing	−0.915 (−0.174)	4.467 (3.200)	30.696	0.370	56.945	2.148	34.393	74.668
Wood products	−2.190 (−0.409)	2.406 (1.492)	133.121	0.173	77.609	2.354	78.120	88.829
Paper products	0.953 (0.929)	9.201 (3.713)	−173.913	0.560	101.176	2.015	103.187	158.675
Printing, publishing, and allied industries	5.949 (0.903)	7.076 (1.613)	−132.613	−0.031	99.090	1.944	63.979	101.589
Iron and steel products	−0.162 (−0.096)	2.383 (3.333)	28.440	0.551	134.758	1.814	61.142	209.220
Transportation equipment	−2.705 (−0.679)	0.515 (0.415)	197.201	−0.160	212.500	2.162	83.721	205.354

(continued)

TABLE 5 *(concluded)*

	I_{gt-1}	ΔO_t	Constant	$\bar{R}^2$	$\bar{S}$	Durbin-Watson Ratio	Mean Change Output per Worker	Standard Deviation of Change
Nonferrous metal products and electrical apparatus and supplies	2.129 (1.342)	3.340 (2.095)	-130.106	0.111	159.616	1.661	127.264	176.218
Nonmetallic minerals and products of petroleum and coal	1.015 (1.000)	6.921 (3.013)	32.987	0.334	124.776	1.457	285.449	159.159
Chemical products	-0.275 (-0.177)	18.852 (3.164)	-87.929	0.420	159.114	1.930	271.469	217.489
Miscellaneous manufacturing	-12.719 (-1.266)	15.823 (5.337)	62.384	0.662	64.211	2.023	59.593	114.988
Total manufacturing	0.143 (0.842)	0.366 (2.770)	-65.889	0.298	79.410	2.111	102.484	98.619

Note: The dependent variable is the change in dollars of gross domestic product (in constant 1949 prices) per worker. Gross investment and output are measured in millions of 1949 dollars. The regressions are based on the period 1948 to 1960. *t*-values for the regression coefficients are given in parentheses. The 5 per cent level of significance for *t* in a one-tailed test is 1.81. The 5 per cent level of significance for $\bar{R}^2$ is .340. The lower and upper 5 per cent significance points for the Durbin-Watson test for positive serial correlation with 15 observations are 0.95 and 1.54.

had a positive sign. We conclude that these regressions do not supply any evidence of embodied technological improvement which has reduced the capital-output ratio in Canadian manufacturing. One of the essential differences between our results and those of Hickman is that the two measures of net stock differ. In general, Hickman's life assumptions are shorter than those underlying the DBS Set I estimates and are based on declining balance depreciation while the Canadian estimates use straight-line depreciation assumptions. He assumes further that average useful lives have been shorter since 1946 than they were in the prewar period.

We also inserted a time trend in our second regression model summarized in Table 4. In only two cases was the partial regression coefficient significantly different from zero. In eight regressions the coefficient was positive and in six, negative. We have already mentioned that this time variable appeared to be collinear with the gross stock variable in this second model.

CONCLUSIONS

We want now briefly to summarize Part I. Our objective in this section of the paper was to throw light indirectly on the role of capital stock in Canadian manufacturing by studying the capital stock adjustment process, i.e., net investment. We demonstrated in our first set of regressions that investment decisions for most industries are related by a very simple model to current levels of output. Our estimates of the adjustment coefficient imply that several years will be required to attain a desired level of capital stock under conditions of real world uncertainty. Our second model, which uses the net capital stock estimate to derive a series for capacity and then relates investment to the gap between capacity and actual output, explains a larger part of the total variation of investment. This model too implies that a period of several years will be required before the optimum relation between capacity and actual output will be attained. This second model does suggest the importance of capacity utilization variables to explain capital expenditures. Our hope to estimate replacement investment directly was probably doomed to failure because the life assumptions of the perpetual inventory method are reflected in the gross capital stock series.

We might conceivably have used these investment regressions as a device to evaluate the alternative estimates of the capital stock that have been prepared by the DBS. Before doing this, however, one would have to be confident that the regression relation was fully and correctly specified. It is conceivable that the set of capital stock estimates that would give the "best fit" with one model might not give the "best fit" with some alternative model. The difficult task of evaluating the life assumptions underlying the alternative capital stock estimates still lies in the future. We have a very great need in Canada for more detailed first-hand knowledge of asset lives and the economic forces that affect them.

Finally, we sought evidence in the investment experience that output per unit of labor had been increasing over time due to the embodiment of technical change in newer capital goods. In Table 5 we summarized a set of regressions which failed to attribute increments of output per worker to recent investment and hence threw doubt on the assertion that output increases result from embodied technical change. The inclusion of time trends in both of our earlier regression models also failed to present any clear evidence that the equilibrium amount of capital (unadjusted for quality) per unit of output was falling over time. This latter contrasts with Hickman's findings which he interpreted as indicating the presence of smooth disembodied technical change. Further work is required to decide if the difference between the measure of the net capital stock we used and that used by Hickman could have accounted for this different conclusion. The difference between the two measures of net stock is basically a matter of the asset life assumptions and depreciation rates assumed.

II. Total Measured Factor Productivity, 1946–60

In this section we examine "total measured factor productivity" at a disaggregated level within the Canadian manufacturing sector. In the Technical Appendix attached to this paper, we set forth our reasons for the various output and input measures which we use. The main set of our estimates are for the period 1946 to 1956; deal with thirteen combined major groups in Canadian manufacturing; use constant-1949-dollar gross domestic product at factor cost as the output measure, employees and paid man-hours as alternate labor input measures, and constant dollar net stock of fixed capital, inventories, and capital consumption allowances as the relevant capital input measures.

In this section, we are in particular concerned with the effects which different assumptions about the average economic lives of fixed capital goods have upon estimates of "total measured factor productivity."

Constant-dollar gross domestic product in manufacturing rose over the period from \$3.5 billion to \$6.1 billion. This expansion in output was interrupted in 1954 and in 1957 and 1958 when output fell from its 1956 level of \$5.9 billion to \$5.8 billion and \$5.7 billion respectively, rose again in 1959 to \$6.1 billion and showed a very moderate decline in 1960. As Chart SA-1 indicates, the interruption in the advance in output which occurred after 1956 was more widely shared among the major groups than was the minor interruption which occurred in 1954.

Even more striking is the sharp decline in gross fixed capital formation measured in constant 1949 dollars which accompanied the decline in output in 1957 and 1958. Total gross fixed capital formation in manufacturing fell from a 1956–57 level of slightly more than \$1 billion to about \$750 million in 1958–59. The food and beverages major group was exceptional in that a steady increase in capital formation prevailed over the period while every other major group suffered interruptions or declines.

The sharp break in the advance of economic activity in Canadian manufacturing in 1956–57 suggests that changes in estimated total measured factor productivity in the latter part of the 1946-to-1960 period would require careful interpretation. Clearly, in the late 1950s a part of the capital stock in Canadian manufacturing was in some sense underemployed. Yet, as is discussed in the Technical Appendix, it is hard to see how our capital input measures (the net stock and capital consumption allowances) could be satisfactorily adjusted to reflect this phenomenon. For this reason, we prefer to focus attention on the 1946–56 period. The estimates for the longer period, 1946 to 1960, are presented largely to show the cyclical sensitivity of estimates of total measured factor productivity.

The format in which our estimates are presented is the identity [14]

$$\frac{\dot{A}}{A} \equiv \frac{\dot{Q}}{Q} - \left[\sum \frac{W_j L_j}{PQ} \left(\frac{\dot{L}_j}{L_j} \right) + \sum_k \frac{r_k P_k{}^N N_k}{PQ} \left(\frac{\dot{N}_k}{N_k} \right) + \sum_l \frac{r_l P_l{}^I I_l}{PQ} \left(\frac{\dot{I}_l}{I_l} \right) + \sum_k \frac{P_k D_k}{PQ} \left(\frac{\dot{D}_k}{D_k} \right) \right]$$

[14] The derivation of this and other identities which we use is provided in the Technical Appendix.

where

$$\dot{A}/A,\ \dot{Q}/Q,\ \dot{L}_j/L_j,\ \dot{N}_k/N_k,\ \dot{I}_l/I_l,\ \text{and}\ \dot{D}_k/D_k$$

are the proportionate rates of change of total measured factor productivity; constant-dollar gross domestic product at factor cost; the *j*th component of the labor input; the *k*th component of the constant-dollar midyear net stock of fixed capital; the *l*th component of the constant-dollar midyear inventory, and the *k*th component of the constant-dollar capital consumption allowances. The weights given to the proportionate rates of growth of the measured factor inputs are their respective shares in current-dollar gross domestic product at factor cost in 1949. A full discussion of our output and input measures and factor weights is provided in the Statistical Appendix, but four points about our data should now be made. First, our labor input data are basically of two types, persons employed and paid man-hours. Ideally we would have preferred measures of labor inputs weighted together by market labor prices. In the Statistical Appendix, we provide measures of the labor input where some account is taken of the fact that the labor force is not as homogeneous as a count of persons employed or man-hours paid implies. Second, in constructing our input weights, we have arbitrarily split the net income of unincorporated businesses between returns to labor and returns to capital. Little of the manufacturing activity in Canada is carried on by unincorporated business, and when we replace the arbitrary split used (50:50) in our estimation procedures by different arbitrary divisions, the estimates of total measured factor productivity are affected only negligibly. Third, we have been unable to account for the role of land as a factor input in our estimates. Fourth, in preparing the estimates of the stock of fixed capital in Canadian manufacturing the DBS was confronted by the virtual absence of reliable estimates of the average economic life of capital goods. To investigate what biases the initial set of life assumptions would have had on the levels and rates of growth of the resulting stock estimates if the initial life estimates had been, in fact, too long or too short, four additional sets of capital stock estimates were prepared, based on a range of average economic lives which, it was felt, would bracket the actual lives of capital goods being used.[15] We have included only three sets in our tables and the effects on our total meas-

[15] See Table SA-9 in the Statistical Appendix and forthcoming DBS reference paper, *Estimates of Fixed Capital Flows and Stocks, Manufacturing, Canada, 1926–1960.*

ured factor productivity estimates are quite significant. The rates of growth of the capital inputs (both the net stock and capital consumption allowances estimates) are affected by the different average economic lives used to prepare them. The weights for the net stock, inventories, and capital consumption allowances are also affected as different lives are used. Longer lives used in the perpetual inventory estimation of the stock of net fixed capital lead to higher levels of the current-dollar net stock for the year in which the factor weights are constructed and, therefore, relatively lower weights for inventories. Current-dollar capital consumption allowances in the base year may fall or rise as longer lives are used in the "perpetual inventory" method of estimation. Thus the factor input weights for the net midyear stock, midyear inventories, and capital consumption allowances will alter in different directions as different lives are used in estimating fixed capital flows and stocks in Canadian manufacturing.

ESTIMATES OF TOTAL MEASURED FACTOR PRODUCTIVITY

In Table 6, we present the first set of estimates of total measured factor productivity for the periods 1946–56 and 1946–60. The output measure is constant-1949-dollars gross domestic product at factor cost. The estimates reveal (1) the expected cyclical sensitivity of total measured factor productivity, (2) substantial intermajor group variations in measured productivity advance, and (3) considerable sensitivity with respect to assumptions about the average economic lives of fixed capital goods.

The cyclical sensitivity of our estimates shows more clearly in Table 7 and Chart SA-1. It would appear that if 1949 had been chosen as the initial year for the food and beverages and tobacco, rubber, and leather products major groups estimates the recorded advances in total measured factor productivity would have been greater in those major groups. It is interesting to note that the tobacco, rubber, and leather products major group is the only one in manufacturing where the data suggests an absolute decline in the inputs used. If 1949 had been chosen as the initial year for the textiles and clothing major groups as well, the measured productivity performance would again have been more impressive. The textiles major group recorded most uneven productivity advance over the period, and the average advances shown by our estimates do not reveal the disturbances to which the major group was clearly subject. The

TABLE 6

Total Measured Factor Productivity (Gross Domestic Product Basis)

Total Manufacturing and Major Groups, 1946-56 and 1946-60•

(continuous annual rates of change)

Set of Lives	Gross Domestic Product at Factor Cost[a]	Labor Input: Employees	Labor Input: Paid Man-Hours	Midyear Net Stock of Fixed Capital[a]	Midyear Inventories[a]	Capital Consumption Allowances[a]	Total Measured Factor Input: Employees	Total Measured Factor Input: Paid Man-Hours	Total Measured Factor Productivity: Employees	Total Measured Factor Productivity: Paid Man-Hours
					Total Manufacturing					
1946-56										
I	5.3	2.5	2.0	5.8	4.3	2.8	3.2	2.9	2.1	2.4
III				5.3		2.2	3.1	2.8	2.2	2.5
V				6.4		4.7	3.4	3.1	1.9	2.2
1946-60										
I	4.0	1.4	1.0	5.6	3.8	3.4	2.5	2.2	1.5	1.8
III				5.1		3.0	2.4	2.1	1.6	1.9
V				5.9		4.9	2.7	2.3	1.4	1.7
					Food and Beverages					
1946-56										
I	3.1	1.3	0.9	6.4	3.3	3.0	2.5	2.3	0.5	0.8
III				5.9		2.9	2.5	2.2	0.6	0.8
V				7.2		5.0	2.8	2.5	0.3	0.6
1946-60										
I	3.0	1.3	0.9	5.8	3.2	3.3	2.5	2.2	0.6	0.8
III				5.4		3.2	2.4	2.2	0.6	0.9
V				6.2		5.0	2.6	2.4	0.4	0.7

(continued)

TABLE 6 *(continued)*

Set of Lives	Gross Domestic Product at Factor Cost[a]	Labor Input: Employees	Labor Input: Paid Man-Hours	Midyear Net Stock of Fixed Capital[a]	Midyear Inventories[a]	Capital Consumption Allowances[a]	Total Measured Factor Input: Employees	Total Measured Factor Input: Paid Man-Hours	Total Measured Factor Productivity: Employees	Total Measured Factor Productivity: Paid Man-Hours
				Tobacco, Rubber and Leather Products						
1946-56										
I	2.6	-0.9	-1.2	3.5	2.7	3.6	0.1	-0.1	2.5	2.8
III				3.4		3.0	0.1	-0.2	2.6	2.8
V				3.1		4.9	0.1	-0.1	2.5	2.7
1946-60										
I	2.0	-1.2	-1.4	3.3	1.9	4.0	-0.2	-0.4	2.2	2.4
III				3.4		3.6	-0.2	-0.4	2.2	2.4
V				2.9		4.3	-0.3	-0.4	2.2	2.4
				Textile Products (excl. clothing and fur)						
1946-56										
I	2.8	0.5	0.1	4.2	12.3	1.6	2.1	1.9	0.7	0.9
III				3.8		1.2	2.0	1.7	0.8	1.1
V				5.4		2.3	2.5	2.2	0.3	0.6
1946-60										
I	2.3	-0.6	-1.0	3.1	9.4	1.2	0.9	0.7	1.4	1.6
III				2.8		1.0	0.9	0.6	1.5	1.7
V				3.5		2.2	1.2	0.9	1.1	1.4
					Clothing					
1946-56										
I	2.1	0.5	0.4	2.0	2.2	2.1	0.9	0.8	1.2	1.3
III				1.9		0.8	0.8	0.7	1.3	1.4
V				1.3		2.2	0.8	0.7	1.3	1.4

(continued)

TABLE 6 *(continued)*

Set of Lives	Gross Domestic Product at Factor Cost[a]	Labor Input: Employees	Labor Input: Paid Man-Hours	Midyear Net Stock of Fixed Capital[a]	Midyear Inventories[a]	Capital Consumption Allowances[a]	Total Measured Factor Input: Employees	Total Measured Factor Input: Paid Man-Hours	Total Measured Factor Productivity: Employees	Total Measured Factor Productivity: Paid Man-Hours
Clothing (continued)										
1946-60										
I	0.9	0.2	0.0	1.0	1.9	0.9	0.5	0.3	0.4	0.6
III				1.1		1.0	0.5	0.3	0.4	0.6
V				-0.2		1.8	0.3	0.2	0.5	0.7
Wood Products										
1946-56										
I	4.7	2.5	2.0	3.8	3.6	0.9	2.6	2.3	2.0	2.4
III				3.1		-0.7	2.4	2.1	2.2	2.6
V				4.3		3.1	2.8	2.5	1.8	2.2
1946-60										
I	3.2	0.9	0.5	3.4	2.8	1.2	1.3	1.0	1.9	2.2
III				2.9		0.2	1.2	0.9	2.0	2.3
V				3.4		3.1	1.5	1.2	1.7	2.0
Paper Products										
1946-56										
I	5.3	3.3	2.1	6.9	2.7	3.8	4.3	3.6	1.1	1.7
III				6.1		3.0	4.0	3.4	1.3	1.9
V				7.6		7.1	4.8	4.2	0.5	1.2
1946-60										
I	4.3	2.4	1.4	6.3	2.7	4.5	3.7	3.2	0.6	1.1
III				5.8		3.9	3.6	3.0	0.8	1.3
V				6.5		6.8	4.0	3.5	0.3	0.8

(continued)

TABLE 6 *(continued)*

Set of Lives	Gross Domestic Product at Factor Cost[a]	Labor Input: Employees	Labor Input: Paid Man-Hours	Midyear Net Stock of Fixed Capital[a]	Midyear Inventories[a]	Capital Consumption Allowances[a]	Total Measured Factor Input: Employees	Total Measured Factor Input: Paid Man-Hours	Total Measured Factor Productivity: Employees	Total Measured Factor Productivity: Paid Man-Hours
Printing, Publishing, and Allied Industries										
1946-56										
I	5.8	4.0	3.5	4.8	4.4	1.8	4.0	3.7	1.8	2.1
III				4.2		1.4	3.9	3.6	1.9	2.2
V				7.0		3.1	4.4	4.1	1.4	1.7
1946-60										
I	4.6	3.1	2.6	5.0	3.7	2.2	3.3	3.0	1.3	1.6
III				4.4		2.0	3.2	2.9	1.4	1.7
V				6.7		3.7	3.7	3.4	0.9	1.2
Iron and Steel Products										
1946-56										
I	5.9	2.6	2.2	5.8	5.4	2.4	3.3	3.0	2.6	2.9
III				5.3		2.3	3.2	2.9	2.6	2.9
V				6.1		3.7	3.4	3.1	2.4	2.8
1946-60										
I	3.8	1.7	1.2	5.8	4.4	3.5	2.7	2.3	1.1	1.5
III				5.5		3.6	2.6	2.3	1.2	1.5
V				6.1		4.7	2.8	2.4	1.0	1.4
Transportation Equipment										
1946-56										
I	6.7	3.4	3.1	4.2	1.5	-1.1	3.2	2.9	3.6	3.8
III				3.3		-1.5	3.0	2.7	3.8	4.0
V				5.5		1.7	3.5	3.2	3.3	3.5

(continued)

TABLE 6 *(continued)*

Set of Lives	Gross Domestic Product at Factor Cost[a]	Labor Input: Employees	Labor Input: Paid Man-Hours	Midyear Net Stock of Fixed Capital[a]	Midyear Inventories[a]	Capital Consumption Allowances[a]	Total Measured Factor Input: Employees	Total Measured Factor Input: Paid Man-Hours	Total Measured Factor Productivity: Employees	Total Measured Factor Productivity: Paid Man-Hours
Transportation Equipment (continued)										
1946-60										
I	3.4	0.6	0.4	3.9	0.4	-0.2	1.1	0.9	2.3	2.5
III				3.1		-0.2	1.0	0.8	2.4	2.6
V				4.6		2.0	1.3	1.1	2.2	2.3
Nonferrous Metal Products and Electrical Apparatus and Supplies										
1946-56										
I	7.6	5.0	4.5	3.4	4.5	1.1	4.2	3.9	3.3	3.6
III				3.3		0.5	4.1	3.8	3.4	3.7
V				2.7		2.3	4.3	4.0	3.3	3.6
1946-60										
I	5.5	2.6	2.3	3.6	5.3	2.3	2.8	2.6	2.7	3.0
III				3.6		1.9	2.8	2.5	2.8	3.0
V				3.0		3.2	2.9	2.6	2.7	2.9
Nonmetallic Mineral Products and Products of Petroleum and Coal										
1946-56										
I	10.2	4.6	4.3	10.4	7.6	6.9	6.6	6.4	3.6	3.7
III				9.5		6.1	6.3	6.2	3.8	4.0
V				11.7		9.0	7.1	6.9	3.1	3.2
1946-60										
I	8.1	3.5	3.2	9.8	6.9	7.0	5.8	5.6	2.3	2.5
III				9.1		6.2	5.6	5.4	2.5	2.7
V				10.7		8.5	6.1	5.9	2.0	2.2

(continued)

TABLE 6 *(concluded)*

Set of Lives	Gross Domestic Product at Factor Cost[a]	Labor Input: Employees	Labor Input: Paid Man-Hours	Midyear Net Stock of Fixed Capital[a]	Midyear Inventories[a]	Capital Consumption Allowances[a]	Total Measured Factor Input: Employees	Total Measured Factor Input: Paid Man-Hours	Total Measured Factor Productivity: Employees	Total Measured Factor Productivity: Paid Man-Hours
Chemical Products										
1946-56										
I	7.0	3.3	2.8	8.8	4.6	7.6	5.2	5.0	1.7	2.0
III				8.2		7.2	5.1	4.8	1.9	2.2
V				10.0		8.9	5.6	5.3	1.4	1.7
1946-60										
I	6.6	2.6	2.2	8.2	3.5	7.4	4.6	4.3	2.0	2.3
III				7.8		7.0	4.5	4.2	2.2	2.4
V				9.0		8.5	4.8	4.6	1.8	2.0
Miscellaneous Manufacturing Industries										
1946-56										
I	6.1	4.6	4.3	3.2	8.0	2.8	4.6	4.4	1.4	1.6
III				3.2		2.2	4.6	4.4	1.5	1.7
V				2.9		2.8	4.6	4.4	1.4	1.6
1946-60										
I	6.2	4.8	4.6	3.6	8.1	3.4	4.9	4.7	1.4	1.5
III				3.6		3.3	4.8	4.7	1.4	1.6
V				3.6		3.9	4.9	4.8	1.3	1.4

Note: See Table SA-12 for the same series recalculated using the revised output data.

Source: See Statistical Appendix. The three different rates of change of midyear net stock and capital consumption allowances are based on the sets I, III, and V of average economic lives used by the DBS in the forthcoming reference paper, *Estimates of Fixed Capital Flows and Stocks, Manufacturing, Canada, 1926-1960*. For five of the combined major groups (foods and beverages; tobacco, rubber, and leather products; paper products; printing, publishing, and allied industries; and chemical products), the average economic lives used in sets I and II were the same. Continuous annual rates of change in this and subsequent tables are calculated as $(\ln GDP_{56} - \ln GDP_{46})/10$.

[a]Measured in constant 1949 dollars.

TABLE 7

Indexes of Constant 1949 Gross Domestic Product and Total Measured Factor Productivity, Total Manufacturing and Major Groups, 1946-60

(1949 = 1.000)

	Total Manufacturing			Food and Beverages			Tobacco, Rubber, and Leather Products			Textiles		
		Factor Productivity			Factor Productivity			Factor Productivity			Factor Productivity	
Year	GDP	Employees	Man-Hours	GDP	Employees	Man-Hours	GDP	Employees	Man-Hours	GDP	Employees	Man-Hours
1946	0.852	0.956	0.947	0.980	1.100	1.097	1.045	1.033	1.015	0.887	1.063	1.043
1947	0.932	0.989	0.983	0.972	1.043	1.048	1.124	1.099	1.090	0.940	1.025	1.017
1948	0.973	1.002	0.999	0.985	1.019	1.019	1.026	1.034	1.040	0.973	1.008	1.008
1949	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1950	1.062	1.053	1.053	1.038	1.039	1.038	1.049	1.053	1.062	1.125	1.091	1.085
1951	1.150	1.075	1.084	1.068	1.038	1.045	1.038	1.048	1.072	1.131	1.055	1.080
1952	1.185	1.066	1.078	1.135	1.077	1.085	1.089	1.111	1.117	1.029	1.049	1.074
1953	1.264	1.085	1.102	1.174	1.084	1.102	1.179	1.167	1.183	1.079	0.998	1.021
1954	1.229	1.067	1.091	1.206	1.094	1.116	1.122	1.148	1.174	0.943	0.944	0.963
1955	1.347	1.150	1.171	1.268	1.135	1.158	1.252	1.268	1.277	1.140	1.101	1.109
1956	1.451	1.179	1.201	1.331	1.157	1.183	1.358	1.330	1.340	1.173	1.095	1.108
1957	1.429	1.124	1.154	1.356	1.127	1.159	1.368	1.338	1.364	1.176	1.109	1.133
1958	1.407	1.126	1.159	1.419	1.166	1.196	1.349	1.345	1.372	1.096	1.079	1.103
1959	1.498	1.178	1.204	1.476	1.182	1.211	1.476	1.451	1.473	1.244	1.224	1.241
1960	1.493	1.162	1.191	1.502	1.184	1.217	1.379	1.383	1.400	1.225	1.209	1.231

(continued)

TABLE 7 *(continued)*

Year	Clothing			Wood Products			Paper Products			Printing, Publishing and Allied Industries		
		Factor Productivity			Factor Productivity			Factor Productivity			Factor Productivity	
	GDP	Employees	Man-Hours	GDP	Employees	Man-Hours	GDP	Employees	Man-Hours	GDP	Employees	Man-Hours
1946	0.953	1.068	1.058	0.868	0.981	0.956	0.810	0.962	0.948	0.769	0.952	0.938
1947	0.922	0.990	0.985	0.982	1.000	0.986	0.891	0.981	0.968	0.836	0.980	0.971
1948	0.976	1.004	1.010	1.006	1.004	1.007	0.949	0.995	0.987	0.926	1.030	1.030
1949	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1950	1.013	1.023	1.022	1.082	1.050	1.049	1.093	1.085	1.082	1.015	0.987	0.991
1951	1.012	1.023	1.046	1.148	1.078	1.079	1.175	1.097	1.098	1.051	0.989	0.998
1952	1.114	1.107	1.111	1.158	1.078	1.074	1.134	1.015	1.035	1.075	1.006	1.024
1953	1.150	1.114	1.119	1.254	1.125	1.118	1.181	1.034	1.067	1.147	1.043	1.062
1954	1.089	1.121	1.149	1.242	1.140	1.146	1.241	1.055	1.100	1.216	1.069	1.085
1955	1.128	1.174	1.186	1.364	1.210	1.209	1.310	1.075	1.123	1.271	1.096	1.112
1956	1.176	1.204	1.206	1.383	1.206	1.214	1.378	1.062	1.109	1.373	1.139	1.160
1957	1.168	1.177	1.199	1.273	1.152	1.172	1.355	0.982	1.033	1.382	1.104	1.124
1958	1.144	1.195	1.212	1.320	1.249	1.265	1.356	0.960	1.013	1.344	1.086	1.113
1959	1.131	1.182	1.188	1.366	1.267	1.273	1.447	1.010	1.062	1.432	1.123	1.148
1960	1.079	1.126	1.143	1.360	1.267	1.285	1.484	1.023	1.074	1.465	1.129	1.160

(continued)

TABLE 7 *(continued)*

Year	Iron and Steel Products			Transportation Equipment			Nonferrous Metal Products and Electrical Apparatus and Supplies			Nonmetallic Mineral Products and Products of Petroleum and Coal		
		Factor Productivity			Factor Productivity			Factor Productivity			Factor Productivity	
	GDP	Employees	Man-Hours	GDP	Employees	Man-Hours	GDP	Employees	Man-Hours	GDP	Employees	Man-Hours
1946	0.808	0.888	0.879	0.806	0.802	0.806	0.752	0.820	0.815	0.729	0.929	0.932
1947	0.936	0.956	0.949	0.953	0.927	0.929	0.896	0.922	0.921	0.838	1.001	0.998
1948	1.015	0.996	0.988	0.972	0.975	0.979	0.956	0.966	0.968	0.913	1.001	1.000
1949	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1950	1.025	1.029	1.035	1.083	1.089	1.085	1.080	1.058	1.062	1.114	1.069	1.069
1951	1.170	1.070	1.084	1.313	1.148	1.159	1.172	1.041	1.052	1.232	1.087	1.091
1952	1.189	1.030	1.047	1.491	1.122	1.138	1.180	1.011	1.028	1.296	1.083	1.094
1953	1.153	0.978	0.999	1.652	1.162	1.180	1.346	1.072	1.090	1.448	1.100	1.111
1954	1.062	0.936	0.964	1.373	1.054	1.082	1.333	1.060	1.088	1.535	1.096	1.111
1955	1.238	1.065	1.090	1.451	1.124	1.159	1.504	1.166	1.191	1.779	1.245	1.259
1956	1.453	1.147	1.170	1.579	1.148	1.183	1.604	1.158	1.183	2.011	1.314	1.334
1957	1.396	1.066	1.098	1.512	1.062	1.105	1.539	1.094	1.125	2.039	1.247	1.267
1958	1.283	1.045	1.083	1.325	1.034	1.075	1.499	1.096	1.133	2.102	1.234	1.254
1959	1.472	1.126	1.157	1.315	1.089	1.122	1.582	1.150	1.179	2.304	1.289	1.307
1960	1.317	1.021	1.054	1.300	1.088	1.118	1.633	1.200	1.229	2.265	1.236	1.258

(continued)

TABLE 7 *(concluded)*

	Chemical Products			Miscellaneous Manufacturing Industries		
		Factor Productivity			Factor Productivity	
Year	GDP	Employees	Man-Hours	GDP	Employees	Man-Hours
1946	0.870	1.002	0.999	0.802	0.997	0.992
1947	0.908	1.017	1.020	0.841	0.962	0.968
1948	0.957	1.038	1.039	0.814	0.937	0.942
1949	1.000	1.000	1.000	1.000	1.000	1.000
1950	1.077	1.059	1.063	1.048	1.018	1.017
1951	1.200	1.084	1.091	1.190	1.110	1.120
1952	1.223	1.031	1.046	1.218	1.086	1.102
1953	1.399	1.045	1.061	1.411	1.166	1.172
1954	1.521	1.077	1.097	1.343	1.124	1.139
1955	1.655	1.171	1.193	1.364	1.135	1.147
1956	1.748	1.176	1.201	1.470	1.154	1.168
1957	1.834	1.153	1.180	1.533	1.139	1.159
1958	1.980	1.198	1.227	1.663	1.191	1.210
1959	2.084	1.243	1.272	1.832	1.246	1.260
1960	2.197	1.280	1.311	1.916	1.208	1.223

Note: See Table SA-13 for the same series recalculated using the revised output data.

Source: Indexes of constant 1949 dollar gross domestic product at factor cost: From DBS 61-505, *Indexes of Real Domestic Product by Industry of Origin 1935-61,* Table 1.

Indexes of total measured factor productivity. See Statistical Appendix. These indexes are based on Set I of the average economic lives of capital goods and correspond to row I in Table 6. The indexed total measured factor productivity is the gross-domestic-product-at-factor-cost version.

rates of productivity advance shown by the clothing major group are biased downward because of an understatement in the increase in output in the latter part of the period which we were unable to correct.[16]

Productivity advance in the paper products major group was also uneven and, on average, surprisingly low. With the exception of the combined nonmetallic mineral products and products of petroleum and

[16] In DBS 61-005, *Annual Supplement to the Monthly Industrial Production,* May 1964, p. 3, it is reported that the constant-dollar gross domestic product index for clothing from ". . . the mid-fifties . . ." has been badly biased downward. There is thus on this account alone also a slight downward bias in the index of constant-dollar gross domestic product for total manufacturing. Confirmation of these suspicions has resulted in our revisions contained in the Statistical Appendix.

coal major group and the chemical products major groups, the paper products major group exhibits the highest rate of advance of fixed capital input in manufacturing. Yet it also exhibits one of the lowest rates of advance in total measured factor productivity. As would be expected from the nature of their products, the productivity performance of the iron and steel products and transportation equipment major groups exhibits marked cyclical sensitivity. Particularly striking are the recorded rates of increase of total measured factor inputs shown by the combined nonmetallic mineral products and products of petroleum and coal major group and the rather high rates of increase in total measured factor productivity. It would appear that the ranking of the major groups, in terms of increased total measured factor productivity is only moderately affected by cyclical variations, with the range of increases in total measured factor productivity exhibited by the different major groups in Tables 6 and 7 being quite wide.

It is well known that estimates of rates of change of total measured factor productivity require careful interpretation. Our method does not take any account of possible changes in returns to scale and the nonneutrality of technological advance, and suffers from all the limitations of the labor input data and difficulties involved in capital measurement in a world of changes in degrees of competition, unsteady technological advance, and an obvious absence of anything like equilibrium prices, wage rates, and rates of return to capital. Moreover, our estimates would not appear to be invariant to changes in the assumed economic lives of capital goods which enter the estimation of stocks of fixed capital and capital consumption allowances.

The data indicate the difficulty clearly. In Table 6 the rates of growth of the midyear net stock of fixed capital and capital consumption allowances shown in the I rows are based on the initial Set I of average economic lives used by DBS in preparing the fixed capital stock and flow estimates in manufacturing. The data in rows III are based, in general, on the longest lives assumed and in V, in general, on the shortest lives assumed.[17] The changes in the estimates of total measured factor

[17] We calculated but have not reported the effects on our estimates of using the two intermediate Sets II and IV of assumed lives used by DBS in the forthcoming reference paper, *Estimates of Fixed Capital Flows and Stocks, Manufacturing, Canada, 1926–1960.* Again, with rows I as standard, the variations in the rates of increase of total measured factor productivity when the sets of intermediate lives are used are less than when the sets of extreme lives are used but are nevertheless substantial.

productivity for the period 1946–56 are generally such that, as assumed lives are longer, it is increased while, as assumed lives are shorter, it is decreased. The reverse relationship would appear to hold with respect to the rates of growth of the net stock of capital and capital consumption allowances. These results are by no means uniform.

Such alterations in observed results are of particular concern when we remember that the average lives of capital goods and the time pattern of depreciation probably change cyclically and secularly. As previously indicated, we have no data about life distributions and, given our findings, conclude that the short-run estimates of total measured factor productivity presented here must be viewed with considerable skepticism.

Even when a longer period is taken, though the variations emanating from different assumed lives of capital goods are sharply reduced, they still introduce some ambiguity into the results. Thus, for total manufacturing over the period 1926–56, we have the estimates presented in Table 8.

As can be seen from a comparison of Table 6 and Table 8 the differences among the growth rates of the two capital inputs and the measured factor inputs and total factor productivity are reduced substantially. However, the secular changes, which have, in all likelihood, been occurring in the average economic lives of capital goods, and on which we have no data, serve to detract from any additional confidence with which such longer-term analysis may be conducted.

The effects of different assumed lives of fixed capital goods are reduced when the estimates of total measured factor productivity are prepared on the net domestic product at factor cost output basis. Slight variations occur in the recorded rates of growth of net domestic product (these variations are implied in the rates of growth of gross domestic product per unit of capital consumption allowances as shown in Table 6) but the variation in the rates of change of total factor inputs and productivity is reduced as the assumed lives are altered.

In the case of the net domestic product variant, the reduction in the variation of the estimates of total measured factor productivity is brought about, of course, by the elimination of capital consumption allowances as one of the inputs and the consequent increased weight given to the labor input. Nonetheless, as Table 9 shows, the differences in the estimates are still considerable for some major groups as stock and capital consumption allowances data based on different assumed average economic lives of fixed capital goods are used.

TABLE 8

Total Measured Factor Productivity (Gross Domestic Product Basis), Total Manufacturing, 1926-56

(continuous annual rates of change)

	Gross Domestic Product at Factor Cost[a]	Employees	Midyear Net Stock of Fixed Capital[a]	Midyear Inventories[a]	Capital Consumption Allowances[a]	Total Measured Factor Input (employees)	Total Measured Factor Productivity (employees)
I	4.4	3.0	2.6	3.7	2.4	3.0	1.4
III			2.5		2.5	2.9	1.5
V			2.9		2.9	3.1	1.4

Source: See Statistical Appendix. No reliable man-hours data are available back to 1926 for total manufacturing.

[a]Measured in constant 1949 dollars.

TABLE 9

Total Measured Factor Productivity (Net Domestic Product Basis), Total Manufacturing and Major Groups, 1946-56

(continuous annual rates of change)

	Set of Lives	Net Domestic Product at Factor Cost[a]	Labor Input		Midyear Net Stock of Fixed Capital[a]	Midyear Inventories[a]	Total Measured Factor Input		Total Measured Factor Productivity	
			Employees	Paid Man-Hours			Employees	Paid Man-Hours	Employees	Paid Man-Hours
Total manufacturing	I	5.5	2.5	2.0	5.8	4.3	3.2	2.9	2.3	2.6
	III	5.6			5.3		3.2	2.8	2.4	2.8
	V	5.4			6.4		3.3	3.0	2.1	2.4
Food and beverages	I	3.1	1.3	0.9	6.4	3.3	2.7	2.4	0.4	0.7
	III	3.1			5.9		2.5	2.2	0.6	0.9
	V	2.9			7.2		2.6	2.3	0.3	0.6
Tobacco, rubber, and leather products	I	2.6	-0.9	-1.2	3.5	2.7	-0.1	-0.4	2.7	3.0
	III	2.6			3.4		-0.1	-0.4	2.7	3.0
	V	2.5			3.1		-0.2	-0.4	2.7	2.9
Textile products	I	2.9	0.5	0.1	4.2	12.3	2.2	1.9	0.8	1.0
	III	2.9			3.8		2.1	1.8	0.9	1.2
	V	2.8			5.4		2.5	2.2	0.3	0.6
Clothing products	I	2.1	0.5	0.4	2.0	2.2	0.9	0.7	1.2	1.4
	III	2.1			1.9		0.8	0.7	1.3	1.4
	V	2.1			1.3		0.8	0.6	1.3	1.5

(continued)

TABLE 9 *(continued)*

	Set of Lives	Net Domestic Product at Factor Cost[a]	Labor Input: Employees	Labor Input: Paid Man-Hours	Midyear Net Stock of Fixed Capital[a]	Midyear Inventories[a]	Total Measured Factor Input: Employees	Total Measured Factor Input: Paid Man-Hours	Total Measured Factor Productivity: Employees	Total Measured Factor Productivity: Paid Man-Hours
Wood products	I	5.0	2.5	2.0	3.8	3.6	2.8	2.4	2.2	2.6
	III	5.1			3.1		2.7	2.3	2.4	2.8
	V	4.8			4.3		2.8	2.4	2.0	2.3
Paper products	I	5.5	3.3	2.1	6.9	2.7	4.3	3.6	1.2	1.9
	III	5.6			6.1		4.1	3.4	1.5	2.2
	V	5.0			7.6		4.4	3.7	0.6	1.3
Printing, publishing, and allied industries	I	6.0	4.0	3.5	4.8	4.4	4.1	3.8	1.9	2.3
	III	6.0			4.2		4.0	3.7	2.0	2.4
	V	5.9			7.0		4.5	4.0	1.5	1.9
Iron and steel products	I	6.1	2.6	2.2	5.8	5.4	3.4	3.0	2.7	3.1
	III	6.1			5.3		3.3	3.0	2.8	3.2
	V	6.0			6.1		3.4	3.1	2.6	3.0
Transportation equipment	I	7.1	3.4	3.1	4.2	1.5	3.4	3.1	3.8	4.0
	III	7.2			3.3		3.2	3.0	4.0	4.3
	V	6.9			5.5		3.5	3.3	3.4	3.7

(continued)

TABLE 9 *(concluded)*

	Set of Lives	Net Domestic Product at Factor Cost[a]	Labor Input		Midyear Net Stock of Fixed Capital[a]	Midyear Inventories[a]	Total Measured Factor Input		Total Measured Factor Productivity	
			Employees	Paid Man-Hours			Employees	Paid Man-Hours	Employees	Paid Man-Hours
Nonferrous metal products and electrical apparatus and supplies	I	8.5	5.0	4.5	3.4	4.5	4.7	4.4	3.8	4.2
	III	8.6			3.3		4.7	4.3	4.0	4.3
	V	8.6			2.7		4.6	4.3	3.9	4.3
Nonmetallic mineral products and products of petroleum and coal	I	10.6	4.6	4.3	10.4	7.6	6.5	6.4	4.1	4.3
	III	10.7			9.5		6.4	6.2	4.3	4.5
	V	10.3			11.7		6.7	6.6	3.6	3.8
Chemical products	I	6.9	3.3	2.8	8.8	4.6	5.0	4.7	1.9	2.2
	III	7.0			8.2		4.9	4.6	2.1	2.4
	V	6.7			10.0		5.1	4.8	1.6	1.9
Miscellaneous manufacturing industries	I	6.3	4.6	4.3	3.2	8.0	4.7	4.5	1.5	1.7
	III	6.3			3.2		4.7	4.5	1.6	1.8
	V	6.3			2.9		4.8	4.6	1.5	1.7

Source: See Statistical Appendix and notes to Table 6.

[a]Measured in constant 1949 dollars.

At the component (i.e., plant and machinery and equipment) level of detail for the capital stock and flow inputs in our estimates of total measured factor productivity, the variations in the rates of growth for the period 1946 to 1956, introduced by using different assumed average economic lives in producting such flow and stock estimates, are substantial and nonuniform. Given the perpetual inventory procedure by which the capital stock and flow estimates have been prepared, different assumed lives interact with the historical pattern of constant-dollar gross fixed capital formation to produce substantial variations in the resulting estimates. In Table 10, rows I give average annual rates of growth of the two components of the net stock and capital consumption allowances, which are based on Set I of the assumed economic lives of capital goods adopted by the Dominion Bureau of Statistics. In rows III, 20 per cent longer lives, compared to rows I, were used for all components. In rows V, 20 per cent shorter lives were used for the construction-type components and 40 per cent shorter lives were used for the machinery and equipment components (excluding capital items charged to operating expenses).

The type of complexity introduced may be seen by examining the estimates for total manufacturing. As is seen in comparing rows III with rows I, the rate of growth of the machinery and equipment component of both the net stock and capital consumption allowances falls sharply although, because of the changed relative importance of the components, the rate of growth of the total net stock is affected to a lesser degree. When shorter lives are used, the rates of growth of both components of the net stock are increased whereas when the capital consumption allowances are examined, for plant it is shown reduced and for machinery and equipment it is shown increased. For total manufacturing, from Table 10 it would appear that when shorter lives are used, the rates of increase of both components and of the total net stock are raised as compared to the results when Set I or Set III lives are used. An examination of the estimates for the major groups reveals, however, that such uniformity is by no means the case.

Since the cyclical and secular history of gross fixed capital formation by component will differ for each major group, it follows that only tentatively can it be argued that shorter lives increase the recorded rates of growth of the capital stock and flow inputs and vice versa. These

TABLE 10

Midyear Net Stock and Capital Consumption Allowances, 1946-56

(continuous annual rates of change)

		Constant 1949 Dollars					
		Net Midyear Stock of Fixed Capital			Capital Consumption Allowances		
	Set of Lives	Plant	Machinery and Equipment	Total	Plant	Machinery and Equipment	Total
Total manufacturing	I	3.6	8.4	5.8	2.9	2.8	2.8
	III	3.5	6.2	5.3	2.9	1.9	2.2
	V	4.1	9.6	6.4	2.5	5.7	4.7
Food and beverages	I	4.6	8.0	6.4	3.9	2.6	3.0
	III	4.5	7.1	5.9	4.2	2.4	2.9
	V	4.9	9.8	7.2	4.1	5.3	5.0
Tobacco, rubber, and leather products	I	1.1	7.7	3.5	2.0	4.2	3.6
	III	1.3	6.9	3.4	2.3	3.2	3.0
	V	0.7	8.4	3.1	1.5	6.2	4.9
Textiles (except clothing and fur)	I	1.9	5.3	4.2	0.2	1.8	1.6
	III	1.7	5.2	3.8	1.6	1.1	1.2
	V	3.1	7.0	5.4	0.0	3.0	2.3
Clothing	I	-3.5	8.9	2.0	0.0	3.8	2.1
	III	-2.6	8.1	1.9	-1.3	2.6	0.8
	V	-4.2	9.0	1.3	-4.1	6.3	2.2

(continued)

TABLE 10 *(continued)*

		Constant 1949 Dollars					
		Net Midyear Stock of Fixed Capital			Capital Consumption Allowances		
	Set of Lives	Plant	Machinery and Equipment	Total	Plant	Machinery and Equipment	Total
Wood products	I	0.1	9.4	3.8	0.5	1.2	0.9
	III	-0.7	7.7	3.1	-1.1	-0.3	-0.7
	V	-1.4	12.3	4.3	-0.8	5.7	3.1
Paper products	I	2.5	13.0	6.9	2.6	4.3	3.8
	III	2.6	10.8	6.1	2.9	3.1	3.0
	V	2.8	15.5	7.6	1.2	9.8	7.1
Printing, publishing, and allied industries	I	3.6	5.7	4.8	3.0	1.4	1.8
	III	3.4	4.7	4.2	3.4	0.9	1.4
	V	4.2	9.6	7.0	2.1	3.5	3.1
Iron and steel products	I	4.2	7.0	5.8	2.5	2.4	2.4
	III	3.9	6.4	5.3	3.5	1.9	2.3
	V	5.5	6.6	6.1	1.7	4.2	3.7
Transportation equipment	I	2.6	5.8	4.2	-0.1	-1.6	-1.1
	III	2.3	4.2	3.3	2.4	-3.5	-1.5
	V	4.4	6.8	5.5	1.4	1.9	1.7

(continued)

TABLE 10 *(concluded)*

		Constant 1949 Dollars					
		Net Midyear Stock of Fixed Capital			Capital Consumption Allowances		
	Set of Lives	Plant	Machinery and Equipment	Total	Plant	Machinery and Equipment	Total
Nonferrous metal products and electrical apparatus and supplies	I	3.1	3.7	3.4	4.1	0.1	1.1
	III	3.3	3.3	3.3	3.8	-0.6	0.5
	V	2.8	2.6	2.7	4.5	1.3	2.3
Nonmetallic mineral products and products of petroleum and coal	I	8.6	14.9	10.4	6.2	7.6	6.9
	III	7.9	13.5	9.5	5.6	6.7	6.1
	V	9.6	17.8	11.7	7.3	10.8	9.0
Chemical products	I	4.5	15.6	8.8	3.8	9.9	7.6
	III	4.4	14.5	8.2	4.1	8.8	7.2
	V	5.5	17.9	10.0	1.1	13.2	8.9
Miscellaneous manufacturing industries	I	1.5	5.9	3.2	2.3	3.0	2.8
	III	1.7	5.6	3.2	1.5	2.6	2.2
	V	1.5	6.1	2.9	0.9	3.8	2.8

Note: Based on data in forthcoming DBS reference paper *Estimates of Fixed Capital Flows and Stocks, Manufacturing, Canada, 1926-1960.*

substantial differences imply considerable variations in recorded capital-output ratios (compare Table 6 and Table 10) and consequent differences in the importance which one attaches to capital accumulation as a contributor to growth. It is our conclusion that much better data on the lives of capital goods are required before much progress can be made in Canada in economic investigations concerned with the relationship over time between capital and output. As we have indicated, for longer periods of comparison, the uncertainties introduced by lack of knowledge about the economic lives of capital goods are reduced; but clearly, the possibility of secular changes in the lives of capital goods should make us cautious in interpreting the reduction in differences in calculated estimates of total measured factor productivity advance. Indeed, when observed historical relationships between output and capital are used for short-run projections of such relationships, the lack of adequate knowledge about the lives of capital goods and actual depreciation patterns weighs against the reliability of these projections.

As the factor weighting diagram reproduced in our Statistical Appendix shows, it is of critical importance to take account of the changes in inventories in estimating total measured factor productivity in Canadian manufacturing. For some major groups inventories would appear to be as significant an input as fixed capital. Failure to take them into account would have led to quite erroneous impressions as to improvements in economic efficiency and a substanial overstatement of the significance of the net stock of fixed capital as a factor input within Canadian manufacturing.

SOME ALTERNATIVE MEASURES

In the Technical Appendix accompanying this paper, we argue that total measured factor productivity estimates can be prepared, at industry levels of detail, with output taken as gross output and with intermediate inputs being handled as inputs (rather than negative outputs) along with the primary factors of production. The gross output version of total measured factor productivity shown for selected major groups in Table 11 are for the shorter period 1946 to 1953 and are based only on the initial Set I of average economic lives of fixed capital goods. The analysis cannot be extended beyond 1953 because reliable estimates of constant-dollar gross output and intermediate inputs by major group are not available. Even for the period shown in Table 11 the gross output and intermediate input data are unsatisfactory.

The rates of growth of total measured factor productivity are reduced when the gross output, rather than the gross domestic product, basis is used, as the comparison offered in Table 11 indicates. In such a short period, it is not surprising that the rates of growth of gross output and intermediate inputs are different. When the rates of growth of gross output and intermediate inputs are similar, the only difference in estimates of total measured factor productivity between the gross output and gross domestic product version will arise from the changed weights attached to the inputs. Data constraints prevent us from ascertaining how different the rates of growth of gross output and intermediate inputs would be in the longer run.

Differences which exist, however, suggest that in comparing the rates of improvement which various major groups have made in transforming inputs into output, the gross output version may be equally as useful as the gross domestic product version. The ranking of the major groups (in terms of the rates of growth of total measured factor productivity) alters as the different output versions are used, and the interpretation of the results would correspondingly be affected. Unfortunately, we are at present unable to press further with such comparisons.

As is indicated in the Technical Appendix, the estimation of total measured factor productivity can also be carried out in terms of the proportionate rates of changes in the prices of inputs and outputs.

In Table 12, we show some very tentative estimates of the rates of growth of prices of outputs and inputs on a gross domestic product basis for all major groups and total manufacturing. Again, these estimates are based on the initial set of assumed lives of capital goods and therefore correspond to rows I in Table 6.

The recorded rates of increase of total measured factor productivity shown in columns (10) and (11) of Table 12, because of data problems, are not as satisfactory as those shown in columns (12) and (13), which are repeated from Table 6. In general, the estimates derived by working with the prices of inputs and outputs would appear to be lower than those derived by working with the constant-dollar output and input measures. The differences amongst the rates of growth of "own-product"

TABLE 11

Total Measured Factor Productivity Gross Output Basis and Gross Domestic Product Basis, Selected Major Groups, 1946-53

(continuous annual rates of change)

		Labor Input				
	Gross Output[a]	Employees	Paid Man-Hours	Midyear Stock of Fixed Capital[a]	Midyear Inventories[a]	Capital Consumption Allowances[a]
Textile products	3.2	1.2	0.4	5.5	17.3	2.1
Clothing products	2.4	1.8	1.5	3.3	3.0	2.4
Wood products	5.0	3.4	3.1	3.9	4.9	0.0
Printing, publishing, and allied industries	5.7	4.4	3.8	4.9	6.4	1.4
Iron and steel products	5.4	3.1	2.4	6.0	7.3	0.4
Transportation equipment	10.2	6.3	6.1	3.1	3.0	-3.7
Nonferrous metal products and electrical apparatus and supplies	8.3	6.0	5.5	2.6	7.8	-1.4
Nonmetallic mineral products and products of petroleum and coal	9.9	4.9	4.7	10.0	13.7	6.3
Chemical products	6.4	4.0	3.5	10.2	1.8	8.0
Miscellaneous manufacturing industries	8.1	6.0	5.8	3.3	10.4	2.1

Source: See Statistical Appendix. Calculations in last five columns are comparable, except for time period, with those in Table 6.

[a]Measured in constant 1949 dollars.

	Total Measured Factor Input		Total Measured Factor Productivity			Total Measured Factor Input		Total Measured Factor Productivity	
Intermediate Input[a]	Employees	Paid Man-Hours	Employees	Paid Man-Hours	Gross Domestic Product[a]	Employees	Paid Man-Hours	Employees	Paid Man-Hours
3.5	3.4	3.1	-0.2	0.0	2.8	3.2	2.7	-0.4	0.1
2.1	2.1	2.0	0.2	0.3	2.7	2.1	1.9	0.6	0.8
4.1	3.8	3.7	1.3	1.4	5.3	3.4	3.1	1.9	2.2
5.7	5.0	4.7	0.7	1.0	5.7	4.4	3.9	1.3	1.8
5.6	4.7	4.5	0.6	0.8	5.1	3.7	3.3	1.3	1.8
10.2	8.0	7.9	2.3	2.3	10.2	5.0	4.8	5.3	5.4
8.3	6.7	6.6	1.6	1.8	8.3	4.6	4.3	3.7	4.0
9.9	9.3	9.2	0.6	0.6	9.8	7.4	7.3	2.4	2.5
6.2	6.0	5.9	0.4	0.5	6.8	5.7	5.4	1.1	1.4
8.1	7.0	6.9	1.1	1.1	8.1	5.9	5.7	2.2	2.3

TABLE 12

Total Measured Factor Productivity (Gross Domestic Product Basis), Total Manufacturing and Major Groups, Prices of Inputs and Outputs, 1946-56

(continuous annual rate of change)

	Persons Employed Price (1)	Paid Man-Hours Price (2)	Net Rate of Return to Capital (3)	Midyear Net Stock of Capital Price (4)	Midyear Inventory Price (5)
Total manufacturing	7.1	7.5	1.3	5.9	-0.4
Food and beverages	6.5	6.9	-2.3	5.6	2.2
Tobacco, rubber, and leather products	6.9	7.2	-0.6	6.0	1.5
Textile products	6.8	7.2	-8.1	5.6	-7.7
Clothing	5.0	5.2	-4.8	5.3	1.1
Wood products	7.1	7.6	-5.6	5.4	4.5
Paper products	7.2	8.3	-5.6	6.1	4.2
Printing, publishing, and allied industries	6.8	7.2	3.8	5.8	2.0
Iron and steel products	7.3	7.8	3.4	5.9	3.0
Transportation equipment	6.7	7.0	4.1	6.1	3.9
Nonferrous metal products and electrical apparatus and supplies	7.5	8.0	15.5	6.0	1.5
Nonmetallic mineral products and products of petroleum and coal	7.9	8.2	5.4	6.4	2.8
Chemical products	7.4	8.0	-5.3	6.0	4.4
Miscellaneous manufacturing	7.0	7.2	4.3	6.0	1.8

Source: See Statistical Appendix. Data in column (10): columns (8) minus (7); column (11): columns (9) minus (7); columns (12) and (13) from Table 6.

Capital Consumption Allowances Price	Gross Domestic Product Price	Total Measured Factor Input Price		Total Measured Factor Productivity		Total Measured Productivity From Table 6	
		Employ-ees	Man-Hours	Employ-ees	Man-Hours	Employ-ees	Man-Hours
(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
5.8	4.9	6.4	6.7	1.5	1.8	2.1	2.4
5.6	4.7	5.1	5.4	0.4	0.7	0.5	0.8
5.8	3.6	6.1	6.3	2.5	2.7	2.5	2.8
5.6	3.4	3.4	3.7	0.0	0.3	0.7	0.9
5.4	2.6	3.6	3.7	1.0	1.1	1.2	1.3
5.5	4.7	5.6	5.9	0.8	1.2	2.0	2.4
6.0	4.6	4.5	5.2	-0.1	0.5	1.1	1.7
5.7	5.2	7.1	7.4	1.9	2.2	1.8	2.1
5.8	5.5	7.4	7.7	1.9	2.3	2.6	2.9
5.9	5.3	7.3	7.6	2.0	2.3	3.6	3.8
5.9	7.6	9.6	9.9	2.1	2.4	3.3	3.6
6.3	5.5	8.5	8.7	3.0	3.2	3.6	3.7
5.8	2.8	4.7	5.0	1.9	2.2	1.7	2.0
6.2	5.5	7.3	7.5	1.8	2.0	1.4	1.6

prices [18] of labor, as shown in Table 13, would appear to be of sufficient interest to warrant further study of total measured factor productivity in Canadian manufacturing over this period, using the relationship between prices of inputs and output as well as the more customary constant-dollar inputs-and-output approach.

CONCLUSIONS

In the third section of this paper, some additional conclusions based on the results of this section are drawn. At this point, however, we may say that in the postwar period, by whatever output variant it is measured, total measured factor productivity grew at substantially different rates over the various major groups making up Canadian manufacturing. The different rates are, of course, cyclically sensitive. We offer some further comparisons, when additional variants of the labor inputs are used, in the Statistical Appendix. Our results would appear to confirm the suspicion that lack of knowledge about the average economic lives of capital goods, secular and cyclical changes in those lives, and the pattern of depreciation of capital goods rule out at present the testing of any simple hypothesis connecting the rate of growth and the changing average age of the net stock of capital and the rate of growth of total measured factor productivity. From our estimates, there is no readily discernible relationship between the rate of growth of the net stock of capital and total measured factor productivity.

Given the crudity of our concepts and data, it was not possible to say anything definitive about the way in which total measured factor productivity increases were shared by the primary inputs in each major group. We suggest, however, that the estimation of total measured factor productivity should be used to cast light on such a phenomenon. Looking at total measured factor productivity changes by means of proportionate rates of change in the prices of inputs and outputs not only gives some idea of the distribution of the fruits of increasing efficiency, but when changes in own-product factor prices are examined, under admittedly restrictive assumptions, we may then gain some knowledge about the changing marginal productivities of the various factors. These are extremely important topics of investigation and much further refine-

[18] The rate of change of the own-product price of labor is defined simply as the proportionate rate of change of the price of labor less the proportionate rate of change in the price of the product it produces.

TABLE 13

Output Per Unit of Labor Input, Own-Product Price of Labor, 1946-56

(continuous annual rates of change)

	Output per Person Employed (1)	Own-Product Price (employees) (2)	Output per Paid Man-Hours (3)	Own-Product Price (paid Man-Hours) (4)
Total manufacturing	2.8	2.2	3.3	2.6
Food and beverages	1.8	1.8	2.2	2.2
Tobacco, rubber, and leather products	3.5	3.3	3.8	3.6
Textiles (except clothing and fur)	2.3	3.4	2.7	3.8
Clothing products	1.6	2.4	1.7	2.6
Wood products	2.2	2.4	2.7	2.9
Paper products	2.0	2.6	3.2	3.7
Printing, publishing, and allied industries	1.8	1.6	2.3	2.0
Iron and steel products	3.3	1.8	3.7	2.3
Transportation equipment	3.3	1.4	3.6	1.7
Nonferrous metal products and electrical apparatus and supplies	2.6	-0.1	3.1	0.4
Nonmetallic mineral products and products of petroleum and coal	5.6	2.4	5.9	2.7
Chemical products	3.7	4.6	4.2	5.2
Miscellaneous manufacturing industries	1.5	1.5	1.8	1.7

Source: Column (1): Table 6, gross domestic product at factor cost minus labor input, employees; column (3): Table 6, gross domestic product at factor cost minus labor input, paid man-hours; column (2): Table 12, column (1) minus column (7): column (4): Table 12, column (2) minus column (7).

ment of concepts and data is necessary before satisfactory results can be obtained.

III. Long-Run Aggregate Economic Performance in Canada

Our study of production relations in Canada in the postwar years has been concentrated upon manufacturing activity. In this section we intend to provide some background for our findings by presenting evidence on the entire economy's progress, and the role of manufacturing therein, together with a longer view of the process of growth in Canada.

The initial major study of growth in Canada was undertaken by Hood and Scott for the Royal Commission on Canada's Economic Prospects.[19] Surveying past economic performance in Canada, the authors were impressed with the stability in certain key relationships among economic variables.[20] These include

1. The ratio of saving to income
2. The ratio of capital to output [21]
3. The share of labor earnings in national income
4. The rate of return on capital.

Since these regularities are consistent with equilibrium conditions derived from simple models of economic growth, the authors conclude that "in a broad way the economic system in the long run is stable and moves toward equilibrium. . . ." [22]

On the basis of this conclusion, a forecast of the level of economic activity in 1980 was made. This involved estimating the growth of labor input and labor productivity and, thereby, the growth of output. From this, it was possible to infer the level of capital required, and hence the savings and investment requirements of the system to validate this program.

For our purposes, their summary of past growth with their strong emphasis on stability of basic relationship is of major interest. In Table 14 we summarize their findings.

[19] William C. Hood and Anthony Scott, *Output, Labour and Capital in the Canadian Economy*, Ottawa, 1957.

[20] This finding parallels Lawrence Klein's in his article "Great Ratios in Economics," *Quarterly Journal of Economics*, May 1961.

[21] Their development of capital stock estimates at the major industry level for the years 1945–55, on both a net and a gross basis, were the first of their kind for Canada.

[22] *Ibid.*, p. 118.

TABLE 14

Basic Relationships Among Economic Variables, Canadian Economy, Selected Years, 1926-55

	Savings as Per Cent of GNE (1)	Ratio, Capital to Output		Labor Share in National Income (4)	Rate of Return to Capital	
		Industrial (2)	Total (3)		Government Bond Yields (5)	Index of Long-Term Yields (6)
1926	20.1	1.5	n.a.	78.1	n.a.	141.3
1935	11.5	1.5	n.a.	68.3	3.0[a]	98.1[a]
1941	19.6	0.9	n.a.	68.4	3.1	100.6
1947	24.5	1.0	2.2	65.1[b]	2.6	84.4
1953	26.3	1.2	2.3	73.6	3.6[c]	116.2[c]
1955	26.4	1.2	2.4	72.9	3.1[d]	101.7[d]

Source: Data are from William C. Hood and Anthony Scott, *Output, Labour and Capital in the Canadian Economy*, Ottawa, 1957: Column (1): Table 2.16, p. 42, in current dollars, savings measured on a gross domestic basis. Columns (2) and (3): Table 2.17, p. 44, in 1949 dollars, net fixed capital to gross domestic product at factor cost; total capital is equal to industrial plus social. Column (4): Table 2.20, p. 57, wages, salaries, and supplementary labor incomes plus estimates of labor income for unincorporated business. Column (5): Table 2.23, pp. 62-63, 15-year Government of Canada theoretical bond yield. Column (6): Table 2.23, pp. 62-63, DBS index of Government of Canada long-term bond yields, 1936-39 = 100.

[a]For 1936.

[b]For 1945.

[c]For 1952.

[d]For 1954.

These data have been utilized in a study of postwar growth supervised by Professor Domar.[23] Following the techniques of Solow and Kendrick, the growth rate of output is allocated to capital, labor, and residual sources, and the results are presented in Table 15. Unfortunately, the lack of capital stock data by industry prior to 1946 led to the use of a rather short period. In an effort to obtain as long a view of growth as

[23] Evsey D. Domar *et al.*, "Economic Growth and Productivity in the United States, Canada, United Kingdom, Germany and Japan in the Post-War Period," *Review of Economics and Statistics*, February 1964.

TABLE 15

Economic Growth in Canada in the Postwar Period, 1949-60

(average annual rates of growth)

	1949-60					1949-56	
Industry	Output	Man-Hours	Capital	Combined Factor Input	Total Factor Productivity	Output	Total Factor Productivity
Agriculture	1.7	-3.7	3.7	-0.3	2.0	4.0	3.5
Forestry, fishing, and trapping	3.1	1.1	4.7	2.4	0.7	5.4	-0.2
Mining, quarrying, and oil wells	8.5	0.5	11.5	7.6	0.9	10.8	1.1
Manufacturing	3.7	0.7	4.8	2.3	1.4	5.3	2.7
Construction	3.8	2.6	6.8	3.2	0.6	6.7	1.9
Public utilities	9.9	4.0	9.3	7.9	2.0	10.3	1.4
Trade	4.1	3.3	7.2	4.7	-0.6	5.3	-0.2
Finance, insurance, and real estate	4.9	4.1	4.4	4.3	0.6	5.0	0.6
Transportation, storage, and communication	3.8	1.3	4.7	2.3	1.5	5.3	2.8
Services (including government)	3.8	4.4	5.7	4.6	-0.8	4.3	0.5
Total economy	4.0	1.2	5.5	2.8	1.2	5.4	2.4

Source: Evsey D. Domar *et al.*, "Economic Growth in the United States, Canada, United Kingdom, Germany, and Japan in the Post-War Period," *Review of Economics and Statistics*, February 1964, Tables 1, 2, 4, and 6, and their unpublished manuscript, Table 2-2, Canada.

possible, the period 1949–60 was selected. This final year, however, was one of significant underutilization of capacity in the Canadian economy.[24] Since no attempt was made to evaluate the potential level of output and resource use in 1960, the measures in Table 15, reflecting actual performance, are dominated by cyclical influences. To indicate this, the growth rates of output and the factor productivity that obtain for a shorter but more comparable period are also presented. It is clear that the elimination of differences in cyclical phases for the two end years yields a more impressive picture of growth in Canada; for in most sectors, the growth of output and the growth rate of factor productivity are substantially increased. These data can be compared to those for the present study by examining the manufacturing sector alone. We find that between 1946 and 1956, manufacturing output grew at a rate of 5.3 per cent per annum and that total factor productivity grew at between 2.2 and 2.5 per cent.[25] This is close to the 1949–56 rates of 5.3 per cent and 2.7 per cent in Domar, and presents a very different picture of growth in Canada than does their published data for the longer period 1949–60, where in manufacturing output grew at 3.7 per cent and total factor productivity at 1.4 per cent.

The implications to be drawn from these findings are limited, however, for they are dominated by the rather unique features of the early postwar years. A second study of growth in Canada [26] has used the same degree of industry detail but has extended the analysis over a longer period. In addition, growth in potential output was considered in order to remove swings in output due primarily to short-run fluctuations. This was obtained by considering the growth rate between years of similar, high-capacity utilization levels. The selected years were 1926 and 1956, when the unemployment rate stood at approximately 3 per cent. If other similar years covering roughly the same span of time are examined, the growth rate does not change significantly, and thus the selected period does give a relatively unbiased estimate of potential growth. While this period enabled examination of growth in the aggregate economy, at the industry level of detail, lack of data necessitated the selection of a slightly shorter period.

An attempt was made to allocate the sources of growth not only to

[24] DBS, *Canadian Statistical Review:* 7 per cent of the labor force was unemployed in 1960. In 1949, the rate was less than one-half of this.

[25] Table 6.

[26] N. H. Lithwick, "Economic Growth in Canada: A Quantitiative Analysis," forthcoming, University of Toronto Press.

conventionally measured factors of production but also to those changes in their quality which could be measured.[27] These findings are presented in Table 16 together with Lithwick's revisions of Denison's results to conform to his definitions. These include a rejection of both the need to correct for extra days of schooling, together with Denison's proposed offset to the decline in hours, neither of which were felt to be warranted. Adjustments for years of schooling, the rent component in the income of the more educated, and age and sex composition of the labor force were made and are included in the labor contribution to growth.

Despite a more rapid increase in man-hours than in the United States, the quality improvement has been very minor indeed, due primarily to the relative backwardness in Canada's investment in education. The greater increase in physical capital input has offset this in part; so the total factor input has grown at approximately the same rate in the two countries. Thus, the much higher growth rate in aggregate output in Canada must be due to the higher growth rate of its factor productivity. This finding is at first surprising, given the relatively much greater allocation of resources to technological advance in the United States.[28]

The second phase of Lithwick's study offers some explanation of this discrepancy. An investigation into growth at the sectoral level was undertaken for a somewhat shorter period.[29] Capital stock estimates for this level of detail were made, and they proved to be consistent both with the estimates made from the aggregate for the longer period, and with Hood and Scott's.[30] Once again the labor input series was adjusted for quality change. The findings are presented in Table 17.

[27] Following the technique developed by E. F. Denison in *The Sources of Economic Growth in the United States and the Alternatives Before Us,* Washington, D.C., 1962.

[28] For example, U.S. research and development expenditures per capita over the period 1955–61, were about ten times as high as in Canada (cf. forthcoming study for the Royal Commission on Taxation by T. Wilson and N. H. Lithwick).

[29] Due primarily to the lack of output data prior to 1935 at the industry level (cf. DBS, *Indexes of Real Domestic Product by Industries of Origin, 1935–61,* Ottawa, 1963).

[30] Lithwick, *op. cit.,* Appendix Table B-11, p. 188. In the postwar period, the growth rates of manufacturing capital on both a net and gross basis are remarkably alike for the DBS, Hood-Scott, and Lithwick series. The *levels* of stock are different, however, with DBS showing the greatest volume, Hood-Scott the lowest, and Lithwick an intermediate amount on both bases. For a longer period, significant differences in the growth rates do emerge. Lithwick's growth rates over the longer period are below the DBS estimates, and Hood-Scott's are greater. This stems

TABLE 16

Contributions to Potential Growth,

Canada, 1926-56, and United States, 1929-57

	Canada, 1926-56			U.S., 1929-57		
Labor input			0.62			0.82
Labor force	1.21			1.00		
Average annual hours	-0.62			-0.53		
Man-hours		.59			.47	
Education	+0.12			0.35		
Age-sex composition	-0.09			0.01		
Quality change		.03			.36	
Gross domestic capital Input			0.55[a]			0.41
Land		.03			.00	
Residential construction		.04			.05	
Other construction and machinery and equipment		.42			.28	
Inventories		.06			.08	
Foreign capital owned by nationals			0.02			0.02
Domestic capital owned by foreigners			-0.05			0.00
Total factor input			1.15			1.25
Contribution of total measured factor productivity			2.74			1.68
Average annual growth rate, GNP			3.89			2.93

Source: N. H. Lithwick, "Economic Growth in Canada: A Quantitative Analysis," unpublished Ph.D. dissertation, Harvard University, 1963, Table 12, p. 37, and Table 13, p. 39; and E. F. Denison, *The Sources of Economic Growth in the United States and the Alternatives Before Us*, Washington, D.C., 1962, Table 32, p. 266.

[a]The gross capital measure is used here to permit comparability with Denison. If net stock is used, the contribution is slightly lower (0.52). due to the slower growth rate of net stock in this period.

The main discrepancy between Lithwick's growth rate of factor productivity in manufacturing of 2.3 per cent and that of the present study

from the respective estimates of early-year capital stock, which differ substantially due to the very weak data used to compile these estimates. (Once again our thanks to Mr. White for suggesting this comparison.)

TABLE 17

Growth Rates in Canada, By Industry, 1937-61

Industry	Gross Domestic Product	Adjusted Labor Input	Net Capital Stock: Construction	Net Capital Stock: Machinery and Equipment	Total Measured Factor Input	Total Measured Factor Productivity
Agriculture	1.2	-1.8	3.3	5.2	-0.4	1.6
Forestry, fishing, and trapping	1.8	-1.1	5.9	4.4	0.2	1.5
Mining, quarrying, oil wells	5.2	0.5	7.7	6.4	3.3	1.9
Manufacturing[a]	4.8	2.2	2.3	4.6	2.6	2.3
Construction	5.7	3.3	4.1	8.7	3.6	2.1
Electric power and gas utilities	8.4	3.7	5.9	6.0	5.0	3.3
Trade, wholesale and retail	4.7	3.0	3.3	8.0	3.3	1.4
Finance, insurance, and real estate	4.5	3.6	3.5	8.2	3.6	1.0
Transportation storage and communication	5.3	1.8	1.1	5.8	2.0	3.3
Commercial and community services	3.8	3.8	2.9	7.6	3.8	0.1
Total private economy	4.3	0.8	3.2	5.1	1.5	2.8

Source: N. H. Lithwick, "Economic Growth in Canada: A Quantitative Analysis," unpublished Ph.D. dissertation, Harvard University, 1963, Table 19, p. 52.

[a]With the revised manufacturing output data, gross domestic product for manufacturing shows an annual growth rate of 5.2 per cent, and productivity grows at 2.7 per cent.

of 2.2 to 2.5 per cent [31] is removal in the former of quality changes that are attributable to labor. This adjustment has been made to the present data in Appendix Table SA-7, and the quality-adjusted growth rate of factor productivity for total manufacturing is estimated to be 2.2 per cent.

There appeared to be some inconsistency between the high growth rate of factor productivity in the aggregate and the rates for the majority of the component industries. Since the aggregate is a weighted average of the productivity advance in the various individual industries, apparently some process was occurring which is not detected when simple aggregates are used.

The explanation of this phenomenon is the interindustry shifts in relative importance.[32] Thus, shifts out of agriculture, where factors of production have relatively low productivity, into industries where it is somewhat higher will serve to raise aggregate productivity.

An evaluation of the importance of these shifts between industries was made for both Canada and the United States, and this factor turned out to explain much of the difference in factor productivity, as can be seen in Table 18.

The discrepancy in the influence of these shifts is largely explained by the fact that in the United States, shifts from agriculture began earlier and extended over a much longer period than in Canada, where this shift was concentrated largely in the decade of the forties.

These findings were confirmed by a variety of tests.[33] During the course of conducting these tests, it was found that at the industry level, the factor productivity growth rates for Canada and the United States were quite similar, as can be seen by comparing Tables 17 and 19.

This similarity in rates of technological advance offers some support for the contention that Canada has been able to borrow not only capital

[31] Table 6.

[32] This was calculated in two ways. The first was to divide the change in output into interindustry and intraindustry growth of product per man-hour. This was calculated as

$$\Delta a = (a_0 \cdot \Delta l) + (l_1 \cdot \Delta a)$$

where a is the product per adjusted man-hour and l is the share of an industry in the labor force. The second was to assume that capital could also be shifted between industries over the long run and to calculate the interindustry share in the growth of output per combined factor input. The results were not very different using the two procedures.

[33] The tests involved an attempt to derive each industry's contribution to the aggregate total measured factor productivity indirectly. Summing these yielded a growth rate in the aggregate factor productivity close to the one calculated directly.

TABLE 18

Sources of Growth, United States and Canada, Private Domestic Economy, 1937-61 and 1929-57

	Canada, 1937-61 (ten industries)		U.S., 1929-57 (five industries)	
Growth Rate of Output		4.3		2.9
Measured factor inputs				
Labor	.6		.5	
Capital	.8	1.5	.5	0.9
Interindustry shifts		0.7		0.1
Net factor productivity		2.2		1.8

Source: N. H. Lithwick, "Economic Growth in Canada: A Quantitative Analysis," unpublished Ph.D. dissertation, Harvard University, Table 37, p. 91.

TABLE 19

Growth Rates in the United States, by Industry, 1927-57

Industry	Gross Domestic Product	Adjusted Labor Input	Net Capital Stock	Total Measured Factor Input	Total Measured Factor Productivity
Agriculture	0.9	−1.1	1.5	−0.7	1.7
Mining	1.5	−0.7	−0.1	−0.5	2.0
Manufacturing	3.5	1.4	2.1	1.6	2.0
Transportation, communications, and public utilities	4.1	−0.2	1.3	0.1	4.0
All other industries	2.4	1.2	2.2	1.4	1.0
Total private economy	2.9	0.6	2.0	0.9	2.0

Source: N. H. Lithwick, "Economic Growth in Canada: A Quantitative Analysis," unpublished Ph.D. dissertation, Harvard University, 1963, Table 34, p. 83.

from the United States, but also the particularly important inputs concealed within measured factor productivity, such as new ideas and new techniques.[34] It also reveals that the difference between the two economies lies largely in the interaction between industrial sectors, rather than within any particular sector or group of sectors.

Further attempts to discover possible sources of interaction led to a decomposition of the manufacturing sectors which contributed one-third of the aggregate measured factor productivity. For the United States, shifts within manufacturing were found to explain .05 percentage points of the net factor productivity.[35] The availability of new data for this study, particularly the DBS capital stock estimates [36] permitted us to evaluate the same interaction effect within Canadian manufacturing which contributes one-half of the aggregate measured factor productivity. This amounted to approximately .07 percentage points in Canada's net factor productivity. Thus, after these effects have been removed, the growth rates of net factor productivity in Canada and the United States are 2.11 and 1.80 respectively. This difference likely reflects specification errors in the simple Cobb-Douglas model used, especially since it was found necessary to neglect returns to scale, and since these will show up in the measured factor productivity.

The main conclusions that may be inferred from this study are that agriculture has played a unique role in Canada's recent growth, and that any attempt to extrapolate aggregate productivity advance on the basis of past experience must keep this condition in mind. As for manufacturing, its growth performance has been rather unspectacular, with output and technical advance proceeding at an average rate.

More comprehensive studies of potential growth in Canada have been recently completed but are not yet available for publication. One, by T. Wilson for the Royal Commission on Taxation, has utilized the Knowles technique [37] to estimate the nature of potential growth. While we are unable to present his findings, he does indicate that his results are not significantly different from Lithwick's aggregative findings.

[34] Insofar as the periods chosen are not strictly comparable, this hypothesis must remain tentative.

[35] Lithwick, *op. cit.*, Table 43, p. 100.

[36] *Estimates of Fixed Capital Flows and Stocks, Manufacturing, Canada, 1926–60,* forthcoming.

[37] James W. Knowles, *The Potential Economic Growth in the United States,* Joint Economic Committee Study of Employment, Growth, and Price Levels, Study Paper No. 21, Washington, D.C., 1960.

One further study may also be referred to, which was available in unpublished form at the time of writing. Professor T. M. Brown has produced a study of Canadian economic growth for the Royal Commission on Health Services, in which econometric tools are used. We were unable to obtain permission to cite his findings prior to publication, however, and are therefore not in a position to report on this work.

Statistical Appendix

CONSTANT-1949-DOLLAR OUTPUT ESTIMATES

The rates of growth of constant-dollar gross domestic product at factor cost for total manufacturing and our thirteen 1948 DBS Standard Industrial Classification major groups are derived from DBS 61-505, *Indexes of Real Domestic Product by Industry of Origin, 1935–61,* Table 1, pages 67–68, and of gross output (for the years where obtainable) from DBS 61-502, *Revised Index of Industrial Production, 1935–1957,* Appendix C. We used DBS 13-513, *Supplement to the Inter-Industry Flow of Goods and Services, Canada, 1949,* Table 1, to obtain approximations to gross output and intermediate inputs (excluding intramajor group consumption) in 1949, in order to obtain the 1946–53 rate of change of constant-1949-dollar intermediate inputs. Minor differences in industrial coverage between the 13-513 and 61-502 indexes of gross output reduce the validity of the estimates of rates of change of constant-dollar gross output and intermediate input presented in Table 11. The various indexes of output purport to relate to manufacturing activity only.

CONSTANT-1949-DOLLAR CAPACITY OUTPUT ESTIMATES

The ratios of gross domestic product in 1949 dollars to the net stock of capital in 1949 dollars based on Set I lives were calculated. By inspection it was determined that there were no persistent trends in the capital-output ratios for seven major groups. For these groups the year 1955 or 1956 was assumed to represent capacity output from the capital stock. The net stock for each group in each postwar year was divided by the selected capital-output ratio to give an estimate of the output that might have been produced if the capital stock had been utilized to the same extent as in 1955 or 1956.

For those major groups for which there appeared to be a trend in the capital-output ratio a straight line was fitted through the ratios of 1948 and 1956. The ratios for each year were calculated from this line, and the net stock for each year was divided by this trend value of the capital-output ratio. This gives the capacity output in each year, on the assumption that the degree of utilization was the same in 1948 as in 1956 and that the capital-output ratio corresponding to capacity did follow a linear trend over the period. The capacity estimates are presented in Table SA–1.

THE LABOR INPUT

The DBS has recently released annual indexes of output per person employed and per man-hour for total manufacturing, based on persons employed and man-hours data which are superior to ours. The labor input we used in Part II of this paper are of two kinds. First, the rates of growth (and indexes) of the number of administrative and office (including working owners and partners) employees and production and related workers are taken from DBS 31-201, *General Review of the Manufacturing Industries of Canada* (various annual issues), and data prepared for the Canadian Political Science Association Historical Statistics project.[1] The number of employees purports to include only those engaged in manufacturing activities and matches the purported activity coverage of the output indexes. As an alternative measure of the labor input, we calculated the rate of growth (index) of administrative and office employees separately from those for production and related workers and weighted the rates of growth (indexes) together by the 1949 proportions between salaries and wages.

In Table SA–2, we compare the two rates of growth and the resulting effects on the estimated rates of change of total measured factor productivity.

As can be seen from Table SA–2, the two series on labor inputs yield only negligible differences for most major groups, though the differences for the tobacco, rubber, and leather and the textiles major groups are substantial.

For man-hours data, we had an even wider choice. Average paid weekly man-hours for both wage earners and salaried employees by major group were obtained from various issues of DBS 72-204, *Earnings and Hours of Work in Manufacturing.* These data are based on an annual survey conducted one week in late October or November and include full-time, short-time, and overtime hours worked and any hours of paid absence in the week. The data pertain to establishments employing fifteen or more persons and include working owners and partners. Data on annual averages of paid weekly man-hours for *wage earners only* in establishments employing fifteen or more persons by major group in manufacturing were obtained from various issues of DBS 72-202, *Review of Man-hours and Hourly Earnings.*

The man-hours statistics include hours worked by full-time and part-time wage earners, including overtime hours actually worked; premium or penalty hours credited for purposes of computing overtime payment are not included. Hours credited to wage-earners absent on leave with pay in the reported pay periods are included in the statistics as though the hours had been worked. The averages are obtained by dividing the aggregated hours reported for the week by the number of full-time and part-time wage earners working such hours.[2]

[1] M. C. Urquhart and K. A. H. Buckley (ed.), *Historical Statistics of Canada*, Toronto, 1965.

[2] DBS 72–202, *Review of Man-hours and Hourly Earnings, 1945–62,* p. 45.

TABLE SA-1

Estimates of Excess Capacity, Total Manufacturing and Major Groups, 1946-60

(millions of constant 1949 dollars)

	Capacity Output	Capacity Minus Actual Output	Capacity Output	Capacity Minus Actual Output	Capacity Output	Capacity Minus Actual Output
	Food and Beverages		*Tobacco, Rubber, and Leather Products*		*Textile Products*	
1946	465.3	-91.6	162.9	-21.9	196.7	-17.9
1947	508.4	-44.0	177.0	-21.8	215.0	-12.4
1948	559.8	0.0	187.6	6.1	235.4	0.0
1949	599.1	30.8	191.2	14.4	249.8	7.9
1950	626.5	36.6	192.1	6.6	257.6	-14.5
1951	648.8	41.9	193.0	9.4	266.0	- 7.6
1952	667.2	22.2	196.0	3.4	274.9	26.0
1953	684.4	17.2	203.4	- 5.2	278.1	17.1
1954	708.1	22.7	213.1	14.7	279.5	51.4
1955	734.0	13.4	221.4	0.0	280.4	4.6
1956	756.4	0.0	230.7	- 9.5	283.7	0.0
1957	777.4	6.8	241.3	- 0.5	289.7	5.2
1958	800.4	- 6.0	247.9	9.3	290.1	24.3
1959	819.0	-19.8	250.7	-10.2	284.4	-16.5
1960	841.6	-12.0	257.8	14.0	279.0	-17.3
	Iron and Steel Products		*Transportation Equipment*		*Nonferrous Metal Products and Electrical Apparatus and Supplies*	
1946	569.8	85.0	409.7	91.2	513.1	174.9
1947	584.8	23.2	400.4	23.9	504.8	101.7
1948	609.0	0.0	392.1	8.1	506.4	76.4
1949	625.2	25.2	390.5	- 4.6	513.9	64.0
1950	630.8	15.8	396.2	-31.7	519.5	33.6
1951	653.9	-48.1	415.4	-103.4	533.6	6.3
1952	716.9	3.5	450.5	-138.6	569.9	39.1
1953	780.1	88.3	508.5	-144.2	614.5	9.1
1954	812.6	175.4	565.7	23.2	647.8	48.1
1955	831.1	88.3	597.9	24.6	676.5	0.0
1956	871.8	0.0	623.9	0.0	722.3	0.7
1957	934.8	97.2	649.7	52.3	783.6	91.2
1958	971.9	202.1	669.9	146.4	828.4	153.8
1959	997.3	114.1	689.7	170.1	840.5	128.6
1960	1,040.4	216.6	705.4	191.8	843.4	108.8

Capacity Output	Capacity Minus Actual Output	Capacity Output	Capacity Minus Actual Output	Capacity Output	Capacity Minus Actual Output	Capacity Output	Capacity Minus Actual Output
Clothing Products		*Wood Products*		*Paper Products*		*Printing, Publishing, and Allied Industries*	
259.3	3.5	297.4	24.8	322.7	3.0	160.4	14.5
274.2	26.7	313.3	4.9	345.5	- 6.2	164.9	6.3
291.0	29.0	331.0	15.0	374.6	0.0	176.7	1.0
303.3	34.9	341.2	27.1	398.0	3.3	190.3	0.6
311.7	39.8	351.2	11.3	413.7	-17.7	201.9	9.4
317.3	45.7	366.2	5.6	435.8	-28.0	214.0	14.6
321.9	22.9	380.6	16.9	465.4	17.8	222.5	18.6
326.7	18.0	390.9	- 3.0	485.7	19.6	226.0	8.4
327.2	34.9	401.1	11.0	493.2	3.4	237.0	6.3
321.9	19.1	414.2	-14.2	504.6	-12.5	250.8	9.7
315.6	0.0	434.4	0.0	543.9	0.0	260.5	0.0
310.8	- 2.7	451.1	51.3	598.2	63.4	275.5	13.3
304.5	- 2.5	453.8	39.2	621.5	86.3	292.2	37.2
299.7	- 3.9	462.0	32.9	616.3	45.2	308.1	36.4
298.7	9.1	477.4	50.2	614.1	28.4	321.6	43.7
Nonmetallic Mineral Products and Products of Petroleum and Coal		*Chemical Products*		*Miscellaneous Manufacturing Industries*		*Total Manufacturing*	
137.8	- 4.1	166.9	- 9.3	59.7	- 2.9	3,564.3	93.2
150.1	-13.0	177.4	- 6.5	65.6	0.0	3,726.5	-70.6
173.9	- 3.9	193.8	0.0	71.5	8.0	3,964.1	0.0
192.8	- 1.9	208.2	5.7	76.5	- 1.5	4,157.4	83.3
204.5	-12.3	214.8	- 3.3	80.6	- 0.5	4,284.9	-41.8
222.1	-17.8	224.1	-18.9	85.2	- 7.6	4,468.7	-216.5
249.2	- 3.1	261.0	13.3	90.4	- 4.6	4,782.0	-45.8
278.4	- 3.5	311.0	27.7	96.2	-13.9	5,117.3	-32.4
309.6	10.7	331.0	23.0	100.8	- 4.0	5,366.8	359.7
345.8	- 0.5	331.8	- 3.3	106.4	0.0	5,575.2	87.4
391.6	0.0	354.0	0.0	114.7	0.0	5,911.5	0.0
442.2	45.1	392.1	20.7	124.6	5.0	6,343.1	521.2
483.8	74.6	419.6	18.6	133.3	3.6	6,633.3	901.1
520.3	71.7	430.4	8.4	142.4	- 0.5	6,792.5	689.5
546.4	105.4	437.4	- 7.5	154.8	5.4	6,947.0	864.4

TABLE SA-2

Unweighted and Weighted Persons Employed, Total Measured Factor Input and Total Measured Factor Productivity, Total Manufacturing and Major Groups, 1946-56 and 1946-60

(continuous annual rates of change)

	Persons Employed		Total Measured Factor Input		Total Measured Factor Productivity	
	(1)	(2)	(3)	(4)	(5)	(6)
Total manufacturing						
1946-56	2.5	2.6	3.2	3.3	2.1	2.0
1946-60	1.4	1.6	2.5	2.6	1.5	1.4
Food and beverages						
1946-56	1.3	1.3	2.5	2.6	0.5	0.5
1946-60	1.3	1.3	2.5	2.5	0.6	0.6
Tobacco, rubber, and leather products						
1946-56	-0.9	-0.7	0.1	0.2	2.5	2.4
1946-60	-1.2	-0.9	-0.2	0.0	2.2	1.9
Textile products						
1946-56	0.5	1.0	2.1	2.5	0.7	0.3
1946-60	-0.6	-0.2	0.9	1.2	1.4	1.1
Clothing products						
1946-56	0.5	0.5	0.9	0.9	1.2	1.2
1946-60	0.2	0.2	0.5	0.5	0.4	0.4
Wood products						
1946-56	2.5	2.5	2.6	2.6	2.0	2.0
1946-60	0.9	0.9	1.3	1.3	1.9	1.9
Paper products						
1946-56	3.3	3.4	4.3	4.3	1.1	1.0
1946-60	2.4	2.5	3.7	3.8	0.6	0.5
Printing, publishing, and allied industries						
1946-56	4.0	4.0	4.0	4.0	1.8	1.8
1946-60	3.1	3.1	3.3	3.3	1.3	1.3

(continued)

TABLE SA-2 *(concluded)*

	Persons Employed		Total Measured Factor Input		Total Measured Factor Productivity	
	(1)	(2)	(3)	(4)	(5)	(6)
Iron and steel products						
1946-56	2.6	2.8	3.3	3.4	2.6	2.4
1946-60	1.7	1.9	2.7	2.8	1.1	1.0
Transportation equipment						
1946-56	3.4	3.7	3.2	3.3	3.6	3.4
1946-60	0.6	0.8	1.1	1.2	2.3	2.2
Nonferrous metal products and electrical apparatus and supplies						
1946-56	5.0	5.2	4.2	4.4	3.3	3.2
1946-60	2.6	2.8	2.8	3.0	2.7	2.6
Nonmetallic mineral products and products of petroleum and coal						
1946-56	4.6	4.8	6.6	6.7	3.6	3.5
1946-60	3.5	3.6	5.8	5.9	2.3	2.2
Chemical products						
1946-56	3.3	3.4	5.2	5.3	1.7	1.7
1946-60	2.6	2.7	4.6	4.6	2.0	2.0
Miscellaneous manufacturing industries						
1946-56	4.6	4.9	4.6	4.8	1.4	1.2
1946-60	4.8	5.0	4.9	5.1	1.4	1.2

Note: Columns (1), (3), and (5) refer to the unweighted persons-employed labor input and are reproduced from Table 6 while columns (2), (4), and (6) refer to persons employed weighted by wages and salaries proportions in 1949.

The measured total factor input and total measured factor productivity rates of change are on a gross domestic product basis. Factor inputs and factor productivity estimates are based on Set I of the average economic lives used by DBS in preparing the manufacturing capital stock estimates.

Charts for each major group were drawn comparing annually:

1. The number of salaried employees from 31-201 and 72-204;
2. The number of wage earners from 31-201, 72-202 and 72-284;
3. Annual averages of paid weekly hours of wage earners from 72-202 and 72-204.

In some instances, significant differences in trend in these comparisons were noted. For purposes of Part II of our paper, the paid man-hours series for which rates of growth and indexes were calculated were based on the number of salaried employees from DBS 31-201 times average weekly hours from DBS 72-204 and the number of wage earners from DBS 31-201 times average weekly hours from DBS 72-202. The two components were added together to derive the paid man-hours input used throughout Part II. To obtain an appraisal of how different selection procedures would have affected our estimates, additional variants of the paid man-hours input were prepared.

As is shown in Table SA–3, differences in estimated rates of change in total measured factor productivity are only negligibly affected when the average weekly hours data for wage-earners is taken from DBS 72-204 rather than DBS 72-202. Greater differences emerge, however, when the hours data are weighted together, using wages and salaries as weights.

We also compared our labor input data with that recently published by DBS for total manufacturing. With respect to persons employed, the variant we used in Part II of this paper, compared to the more refined DBS data, would suggest a slight downward bias in our data. It would appear that our growth rate for persons employed in total manufacturing may be biased downward by one-tenth of one percentage point. Given the weight for labor (see below) in our estimation of total measured factor productivity, an increase in the growth rate of our persons employed input of 0.1 would lead to a decrease in the rate of growth of total measured factor productivity in total manufacturing of approximately two-thirds of 0.1, a variation substantially below that introduced by variations in the different capital inputs when the average economic lives of the capital goods were changed. Moreover, the foregoing tables suggest that the use of market prices to weight the labor inputs together would lead to higher rates of growth of the labor input than are shown in Part II of our paper.

We are somewhat surprised at the close correspondence between the DBS man-hours worked series and our man-hours paid series used in Part II. We have tentative evidence which would suggest that our man-hours paid series should be running ahead of the DBS man-hours worked series more than it does. The relatively close match between our crude labor input data and the better data from DBS for total manufacturing does not ensure that a similarly close match would exist at the major group level of detail.

In addition to the differences between hours paid and hours worked, differences in the quality of the labor input in the various industries may lead to total measured factor productivity growth rates that are not really

TABLE SA-3

Unweighted and Weighted Variants of Man-Hours, Total Measured Factor Input, and Total Measured Factor Productivity, Total Manufacturing and Major Groups, 1946-56 and 1946-60

(continuous annual rates of change)

	Paid Man-Hours				Total Measured Factor Input				Total Measured Factor Productivity			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Total manufacturing												
1946-56	2.0	2.0	2.2	2.2	2.9	2.9	3.0	3.0	2.4	2.4	2.3	2.3
1946-60	1.0	1.0	1.2	1.2	2.2	2.2	2.3	2.3	1.8	1.9	1.7	1.7
Food and beverages												
1946-56	0.9	0.8	0.9	0.8	2.3	2.2	2.3	2.2	0.8	0.9	0.8	0.8
1946-60	0.9	0.8	0.9	0.8	2.2	2.1	2.2	2.2	0.8	0.9	0.8	0.8
Tobacco, rubber, and leather products												
1946-56	-1.2	-1.5	-1.1	-1.3	-0.1	-0.4	-0.0	-0.2	2.8	3.0	2.7	2.8
1946-60	-1.4	-1.6	-1.3	-1.4	-0.4	-0.5	-0.3	-0.4	2.4	2.5	2.2	2.4
Textile products												
1946-56	0.1	0.3	0.6	0.8	1.9	2.0	2.2	2.3	0.9	0.8	0.6	0.5
1946-60	-1.0	-0.9	-0.6	-0.4	0.7	0.8	1.0	1.0	1.6	1.6	1.4	1.3
Clothing products												
1946-56	0.4	0.2	0.3	0.2	0.8	0.6	0.7	0.6	1.3	1.5	1.4	1.5
1946-60	0.0	-0.2	-0.1	-0.2	0.3	0.2	0.2	0.3	0.6	0.7	0.7	0.6

(continued)

TABLE SA-3 *(continued)*

	Paid Man-Hours				Total Measured Factor Input				Total Measured Factor Productivity			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Wood products												
1946-56	2.0	2.1	2.0	2.0	2.3	2.3	2.3	2.3	2.4	2.4	2.4	2.4
1946-60	0.5	0.4	0.5	0.4	1.0	1.0	1.0	1.0	2.2	2.2	2.2	2.2
Paper products												
1946-56	2.1	2.2	2.3	2.4	3.6	3.7	3.7	3.8	1.7	1.6	1.6	1.5
1946-60	1.4	1.6	1.6	1.7	3.2	3.3	3.3	3.4	1.1	1.0	1.0	1.0
Printing, publishing, and allied industries												
1946-56	3.5	3.4	3.6	3.5	3.7	3.6	3.7	3.6	2.1	2.2	2.1	2.2
1946-60	2.6	2.6	2.7	2.6	3.0	3.0	3.0	3.0	1.6	1.6	1.6	1.6
Iron and steel products												
1946-56	2.2	2.0	2.3	2.2	3.0	2.9	3.1	3.0	2.9	3.0	2.8	2.9
1946-60	1.2	1.1	1.4	1.3	2.3	2.2	2.5	2.4	1.5	1.6	1.3	1.4
Transportation equipment												
1946-56	3.1	3.0	3.3	3.3	2.9	2.9	3.1	3.1	3.8	3.8	3.6	3.6
1946-60	0.4	0.3	0.6	0.5	0.9	0.9	1.1	1.0	2.5	2.6	2.3	2.4
Nonferrous metal products and electrical apparatus and supplies												
1946-56	4.5	4.6	4.8	4.9	3.9	4.0	4.1	4.2	3.6	3.6	3.4	3.4
1946-60	2.3	2.2	2.5	2.5	2.6	2.6	2.7	2.7	3.0	3.0	2.8	2.8

(continued)

TABLE SA-3 *(concluded)*

	Paid Man-Hours				Total Measured Factor Input				Total Measured Factor Productivity			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Nonmetallic mineral products and products of petroleum and coal												
1946-56	4.3	4.1	4.6	4.4	6.4	6.3	6.6	6.5	3.7	3.8	3.6	3.7
1946-60	3.2	3.0	3.4	3.3	5.6	5.5	5.7	5.7	2.5	2.6	2.4	2.4
Chemical products												
1946-56	2.8	2.7	2.9	2.8	5.0	4.9	5.0	5.0	2.0	2.1	1.9	2.0
1946-60	2.2	2.1	2.3	2.2	4.3	4.3	4.4	4.4	2.3	2.3	2.2	2.3
Miscellaneous manufacturing industries												
1946-56	4.3	4.4	4.6	4.6	4.4	4.5	4.7	4.7	1.6	1.6	1.4	1.4
1946-60	4.6	4.5	4.9	4.9	4.7	4.7	4.9	4.9	1.5	1.5	1.3	1.3

Source: Columns (1), (5), and (9): Based on persons-employed data from DBS 31-201, *General Review of the Manufacturing Industries of Canada,* average weekly hours for salaried employees from DBS 72-204, *Earnings and Hours of Work in Manufacturing,* and average weekly hours for wage earners from DBS 72-202, *Review of Man-hours and Hourly Earnings 1945-62,* and are reproduced from Table 6. Columns (2), (6), and (10): Based on persons-employed data from DBS 31-201, average weekly hours for salaried employees and wage earners from DBS 72-204. Columns (3), (7), and (11): Same as column (1) with hours data for two components weighted together using 1949 wages and salaries proportions. Columns (4), (8), and (12): Same as column (2) with hours data for two components weighted together using 1949 wages and salaries proportions.

The total measured factor input and total measured factor productivity rates of changes are on the gross domestic product basis. Data refer only to Set I of the average economic lives used by DBS in preparing the capital stock estimates.

TABLE SA-4

Comparison of Indexes of Labor Input,

Total Manufacturing, 1947-60

(1949 = 100.0)

	Persons Employed			Man-Hours Worked,	Man-Hours Paid			
	DBS	Our Indexes		DBS		Our Indexes		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1947	96.3	96.6	95.9	97.7	97.4	97.6	96.6	96.7
1948	98.5	98.7	98.1	100.4	99.1	99.4	98.4	98.7
1949	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
1950	101.7	101.0	101.3	100.8	101.0	101.1	101.1	101.3
1951	107.9	107.4	107.7	104.9	106.0	104.4	106.3	104.9
1952	110.8	110.0	110.6	106.6	108.1	108.0	108.7	108.7
1953	114.2	113.3	114.0	110.5	110.6	109.2	111.4	110.1
1954	109.3	108.3	109.4	103.9	104.4	103.8	105.7	105.3
1955	112.1	110.9	112.1	107.0	107.6	107.4	109.0	108.9
1956	116.8	115.5	116.8	112.3	112.0	111.3	113.5	112.9
1957	117.3	116.0	117.7	111.4	111.0	108.9	112.9	111.0
1958	111.5	110.1	112.0	105.9	104.8	104.4	106.9	106.6
1959	112.9	111.3	113.1	107.8	107.0	106.2	108.9	108.3
1960	111.4	110.3	112.2	105.6	105.4	104.4	107.6	106.7
			(continuous annual rates of change)					
1947-56	2.1	2.0	2.2	1.5	1.6	1.5	1.8	1.7
1947-60	1.1	1.0	1.2	0.6	0.6	0.5	0.8	0.8

Note: See revisions using new GDP data in Table SA-14.

Source: Columns (1) and (4): DBS 14-501, *Indexes of Output Per Person Employed and Per Man-Hour in Canada, Commercial Non-Agricultural Industries, 1947-63,* Table 2. These DBS series are not available prior to 1947. Column (2): Unweighted persons employed. Column (3): Persons employed with wages and salaries as weights. Column (5): See source note to column (1), Table SA-3. Column (6): See source note to column (2), Table SA-3. Column (7): See source note to column (3), Table SA-3. Column (8): See source note to column (4), Table SA-3.

indicators of the differences in rates of technological advance. We have attempted to adjust our data to indicate the results of not correcting for these factors.

The first adjustment undertaken was to try to estimate the number of hours worked per week. Since the published DBS data which we have used are on a paid basis, and since wages have included a rising component of paid time off, there has been a growing gap between the number of hours actually worked and the number of hours for which workers have received payment. Our procedure was to use some sample evidence on the value of paid time off between 1953 and 1960 in selected manufacturing industries of Canada.[3]

These data are certainly not completely satisfactory, the sampling unit being "companies." Eighty-eight manufacturing companies were sampled in the first survey, having just under a quarter million employees or one-sixth of the total number of employees in manufacturing in that year. No evidence is presented on the sampling procedures, so no estimate of the degree of bias or the size of the sampling error can be determined.

With these serious problems in mind, let us nevertheless consider their findings and the implications of these for our own results. Table SA–6 presents the effect of removing hours paid but not worked upon the growth rate of man-hours. In all cases, the effect is very substantial indeed, with labor input showing a much slower growth rate than on the paid basis.

It is clear that a slower-growing labor input will have the effect of increasing the rate of growth of total measured factor productivity. To get a rough idea of the extent of that increase, we take the growth rate of the total measured factor productivity in the period 1946–60 and calculate the effect of our adjustment. These data are presented in Table SA–7.

The effect of this adjustment is to raise total measured factor productivity by about one-third on the average, with a very great degree of variability between industries. This suggests that a large part of the increase in productivity has been concealed through the use of hours paid data in studies of Canadian growth.[4]

If the orders of magnitude suggested here are correct, it is essential, for any accurate evaluation of growth in Canada, that data on hours worked be obtained.

The second aspect of labor input which we wish to consider is the changing quality as reflected in amount of education and changes in age and sex composition. The treatment follows that of Denison [5] with the adjustment for days of schooling neglected. The results, summarized in Table SA–8, reveal that for all but one major group (tobacco, rubber, and leather

[3] *Fringe Benefit Costs in Canada,* Toronto, Industrial Relations Counsellors Service, Inc., No. 1, December 1954. Recent studies have been conducted by the Thorne Group, but reasonable consistency has been maintained.

[4] This leads to an overstatement of labor's role in growth to the same extent.

[5] E. F. Denison, *The Sources of Economic Growth in the United States and the Alternatives Before Us,* Washington, D.C., 1962.

TABLE SA-5

Indexes of Output Per Labor Input, Total Manufacturing, 1947-60

(1949 = 1.000)

	Output Per Person Employed			Output Per Man-Hour Worked,	Output Per Man-Hour Paid			
	DBS	Our Indexes		DBS		Our Indexes		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1947	0.968	0.965	0.972	0.954	0.957	0.955	0.965	0.964
1948	0.988	0.986	0.992	0.969	0.982	0.979	0.989	0.986
1949	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1950	1.044	1.051	1.048	1.054	1.051	1.050	1.050	1.048
1951	1.066	1.071	1.068	1.096	1.085	1.102	1.082	1.096
1952	1.069	1.077	1.071	1.112	1.096	1.097	1.090	1.090
1953	1.107	1.116	1.109	1.144	1.143	1.158	1.135	1.148
1954	1.124	1.135	1.123	1.183	1.177	1.184	1.163	1.117
1955	1.202	1.215	1.202	1.259	1.252	1.254	1.236	1.237
1956	1.242	1.256	1.242	1.292	1.296	1.304	1.278	1.285
1957	1.218	1.232	1.214	1.283	1.287	1.312	1.266	1.287
1958	1.262	1.278	1.256	1.329	1.343	1.348	1.316	1.320
1959	1.327	1.346	1.324	1.390	1.400	1.411	1.376	1.383
1960	1.340	1.354	1.331	1.414	1.416	1.430	1.388	1.399
	(continuous average annual rates of change)							
1947-56	2.8	2.9	2.7	3.4	3.4	3.5	3.1	3.2
1947-60	2.5	2.6	2.4	3.0	3.0	3.1	2.8	2.9

Note: See revisions using the revised output data in Table SA-15.

Source: Columns (1) and (4): DBS 14-501 (see source note, Table SA-4); columns (2), (3), and (5)-(8) derived by dividing index of constant 1949 dollar gross domestic product at factor cost for total manufacturing, DBS 61-505, *Indexes of Real Domestic Product by Industry of Origin 1935-61,* by respective indexes in Table SA-4.

products) the quality of the labor input increased at an average rate for all manufacturing of one-third of 1 per cent over the decade 1946–56. If we allocate this increase to labor input, then its contribution to growth increased by about one-quarter of 1 per cent per year, and the growth rate of factor productivity declines by that much. Once again there is great variability between the quality gains in the different industries with only weak association between the rate of quality gain and the growth rate of total factor pro-

TABLE SA-6

Correction of Labor Input for Hours Paid But Not Worked, Canada, 1953-60

	Average Hourly Wage (1)	Average Annual Hours Paid (2)	Paid Time Off Per Year (3)	Hours Paid But Not Worked (4)	Average Annual Hours Worked (5)	Number of Employees (6)	Man-Hours Worked Per Year (7)	Man-Hours Paid Per Year (8)	Continuous Annual Rates of Change: Hours Worked (9)	Continuous Annual Rates of Change: Hours Paid (10)
Total manufacturing										
1953	$1.44	2,137	$205	142	1,995	1,327	2,613	2,837		
1960	2.01	2,101	523	260	1,841	1,292	2,328	2,724	-1.53	-0.58
Food and beverages										
1953	1.22	2,189	207	170	2,020	177	357	387		
1960	1.73	2,106	535	309	1,797	193	347	417	-0.38	1.08
Textile products										
1953	1.23	2,127	167	136	1,991	73	146	156		
1960	1.63	2,163	373	229	1,934	62	120	134	-2.82	-2.16
Paper products										
1953	1.72	2,122	205	119	2,002	84	169	187		
1960	2.38	2,064	410	172	1,892	95	179	202	0.85	1.08

(continued)

TABLE SA-6 *(concluded)*

	Average Hourly Wage (1)	Average Annual Hours Paid (2)	Paid Time Off Per Year (3)	Hours Paid But Not Worked (4)	Average Annual Hours Worked (5)	Number of Employees (6)	Man-Hours Worked Per Year (7)	Man-Hours Paid Per Year (8)	Continuous Annual Rates of Change: Hours Worked (9)	Continuous Annual Rates of Change: Hours Paid (10)
Chemical products										
1953	$1.60	2,116	$211	132	1,984	50	100	106		
1960	2.39	2,049	545	228	1,821	55	100	113	0.07	0.84
Nonmetallic minerals and products of petroleum and coal										
1953	1.59	2,075	291	183	1,892	17	32	36		
1960	2.25	2,012	682	303	1,709	17	29	34	−1.73	−0.73
Iron and steel products										
1953	1.64	2,153	201	123	2,030	188	382	405		
1960	2.28	2,096	464	204	1,892	192	364	403	−0.71	−0.08

Note: Column (3): Expressed in dollars, includes vacations with pay and holidays with pay together with other time paid off (Studies in Industrial Relations "Fringe Benefit Costs in Canada," 1953, Table 7, p. 23; 1959, Table 7, p. 29; and 1961, Table 7, p. 29) Column 4: Column (3) divided by column (1). Column 5: Column (2) minus column (4). Column 6: Expressed in thousands of persons. Column 7: Column (5) times column (6) expressed in millions of man-hours. Column 8: Column (2) times column (6) expressed in millions of man-hours. Column (9) and (10) are derived from columns (7) and (8).

TABLE SA-7

Growth Rate of Total Measured Factor Productivity Based on Hours Worked, Canada, 1953-60

	Difference in Growth Rate of Man-Hours (1)	Labor Coefficient (2)	Increase in Growth Rate of Factor Productivity (3)	Measured Factor Productivity: Growth Rate: Man-Hours Paid (4)	Measured Factor Productivity: Growth Rate: Man-Hours Worked (5)	Measured Factor Productivity: Percentage Increase Due to Adjustment (6)
Total manufacturing	-0.95	.676	.6	1.8	2.5	35
Food and beverages	-1.46	.644	.9	0.8	1.8	115
Textile products	-0.66	.678	.4	1.6	2.1	27
Paper products	-0.23	.531	.1	1.1	1.2	111
Chemical products	-0.77	.548	.4	2.3	2.7	18
Nonmetallic mineral products and products of petroleum and coal	-1.00	.518	.5	2.5	3.0	21
Iron and steel products	-0.63	.700	.4	1.5	1.9	30

Source: Column (1): Table SA-6, column (9) minus column (10). Column (3): Column (2) times minus column(1). Column (4): Table 6, 1946 to 1960 Set III. Column (5): Column (3) plus column (4). Column (6): Percentage increase, column (5) over column (4).

TABLE SA-8

The Effect of Changing Labor Quality

	Rate of Growth of Factor Productivity (1946-56) (1)	Rate of Growth of Education (2)	Age-Sex Quality (3)	Labor Weight (4)	Contribution of Education (5)	Contribution of Age-Sex (6)	Total Quality Contribution (7)	Factor Productivity Net of Quality Change (8)	Percentage Decrease of Factor Productivity After Quality Adjustment (9)
Food and beverages	0.85	0.07	.03	.63	.05	.02	.07	0.78	7.9
Tobacco, rubber and leather products	3.00	-0.48	.01	.76	-.36	.01	-.35	3.35	17.9[a]
Textile products	0.82	0.10	.60	.67	.06	.41	.47	0.35	57.4
Clothing products	1.48	0.16	.16	.77	.13	.13	.25	1.23	17.0
Wood products	2.37	0.08	.07	.74	.06	.05	.11	2.26	4.5
Paper products	1.63	0.09	.20	.53	.05	.11	.15	1.48	9.4
Printing, publishing, and allied industries	2.20	1.03	-.31	.76	.78	-.24	.55	1.66	24.8
Iron and steel products	2.98	0.12	.37	.70	.08	.26	.34	2.64	11.3
Transportation equipment	3.83	0.04	.46	.69	.02	.31	.34	3.49	8.8

(continued)

TABLE SA-8 *(concluded)*

	Rate of Growth of Factor Productivity (1946-56) (1)	Rate of Growth of Education (2)	Age-Sex Quality (3)	Labor Weight (4)	Contribution of Education (5)	Contribution of Age-Sex (6)	Total Quality Contribution (7)	Factor Productivity Net of Quality Change (8)	Percentage Decrease of Factor Productivity After Quality Adjustment (9)
Nonferrous metal products and electrical apparatus and supplies	3.60	0.16	.01	.69	.11	.01	.11	3.49	3.1
Nonmetallic mineral products and products of petroleum and coal	3.82	0.15	.13	.52	.08	.07	.14	3.67	3.8
Chemical products	2.14	0.26	.35	.55	.14	.19	.34	1.81	15.7
Miscellaneous manufacturing industries	1.62	0.20	.25	.71	.14	.18	.32	1.30	19.6
Total manufacturing	2.46	0.11	.23	.67	.08	.15	.23	2.24	9.2

Source: Column (4): Set I lives, row b of column (1), Table SA-10. Column (5): column (4) times column (2). Column (6): column (4) times column (3). Column (7): column (5) plus column (6). Column (8): column (1) minus column (7). Column (9): column (7) divided by column (1).

[a]Increase.

ductivity. Some stronger association was found between the level of quality in the various industries in 1951 and the growth rate of factor productivity.[6]

These findings may be briefly summarized. The use of hours paid data yields a rather large downward bias in the growth rate of factor productivity of about one-third. On the other hand, failure to attribute quality improvements to labor leads to an overstatement of factor productivity by about one-tenth on the average. What is evident is that rather large swings in the size of total measured factor productivity can be obtained by making quite straightforward adjustments to our labor input series.

FIXED CAPITAL INPUT

Preliminary data on constant-1949 and current-dollar gross fixed capital formation, midyear net stock, and capital consumption allowances by major group and total manufacturing were obtained from preliminary worksheets lying behind the forthcoming DBS reference paper, *Estimates of Fixed Capital Flows and Stocks, Manufacturing, Canada, 1926–1960.* Historical gross fixed capital formation data were not adequate to permit DBS to make these estimates for the seventeen major groups in the 1948 DBS Standard Industrial Classification Manufacturing Division, with the result that the estimates are prepared for the combined tobacco, rubber, and leather products; the nonferrous metal products and electrical apparatus and supplies; and nonmetallic mineral products and products of petroleum and coal major groups. As indicated in Part II the estimates were prepared using five different sets of average economic lives of fixed capital goods. The five different sets are reproduced here in Table SA–9.

The estimates of current-dollar gross fixed capital formation by industry, which provide the basic source data for the DBS capital stock measurement program, have been shifted, for 1961 and all subsequent years, from the 1948 DBS SIC to the 1960 DBS SIC.[7] The break in the investment series that results necessitates further work before the capital stock estimates in manufacturing can be extended beyond 1960.

INVENTORIES

Estimates of rates of change of constant-1949 and current-dollar end-of-second-quarter inventories by major group in manufacturing were computed from confidential data kindly supplied by the National Accounts and Balance

[6] We fitted the function

$$A = -15.4 + \underset{(2.7)}{9.2S} + \underset{(1.6)}{9.3E}$$

The t .95 values for the b coefficients is 2.23. $R_c = .630$, and a variance test yielded a significant regression plane at the 95 per cent level. A is the growth rate of factor productivity, S is the level of the age-sex index, and E is the level of the education index.

[7] See Department of Trade and Commerce, *Private and Public Investment in Canada, Outlook, 1962.*

TABLE SA-9

Five Sets of Average Economic Lives of Capital Goods, Used in DBS Estimates of Fixed Capital Stocks and Flows in Canadian Manufacturing

Set	Building Construction	Engineering Construction	Machinery and Equipment	Capital Items Charged to Operating Expenses	Building Construction	Engineering Construction	Machinery and Equipment	Capital Items Charged to Operating Expenses	Building Construction	Engineering Construction	Machinery and Equipment	Capital Items Charged to Operating Expenses
	Food and Beverages				*Tobacco, Rubber and Leather Products*				*Textile Products*			
I	50	55	29	5	50	55	15	5	45	50	26	5
II	50	55	29	5	50	55	15	5	50	55	26	5
III	60	66	35	7	60	66	18	7	54	60	31	7
IV	40	44	23	3	40	44	12	3	36	40	21	3
V	40	44	17	3	40	44	9	3	36	40	16	3
	Clothing Products				*Wood Products*				*Paper Products*			
I	30	0	21	5	30	35	26	5	50	55	22	5
II	50	0	21	5	50	55	26	5	50	55	22	5
III	36	0	25	7	36	42	31	7	60	66	26	7
IV	24	0	17	3	24	28	21	3	40	44	18	3
V	24	0	13	3	24	28	16	3	40	44	13	3
	Printing, Publishing and Allied Industries				*Iron and Steel Products*				*Transportation Equipment*			
I	50	55	30	5	45	50	21	5	40	45	30	5
II	50	55	30	5	50	55	21	5	50	55	30	5
III	60	66	36	7	54	60	25	7	48	54	36	7
IV	40	44	24	3	36	40	17	3	32	36	24	3
V	40	44	18	3	36	40	13	3	32	36	18	3

(continued)

TABLE SA-9 *(concluded)*

Set	Building Construction	Engineering Construction	Machinery and Equipment	Capital Items Charged to Operating Expenses	Building Construction	Engineering Construction	Machinery and Equipment	Capital Items Charged to Operating Expenses	Building Construction	Engineering Construction	Machinery and Equipment	Capital Items Charged to Operating Expenses
	Nonferrous Metal Products and Electrical Apparatus and Supplies				*Nonmetallic Mineral Products and Products of Petroleum and Coal*				*Chemical Products*			
I	40	45	22	5	35	40	26	5	50	55	22	5
II	50	55	22	5	50	55	26	5	50	55	22	5
III	48	54	26	7	42	48	31	7	60	66	26	7
IV	32	36	18	3	28	32	21	3	40	44	18	3
V	32	36	13	3	28	32	16	3	40	44	13	3
					Miscellaneous Manufacturing Industries							
I					30	35	13	5				
II					50	55	13	5				
III					36	42	16	7				
IV					24	28	10	3				
V					24	28	8	3				

Source: Forthcoming DBS reference paper, on *Estimates of Fixed Capital Flows and Stocks, Manufacturing, Canada, 1926-1960.* Negligible engineering construction occurred in the clothing products major group. Row headings (I, II, III, IV, V) correspond with those in tables in Part II of this paper.

of Payments Division of DBS. Estimates for 1946 were obtained by us by graphical interpolation.

LAND

The only data on the stock of land used in manufacturing are those of the Department of National Revenue, in *Taxation Statistics*. The data suffer from a number of conceptual and classification problems, and we were unable to use them. Thus, the weights for the net stock of capital are overstated and, if land was a significant factor in any major group, our estimates of total measured factor productivity suffer from the failure to take land into account. While for an aggregate economy of fixed territorial boundaries, it can be argued that the constant-price stock of land, and other natural agents, remains unchanged, it is clearly not defensible to make such an assumption in any disaggregated analysis of total measured factor productivity.

FACTOR WEIGHTS

The weighting diagram for the year 1949 was obtained from DBS 13-513, *Supplement to the Inter-Industry Flow of Goods and Services, Canada, 1949,* Table 1. Estimates of current-dollar gross domestic product are provided for 29 two- and three-digit 1948 DBS SIC industries in manufacturing, broken down into wages, salaries and supplementary labor income; investment income; net income of unincorporated business; and capital consumption allowances and inventory valuation adjustments. These data were combined into our thirteen major groups, and the last item was replaced by the estimates of current-dollar capital consumption allowances derived from the DBS fixed capital stocks and flows study for manufacturing. We were not able to deal with the inventory valuation adjustment satisfactorily, and our weights have some slight ambiguity in this respect. In addition, as previously mentioned, the DBS 13-513 industry and activity coverage in manufacturing is slightly different than that for manufacturing in DBS 61-505. We arbitrarily split the net income of unincorporated enterprises three ways: 25:75; 50:50, and 75:25 to labor and net returns to capital, respectively. The net returns to capital were split between the net stock of fixed capital and inventories on the basis of their respective current-dollar values in mid-1949. Each time a different set of life assumptions for fixed capital goods were used, the weights for capital consumption allowances, the net stock of capital, and inventories were revised. The resulting weighting diagram for the gross domestic product version of our estimates of total measured factor productivity is reproduced below in Table SA–10.

The weighting diagram for the net domestic product version was derived by expressing the weights for labor net stock of fixed capital and inventories as a fraction of one minus the weight for capital consumption allowances in Table SA–10.

Differences in the handling of net income of unincorporated businesses appear to have little effect. Table SA–11 presents the total measured factor productivity estimates contained in Table 6 as well as the variants just described. As can be seen from Table SA–11, the three alternative allocations have little effect upon the resulting estimates.

ALTERNATIVE MEASURES

As indicated in the text, our data for the right-hand side of the basic identity developed in the Technical Appendix are far from satisfactory.

Two principal statistics for manufacturing were required to estimate the rate of change of the price of gross domestic product at factor cost. We needed the estimates of census value added based on historical data developed within DBS and brought up to date to 1960 by examining various DBS 31-201, *General Reviews of the Manufacturing Industries of Canada,* and special conversion statements supplied by DBS to permit the conversion of 1960 data based on the DBS 1960 Standard Industrial Classification to the DBS 1948 Standard Industrial Classification. The conversion is not wholly satisfactory and reduces the validity of those of our estimates for which 1960 is a terminal year. We also needed expenditures on repair to capital goods by major group from the DBS Capital Expenditures Survey.[8] These latter data, when subtracted from the Census value-added data, yielded our first approximation to current-dollar gross domestic product. The 1949 current-dollar gross domestic product by major group from DBS 13-513 was extrapolated to 1946 and 1960 on the basis of the movement of our approximation. The procedure has two grave drawbacks. The DBS 13-513 and 61-505 industry and activity coverage are slightly different, and our approximation is weak owing to imperfections in the repair expenditures data, and the failure to account for the remaining intermediate inputs may well bias our approximation to current-dollar gross domestic product upward over time. The rate of growth of our approximation was calculated, and from it was subtracted the rate of growth of constant-1949 gross domestic product to derive the rate of growth of the price of gross domestic product. Accordingly, the latter estimate may be too high, which may impart the general downward bias we observed in our estimates of total measured factor productivity shown in Table 12.

From our approximation of current-dollar gross domestic product, we subtracted an estimate, at the major group level, of wages and salaries and supplementary labor income, the latter derived for total manufacturing from DBS 72-502, *Labour Income, 1926–1958,* and subsequent monthly bulletins and allocated over major groups by shares of wages and salaries, and current-dollar capital consumption allowances to derive an estimate of the current-dollar net returns to capital. Again, we were unable to make the inventory valuation adjustment or to adjust for net income of unincorporated enterprises. The remaining portion when divided by the sum of the current-dollar midyear net stock of fixed capital and end-of-second-quarter inventories yielded a very weak estimate indeed of the net rate of return to capital.

[8] DBS 610-504, *Private and Public Investment in Canada, 1946–1957,* and subsequent Department of Trade and Commerce *Outlooks.*

TABLE SA-10

1949 Weighting Diagram for Gross Domestic Product Version of Total Measured Factor Productivity

Set of Lives	Split of Unincorporated Income[a]	Labor	Net Stock of Fixed Capital	Inventories	Capital Consumption Allowances	Labor	Net Stock of Fixed Capital	Inventories	Capital Consumption Allowances	Labor	Net Stock of Fixed Capital	Inventories	Capital Consumption Allowances
		Total Manufacturing				*Food and Beverages*				*Tobacco, Rubber, and Leather Products*			
I	a	.657	.168	.095	.080	.623	.183	.120	.074	.741	.089	.112	.060
	b	.666	.162	.092		.633	.177	.115		.757	.082	.102	
	c	.676	.156	.088		.644	.170	.111		.773	.074	.093	
III	a		.178	.088	.078		.196	.113	.069		.097	.108	.054
	b		.171	.084			.189	.109			.090	.100	
	c		.164	.081			.182	.105			.082	.091	
V	a		.150	.109	.084		.166	.135	.076		.077	.118	.065
	b		.145	.105			.160	.130			.070	.108	
	c		.139	.100			.154	.126			.064	.098	
		Textile Products				*Clothing Products*				*Wood Products*			
I	a	.670	.156	.082	.092	.745	.088	.132	.034	.722	.125	.080	.073
	b	.674	.154	.081		.766	.082	.120		.738	.116	.074	
	c	.678	.151	.079		.786	.072	.107		.757	.104	.066	
III	a		.170	.077	.084		.096	.124	.034		.133	.072	.073
	b		.167	.076			.087	.113			.123	.066	
	c		.164	.074			.078	.101			.110	.060	
V	a		.139	.100	.092		.124	.090	.041		.113	.092	.073
	b		.136	.098			.112	.081			.104	.085	
	c		.134	.096			.100	.072			.094	.076	

(continued)

TABLE SA-10 *(continued)*

Set of Lives	Split of Unincorporated Income[a]	Labor	Net Stock of Fixed Capital	Inventories	Capital Consumption Allowances	Labor	Net Stock of Fixed Capital	Inventories	Capital Consumption Allowances	Labor	Net Stock of Fixed Capital	Inventories	Capital Consumption Allowances
		Paper Products				*Printing, Publishing, and Allied Industries*				*Iron and Steel Products*			
I	a	.531	.265	.086	.118	.757	.158	.027	.058	.693	.135	.104	.068
	b					.762	.154	.026		.696	.134	.102	
	c									.700	.132	.101	
III	a		.275	.077	.118		.166	.024	.053		.144	.095	.068
	b						.162	.023			.142	.094	
	c										.140	.093	
V	a		.244	.100	.125		.153	.038	.053		.118	.117	.073
	b						.148	.037			.116	.115	
	c										.114	.113	
		Transportation Equipment				*Nonferrous Metal Products and Electrical Apparatus and Supplies*				*Nonmetallic Mineral Products and Products of Petroleum and Coal*			
I	a	.665	.180	.104	.051	.685	.143	.044	.128	.513	.216	.139	.132
	b	.687	.166	.096		.692	.138	.042		.518	.213	.137	
	c	.709	.152	.088		.702	.131	.040					
III	a		.187	.088	.060		.144	.040	.131		.234	.132	.122
	b		.172	.081			.138	.039			.231	.130	
	c		.157	.074			.131	.036					
V	a		.163	.130	.042		.115	.043	.157		.196	.154	.137
	b		.151	.120			.110	.041			.194	.152	
	c		.138	.110			.103	.038					

(continued)

TABLE SA-10 *(concluded)*

Set of Lives	Split of Unincorporated Income[a]	Labor	Net Stock of Fixed Capital	Inventories	Capital Consumption Allowances	Labor	Net Stock of Fixed Capital	Inventories	Capital Consumption Allowances
			Chemical Products				*Miscellaneous Manufacturing Industries*		
I	a	.543	.246	.111	.100	.683	.145	.111	.061
	b	.548	.242	.109		.707	.131	.100	
	c					.744	.111	.084	
III	a		.261	.106	.090		.155	.101	.061
	b		.257	.105			.140	.092	
	c						.118	.077	
V	a		.211	.126	.121		.123	.120	.073
	b		.208	.124			.111	.108	
	c						.092	.090	

Note: Data will not necessarily add to 1.000 in all cases owing to rounding.

[a]Rows labeled a, b, and c correspond to three alternative allocations of the net income of unincorporated businesses. The assumed share of labor and net capital are: (a) 25:75, (b) 50:50, and (c) 75:25.

We derived an estimate of the rate of change of the price of the net stock of fixed capital by subtracting the rate of growth of the constant-1949-dollar net stock of fixed capital from its current-dollar counterpart, and the rate of growth of the price of capital consumption allowances and inventories by the same procedure. The rate of growth of the "price" of the labor inputs, which is no more than the rate of growth of the unit value of the labor inputs, was derived by subtracting the rates of growth of the two labor inputs used in Part II of our paper from the rates of growth of wages, salaries, and supplementary labor income. Obviously, these estimates are weak, and, as we stated in the text, further research is required before the estimates presented in Table 12 can be accepted with any confidence.

REVISION OF OUTPUT DATA

As was pointed out in the introductory preface, the publication of substantial revisions in the constant-dollar GDP series by DBS in mid-1966 has invalidated much of our analysis. In this section we present several tables based on the revised data. Table SA–12 corresponds to text Table 6; Table SA–13 is the revision of Table 7; Table SA–14 is the revision of Table SA–4; and Table SA–15 is the revision of Table SA–5. The effect of the revisions is presented in Chart SA–1, which compares the old and the revised GDP and GDP-per-man-hours series.

TABLE SA-11

Total Measured Factor Productivity (Gross Domestic Product Basis), Alternative Allocation of Net Income of Unincorporated Businesses, Total Manufacturing and Major Groups, 1946-56

(continuous annual rates of change)

Set of Lives	Split of Unincorporated Income[a]	Employees	Paid Man-Hours	Employees	Paid Man-Hours	Employees	Paid Man-Hours	Employees	Paid Man-Hours	Employees	Paid Man-Hours
		Total Manufacturing		*Food and Beverages*		*Tobacco, Rubber, and Leather Products*		*Textile Products*		*Clothing Products*	
I	a	2.1	2.4	0.5	0.7	2.5	2.7	0.6	0.9	1.2	1.3
	b	2.1	2.4	0.5	0.8	2.5	2.8	0.7	0.9	1.2	1.3
	c	2.1	2.4	0.6	0.8	2.6	2.8	0.7	1.0	1.2	1.4
III	a	2.2	2.5	0.5	0.8	2.5	2.7	0.8	1.0	1.2	1.3
	b	2.2	2.5	0.6	0.8	2.6	2.8	0.8	1.1	1.3	1.4
	c	2.3	2.6	0.6	0.9	2.6	2.9	0.8	1.1	1.3	1.4
V	a	1.9	2.2	0.2	0.5	2.4	2.7	0.3	0.5	1.3	1.4
	b	1.9	2.2	0.3	0.6	2.5	2.7	0.3	0.6	1.3	1.4
	c	1.9	2.2	0.3	0.6	2.6	2.8	0.3	0.6	1.3	1.4

(continued)

TABLE SA-11 *(continued)*

Set of Lives	Split of Unincorporated Income[a]	Employees	Paid Man-Hours	Employees	Paid Man-Hours	Employees	Paid Man-Hours	Employees	Paid Man-Hours	Employees	Paid Man-Hours
		Wood Products		*Paper Products*[b]		*Printing, Publishing and Allied Industries*[c]		*Iron and Steel Products*		*Transportation Equipment*	
I	a	2.0	2.4			1.8	2.1	2.6	2.9	3.6	3.8
	b	2.0	2.4	1.1	1.7			2.6	2.9	3.6	3.8
	c	2.1	2.4			1.8	2.1	2.6	2.9	3.6	3.8
III	a	2.2	2.6			1.9	2.2	2.6	2.9	3.8	4.0
	b	2.2	2.6	1.3	1.9			2.6	2.9	3.8	4.0
	c	2.3	2.6			1.9	2.2	2.6	3.0	3.7	4.0
V	a	1.8	2.1			1.4	1.7	2.4	2.7	3.3	3.5
	b	1.8	2.2	0.5	1.2			2.4	2.8	3.3	3.5
	c	1.9	2.2			1.4	1.7	2.5	2.8	3.3	3.5

(continued)

TABLE SA-11 *(concluded)*

Set of Lives	Split of Unincorporated Income[a]	Employees	Paid Man-Hours	Employees	Paid Man-Hours	Employees	Paid Man-Hours	Employees	Paid Man-Hours
		Nonferrous Metal Products and Electrical Apparatus and Supplies		*Nonmetallic Mineral Products and Products of Petroleum and Coal*[c]		*Chemical Products*[c]		*Miscellaneous Manufacturing Industries*	
I	a	3.4	3.6	3.6	3.7	1.7	2.0	1.4	1.6
	b	3.3	3.6					1.4	1.6
	c	3.3	3.6	3.6	3.7	1.8	2.0	1.5	1.6
III	a	3.4	3.7	3.8	4.0	1.9	2.2	1.5	1.7
	b	3.4	3.7					1.5	1.7
	c	3.4	3.7	3.8	4.0	1.9	2.2	1.5	1.7
V	a	3.3	3.6	3.1	3.2	1.4	1.7	1.4	1.6
	b	3.3	3.6					1.4	1.6
	c	3.3	3.6	3.1	3.3	1.4	1.7	1.5	1.6

[a]Under each set of lives, rows labeled a, b, and c indicate change in rate of growth of total measured factor productivity when net income of unincorporated businesses is split 25:75, 50:50, 75:25 between labor and net capital input, respectively. Estimates in row b correspond to estimates presented in Part II.

[b]No net income of unincorporated businesses was shown in 1949 for the paper products major Group; see DBS 13-513, *Supplement to the Inter-Industry Flow of Goods and Services, Canada, 1949,* Table 1.

[c]Net unincorporated income was so small that all allocations yielded practically the same result.

TABLE SA-12

Revised Estimate:[a] *Total Measured Factor Productivity (Gross Domestic Product Basis)*

Total Manufacturing and Major Groups, 1946-56 and 1946-60

(continuous annual rates of change)

Set of Lives	Gross Domestic Product at Factor Cost[b]	Labor Input: Employees	Labor Input: Paid Man-Hours	Midyear Net Stock of Fixed Capital[b]	Midyear Inventories[b]	Capital Consumption Allowances[b]	Total Measured Factor Input: Employees	Total Measured Factor Input: Paid Man-Hours	Total Measured Factor Productivity: Employees	Total Measured Factor Productivity: Paid Man-Hours
					Total Manufacturing					
1946-56										
I	5.7	2.5	2.0	5.8	4.3	2.8	3.2	2.9	2.5	2.8
III				5.3		2.2	3.1	2.8	2.7	3.0
V				6.4		4.7	3.4	3.1	2.3	2.6
1946-60										
I	4.6	1.4	1.0	5.6	3.8	3.4	2.5	2.2	2.1	2.4
III				5.1		3.0	2.4	2.1	2.1	2.5
V				5.9		4.9	2.7	2.3	1.9	2.2
					Food and Beverages					
1946-56										
I	3.1	1.3	0.9	6.4	3.3	3.0	2.5	2.3	0.5	0.8
III				5.9		2.9	2.5	2.2	0.6	0.8
V				7.2		5.0	2.8	2.5	0.3	0.6
1946-60										
I	3.2	1.3	0.9	5.8	3.2	3.3	2.5	2.2	0.7	1.0
III				5.4		3.2	2.4	2.2	0.8	0.9
V				6.2		5.0	2.6	2.4	0.6	0.8

(continued)

TABLE SA-12 *(continued)*

Set of Lives	Gross Domestic Product at Factor Cost[b]	Labor Input: Employees	Labor Input: Paid Man-Hours	Midyear Net Stock of Fixed Capital[b]	Midyear Inventories[b]	Capital Consumption Allowances[b]	Total Measured Factor Input: Employees	Total Measured Factor Input: Paid Man-Hours	Total Measured Factor Productivity: Employees	Total Measured Factor Productivity: Paid Man-Hours
				Tobacco, Rubber, and Leather Products						
1946-56										
I	2.8	-0.9	-1.2	3.5	2.7	3.6	0.1	-0.1	2.8	3.0
III				3.4		3.0	0.1	-0.2	2.8	3.0
V				3.1		4.9	0.1	-0.1	2.7	2.9
1946-60										
I	2.9	-1.2	-1.4	3.3	1.9	4.0	-0.2	-0.4	3.1	3.3
III				3.4		3.6	-0.2	-0.4	3.1	3.4
V				2.9		4.3	-0.3	-0.4	3.1	3.4
				Textile Products (excl. Clothing and Fur)						
1946-56										
I	3.4	0.5	0.1	4.2	12.3	1.6	2.1	1.9	1.2	1.5
III				3.8		1.2	2.0	1.7	1.4	1.6
V				5.4		2.3	2.5	2.2	0.9	1.2
1946-60										
I	3.0	-0.6	-1.0	3.1	9.4	1.2	0.9	0.7	2.1	2.4
III				2.8		1.0	0.9	0.6	2.2	2.4
V				3.5		2.2	1.2	0.9	1.8	2.1
				Clothing Products						
1946-56										
I	2.4	0.5	0.4	2.0	2.2	2.1	0.9	0.8	1.5	1.6
III				1.9		0.8	0.8	0.7	1.5	1.7
V				1.3		2.2	0.8	0.7	1.6	1.7

(continued)

TABLE SA-12 *(continued)*

Set of Lives	Gross Domestic Product at Factor Cost[b]	Labor Input: Employees	Labor Input: Paid Man-Hours	Midyear Net Stock of Fixed Capital[b]	Midyear Inventories[b]	Capital Consumption Allowances[b]	Total Measured Factor Input: Employees	Total Measured Factor Input: Paid Man-Hours	Total Measured Factor Productivity: Employees	Total Measured Factor Productivity: Paid Man-Hours
Clothing Products (continued)										
1946-60										
I	2.1	0.2	0.0	1.0	1.9	0.9	0.5	.03	1.6	1.8
III				1.1		1.0	0.5	.03	1.6	1.8
V				-0.2		1.8	0.3	0.2	1.8	1.9
Wood Products										
1946-56										
I	5.0	2.5	2.0	3.8	3.6	0.9	2.6	2.3	2.4	2.7
III				3.1		-0.7	2.4	2.1	2.6	2.9
V				4.3		3.1	2.8	2.5	2.2	2.5
1946-60										
I	3.6	0.9	0.5	3.4	2.8	1.2	1.3	1.0	2.2	2.6
III				2.9		0.2	1.2	0.9	2.4	2.7
V				3.4		3.1	1.5	1.2	2.1	2.4
Paper Products										
1946-56										
I	5.2	3.3	2.1	6.9	2.7	3.8	4.3	3.6	1.0	1.6
III				6.1		3.0	4.0	3.4	1.3	1.9
V				7.6		7.1	4.8	4.2	0.5	1.1
1946-60										
I	4.4	2.4	1.4	6.3	2.7	4.5	3.7	3.2	0.7	1.2
III				5.8		3.9	3.6	3.0	0.9	1.5
V				6.5		6.8	4.0	3.5	0.4	1.0

(continued)

TABLE SA-12 *(continued)*

Set of Lives	Gross Domestic Product at Factor Cost[b]	Labor Input: Employees	Labor Input: Paid Man-Hours	Midyear Net Stock of Fixed Capital[b]	Midyear Inventories[b]	Capital Consumption Allowances[b]	Total Measured Factor Input: Employees	Total Measured Factor Input: Paid Man-Hours	Total Measured Factor Productivity: Employees	Total Measured Factor Productivity: Paid Man-Hours
				Printing, Publishing, and Allied Industries						
1946-56										
I	7.2	4.0	3.5	4.8	4.4	1.8	4.0	3.7	3.2	3.5
III				4.2		1.4	3.9	3.6	3.3	3.6
V				7.0		3.1	4.4	4.1	2.8	3.1
1946-60										
I	5.9	3.1	2.6	5.0	3.7	2.2	3.3	3.0	2.6	2.9
III				4.4		2.0	3.2	2.9	2.7	3.0
V				6.7		3.7	3.7	3.4	2.3	2.6
				Iron and Steel Products						
1946-56										
I	6.4	2.6	2.2	5.8	5.4	2.4	3.3	3.0	3.1	3.4
III				5.3		2.3	3.2	2.9	3.2	3.5
V				6.1		3.7	3.4	3.1	3.0	3.3
1946-60										
I	4.3	1.7	1.2	5.8	4.4	3.5	2.7	2.3	1.7	2.0
III				5.5		3.6	2.6	2.3	1.7	2.0
V				6.1		4.7	2.8	2.4	1.6	1.9
				Transportation Equipment						
1946-56										
I	6.8	3.4	3.1	4.2	1.5	-1.1	3.2	2.9	3.7	3.9
III				3.3		-1.5	3.0	2.7	3.8	4.1
V				5.5		1.7	3.5	3.2	3.4	3.6

(continued)

TABLE SA-12 *(continued)*

Set of Lives	Gross Domestic Product at Factor Cost[b]	Labor Input: Employees	Labor Input: Paid Man-Hours	Midyear Net Stock of Fixed Capital[b]	Midyear Inventories[b]	Capital Consumption Allowances[b]	Total Measured Factor Input: Employees	Total Measured Factor Input: Paid Man-Hours	Total Measured Factor Productivity: Employees	Total Measured Factor Productivity: Paid Man-Hours
Transportation Equipment (continued)										
1946-60										
I	3.8	0.6	0.4	3.9	0.4	-0.2	1.1	0.9	2.7	2.9
III				3.1		-0.2	1.0	0.8	2.8	3.0
V				4.6		2.0	1.3	1.1	2.5	2.7
Nonferrous Metal Products and Electrical Apparatus and Supplies										
1946-56										
I	7.8	5.0	4.5	3.4	4.5	1.1	4.2	3.9	3.6	3.9
III				3.3		0.5	4.1	3.8	3.7	4.0
V				2.7		2.3	4.3	4.0	3.5	3.8
1946-60										
I	5.9	2.6	2.3	3.6	5.3	2.3	2.8	2.6	3.1	3.3
III				3.6		1.9	2.8	2.5	3.1	3.4
V				3.0		3.2	2.9	2.6	3.0	3.3
Nonmetallic Mineral Products and Products of Petroleum and Coal										
1946-56										
I	10.3	4.6	4.3	10.4	7.6	6.9	6.6	6.4	3.7	3.8
III				9.5		6.1	6.3	6.2	3.9	4.1
V				11.7		9.0	7.1	6.9	3.2	3.4
1946-60										
I	8.6	3.5	3.2	9.8	6.9	7.0	5.8	5.6	2.8	2.9
III				9.1		6.2	5.6	5.4	3.0	3.1
V				10.7		8.5	6.1	5.9	2.5	2.6

(continued)

TABLE SA-12 *(concluded)*

Set of Lives	Gross Domestic Product at Factor Cost[b]	Labor Input		Midyear Net Stock of Fixed Capital[b]	Midyear Inventories[b]	Capital Consumption Allowances[b]	Total Measured Factor Input		Total Measured Factor Productivity	
		Employees	Paid Man-Hours				Employees	Paid Man-Hours	Employees	Paid Man-Hours
					Chemical Products					
1946-56										
I	7.9	3.3	2.8	8.8	4.6	7.6	5.2	5.0	2.7	3.0
III				8.2		7.2	5.1	4.8	2.9	3.1
V				10.0		8.9	5.6	5.3	2.4	2.7
1946-60										
I	7.2	2.6	2.2	8.2	3.5	7.4	4.6	4.3	2.7	2.9
III				7.8		7.0	4.5	4.2	2.8	3.0
V				9.0		8.5	4.8	4.6	2.4	2.7
					Miscellaneous Manufacturing Industries					
1946-56										
I	9.4	4.6	4.3	3.2	8.0	2.8	4.6	4.4	4.7	4.9
III				3.2		2.2	4.6	4.4	4.8	5.0
V				2.9		2.8	4.6	4.4	4.7	4.9
1946-60										
I	8.6	4.8	4.6	3.6	8.1	3.4	4.9	4.7	3.7	3.8
III				3.6		3.3	4.8	4.7	3.8	3.9
V				3.6		3.9	4.9	4.8	3.6	3.8

Source: See this appendix. The three different rates of change of midyear net stock and capital consumption allowances are based on the sets I, III, and V of average economic lives used by the DBS in the forthcoming reference paper, *Estimates of Fixed Capital Flows and Stocks, Manufacturing, Canada, 1926-1960*. For five of the combined major groups (foods and beverages; tobacco, rubber, and leather products; paper products; printing, publishing, and allied industries; and chemical products), the average economic lives used in sets I and II were the same. Continuous annual rates of change in this and subsequent tables are calculated as $\ln GDP_{56} - \ln GDP_{46} / 10$.

[a]This table is a revision of Table 6.

[b]Measured in constant 1949 dollars.

TABLE SA-13

Revised[a] Indexes of Constant 1949 Gross Domestic Product and Total Measured Factor Productivity, Total Manufacturing and Major Groups, 1946-60

(1949 = 1.000)

Year	Total Manufacturing: GDP	Total Manufacturing: Factor Productivity: Employees	Total Manufacturing: Factor Productivity: Man-Hours	Food and Beverages: GDP	Food and Beverages: Factor Productivity: Employees	Food and Beverages: Factor Productivity: Man-Hours	Tobacco, Rubber, and Leather Products: GDP	Tobacco, Rubber, and Leather Products: Factor Productivity: Employees	Tobacco, Rubber, and Leather Products: Factor Productivity: Man-Hours	Textiles: GDP	Textiles: Factor Productivity: Employees	Textiles: Factor Productivity: Man-Hours
1946	0.852	0.956	0.947	0.980	1.100	1.097	1.045	1.033	1.015	0.887	1.063	1.043
1947	0.932	0.989	0.983	0.972	1.043	1.048	1.124	1.099	1.090	0.940	1.025	1.017
1948	0.973	1.002	0.999	0.985	1.019	1.019	1.026	1.034	1.040	0.973	1.008	1.008
1949	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1950	1.067	1.059	1.059	1.029	1.030	1.029	1.049	1.053	1.062	1.125	1.091	1.085
1951	1.159	1.083	1.092	1.065	1.035	1.042	1.039	1.048	1.072	1.151	1.074	1.099
1952	1.202	1.081	1.094	1.135	1.077	1.085	1.082	1.104	1.112	1.045	1.065	1.091
1953	1.289	1.106	1.124	1.166	1.077	1.095	1.192	1.180	1.196	1.111	1.028	1.051
1954	1.260	1.094	1.119	1.209	1.097	1.118	1.109	1.135	1.160	1.002	1.003	1.023
1955	1.383	1.181	1.203	1.257	1.125	1.148	1.254	1.271	1.280	1.200	1.159	1.167
1956	1.512	1.228	1.252	1.332	1.158	1.184	1.389	1.360	1.371	1.244	1.162	1.175
1957	1.509	1.187	1.219	1.385	1.151	1.184	1.381	1.351	1.377	1.254	1.183	1.208
1958	1.480	1.185	1.219	1.451	1.192	1.223	1.420	1.416	1.443	1.212	1.191	1.217
1959	1.590	1.250	1.278	1.523	1.219	1.249	1.554	1.528	1.552	1.370	1.367	1.367
1960	1.612	1.254	1.287	1.539	1.213	1.247	1.466	1.470	1.488	1.389	1.371	1.396

(continued)

235

TABLE SA-13 *(continued)*

Year	GDP	Factor Productivity Employees	Factor Productivity Man-Hours	GDP	Factor Productivity Employees	Factor Productivity Man-Hours	GDP	Factor Productivity Employees	Factor Productivity Man-Hours	GDP	Factor Productivity Employees	Factor Productivity Man-Hours
	Clothing			Wood Products			Paper Products			Printing, Publishing, and Allied Industries		
1946	0.953	1.068	1.058	0.868	0.981	0.956	0.810	0.962	0.948	0.769	0.952	0.938
1947	0.922	0.990	0.985	0.982	1.000	0.986	0.891	0.981	0.968	0.836	0.980	0.971
1948	0.976	1.004	1.010	1.006	1.004	1.007	0.949	0.995	0.987	0.926	1.030	1.030
1949	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1950	1.013	1.023	1.022	1.082	1.050	1.049	1.083	1.075	1.072	1.098	1.068	1.072
1951	1.009	1.020	1.043	1.148	1.078	1.079	1.170	1.092	1.093	1.129	1.062	1.072
1952	1.110	1.103	1.107	1.169	1.088	1.084	1.123	1.005	1.025	1.148	1.075	1.093
1953	1.139	1.104	1.108	1.262	1.132	1.125	1.181	1.034	1.067	1.257	1.143	1.164
1954	1.090	1.123	1.150	1.253	1.151	1.156	1.222	1.039	1.083	1.355	1.192	1.209
1955	1.151	1.198	1.210	1.395	1.238	1.237	1.272	1.044	1.091	1.423	1.227	1.245
1956	1.238	1.267	1.270	1.435	1.251	1.260	1.368	1.055	1.101	1.574	1.306	1.329
1957	1.242	1.252	1.275	1.346	1.218	1.239	1.343	0.974	1.024	1.599	1.277	1.301
1958	1.216	1.271	1.288	1.358	1.285	1.302	1.335	0.955	0.997	1.572	1.270	1.302
1959	1.291	1.349	1.356	1.434	1.330	1.327	1.439	1.001	1.053	1.696	1.330	1.360
1960	1.280	1.336	1.356	1.436	1.338	1.357	1.509	1.040	1.093	1.762	1.357	1.395

(continued)

TABLE SA-13 *(continued)*

Year	GDP	Factor Productivity Employees	Factor Productivity Man-Hours	GDP	Factor Productivity Employees	Factor Productivity Man-Hours	GDP	Factor Productivity Employees	Factor Productivity Man-Hours	GDP	Factor Productivity Employees	Factor Productivity Man-Hours
	Iron and Steel Products			Transportation Equipment			Nonferrous Metal Products and Electrical Apparatus and Supplies			Nonmetallic Mineral Products and Products of Petroleum and Coal		
1946	0.808	0.888	0.879	0.806	0.802	0.806	0.752	0.820	0.815	0.729	0.929	0.932
1947	0.936	0.962	0.949	0.953	0.927	0.929	0.896	0.922	0.921	0.838	1.001	0.998
1948	1.015	0.996	0.988	0.972	0.975	0.979	0.956	0.966	0.968	0.913	1.001	1.000
1949	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1950	1.027	1.031	1.037	1.079	1.086	1.081	1.080	1.058	1.062	1.114	1.069	1.069
1951	1.181	1.081	1.095	1.304	1.140	1.151	1.172	1.041	1.052	1.246	1.100	1.104
1952	1.206	1.045	1.062	1.494	1.124	1.140	1.173	1.005	1.022	1.328	1.109	1.121
1953	1.180	1.001	1.023	1.686	1.186	1.204	1.344	1.071	1.088	1.458	1.108	1.119
1954	1.109	0.978	1.007	1.381	1.060	1.088	1.338	1.064	1.092	1.540	1.100	1.114
1955	1.307	1.125	1.151	1.477	1.144	1.180	1.501	1.164	1.188	1.766	1.236	1.251
1956	1.536	1.212	1.237	1.592	1.158	1.193	1.644	1.187	1.212	2.029	1.326	1.346
1957	1.506	1.150	1.185	1.558	1.075	1.139	1.568	1.115	1.146	2.072	1.267	1.288
1958	1.354	1.103	1.143	1.370	1.069	1.111	1.531	1.119	1.157	2.126	1.248	1.268
1959	1.559	1.193	1.226	1.357	1.124	1.158	1.697	1.197	1.227	2.308	1.292	1.309
1960	1.515	1.126	1.164	1.369	1.146	1.177	1.721	1.265	1.295	2.284	1.247	1.269

(continued)

TABLE SA-13 *(concluded)*

Year	GDP	Factor Productivity Employees	Factor Productivity Man-Hours	GDP	Factor Productivity Employees	Factor Productivity Man-Hours
	Chemical Products			Miscellaneous Manufacturing Products		
1946	0.870	1.002	0.999	0.802	0.997	0.992
1947	0.908	1.017	1.020	0.841	0.962	0.968
1948	0.957	1.038	1.039	0.814	0.937	0.942
1949	1.000	1.000	1.000	1.000	1.000	1.000
1950	1.089	1.071	1.075	1.190	1.156	1.155
1951	1.239	1.119	1.126	1.311	1.223	1.234
1952	1.330	1.121	1.138	1.412	1.166	1.278
1953	1.487	1.111	1.127	1.752	1.448	1.455
1954	1.617	1.145	1.166	1.794	1.501	1.522
1955	1.753	1.241	1.264	1.854	1.542	1.559
1956	1.924	1.295	1.322	2.060	1.617	1.638
1957	2.086	1.311	1.342	2.211	1.643	1.671
1958	2.220	1.343	1.375	2.281	1.634	1.660
1959	2.287	1.365	1.396	2.488	1.693	1.711
1960	2.455	1.431	1.465	2.659	1.677	1.698

Source: Indexes of constant 1949 dollar gross domestic product at factor cost: From DBS 61-005, *Annual Supplement to the Monthly Index of Industrial Production*, May 1966. Indexes of total measured factor productivity: See this appendix. These indexes are based on Set I of the average economic lives of capital goods and correspond to row I in Table 6. The indexed total measured factor productivity is the gross-domestic-product-at-factor-cost version.

[a]This table is a revision of Table 7.

TABLE SA-14

Comparison of Revised[a] Indexes of Labor Input, Total Manufacturing, 1946-60

(1949 = 100.0)

	Persons Employed			Man-Hours Worked	Man-Hours Paid			
	DBS	Our Indexes		DBS	Our Indexes			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1946	90.0	90.3	89.7	92.3	91.6	91.4	91.0	90.8
1947	96.3	96.6	95.9	97.7	97.4	97.6	96.6	96.7
1948	98.5	98.7	98.1	100.4	99.1	99.4	98.4	98.7
1949	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
1950	101.7	101.0	101.3	100.8	101.0	101.1	101.1	101.3
1951	107.9	107.4	107.7	104.9	106.0	104.4	106.3	104.9
1952	110.8	110.0	110.6	106.7	108.1	108.0	108.7	108.7
1953	114.2	113.3	114.0	110.5	110.6	109.2	111.4	110.1
1954	109.3	108.3	109.4	103.9	104.4	103.8	105.7	105.3
1955	112.1	110.9	112.1	107.1	107.6	107.4	109.0	108.9
1956	116.8	115.5	116.8	112.3	112.0	111.3	113.5	112.9
1957	117.3	116.0	117.7	111.4	111.0	108.9	112.9	111.0
1958	111.5	110.1	112.0	105.9	104.8	104.4	106.9	106.6
1959	112.9	111.3	113.1	107.8	107.0	106.2	108.9	108.3
1960	111.4	110.3	112.2	105.6	105.4	104.4	107.6	106.7
			(continuous annual rates of change)					
1946-56	2.6	2.5	2.6	2.0	2.0	2.0	2.2	2.2
1946-60	1.5	1.4	1.6	1.0	1.0	1.0	1.2	1.2

Source: Columns (1) and (4): DBS 11-001, *Daily Bulletin,* June 7, 1966. This document provides data for 1946 which permit more useful comparisons than were possible in Tables SA-4 and SA-5. Column (2): Unweighted persons employed. Column (3): Persons employed with wages and salaries as weights. Column (5): See source note to column (1), Table SA-3. Column (6): See source note to column (2), Table SA-3. Column (7): See source note to column (3), Table SA-3. Column (8): See source note to column (4), Table SA-3.

[a]This table is a revision of Table SA-4.

TABLE SA-15

Revised[a] *Indexes of Output Per Labor Input,*

Total Manufacturing, 1946-60

(1949 = 1.000)

	Output Per Person Employed			Output Per Man-Hour Worked	Output Per Man-Hour Paid			
	DBS	Our Indexes		DBS	Our Indexes			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1946	0.947	0.944	0.950	0.923	0.930	0.932	0.936	0.938
1947	0.968	0.965	0.972	0.954	0.957	0.955	0.965	0.964
1948	0.988	0.986	0.992	0.969	0.982	0.979	0.989	0.986
1949	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1950	1.049	1.056	1.053	1.059	1.056	1.055	1.055	1.053
1951	1.074	1.079	1.076	1.105	1.093	1.110	1.090	1.105
1952	1.084	1.093	1.087	1.127	1.112	1.113	1.106	1.106
1953	1.129	1.138	1.131	1.166	1.165	1.180	1.157	1.171
1954	1.152	1.163	1.152	1.213	1.207	1.214	1.192	1.197
1955	1.232	1.247	1.234	1.292	1.285	1.288	1.269	1.270
1956	1.295	1.309	1.295	1.347	1.350	1.358	1.330	1.339
1957	1.286	1.301	1.282	1.355	1.359	1.385	1.337	1.359
1958	1.328	1.344	1.321	1.399	1.412	1.418	1.384	1.388
1959	1.409	1.429	1.406	1.475	1.486	1.497	1.460	1.468
1960	1.447	1.461	1.437	1.527	1.529	1.544	1.498	1.511
	(continuous average annual rates of change)							
1946-56	3.1	3.3	3.1	3.8	3.7	3.8	3.5	3.6
1946-60	3.0	3.1	3.0	3.6	3.6	3.6	3.4	3.4

Source: Columns (1) and (4): DBS 11-001, *Daily Bulletin,* June 7, 1966. Columns (2), (3), and (5)-(8) derived by dividing index of constant -1949- dollar gross domestic product at factor cost for total manufacturing, DBS 61-005, *Annual Supplement to the Monthly Index of Industrial Production,* May 1966, by respective indexes in Table SA-14.

[a]This table is a revision of Table SA-5.

CHART SA-1

Indexes of Constant 1949 Gross Domestic Product and "Total Measured Factor Productivity," Total Manufacturing and Major Groups

(plotted on ratio scale; index, 1949 = 1.0)

TOTAL MANUFACTURING FOOD AND BEVERAGES

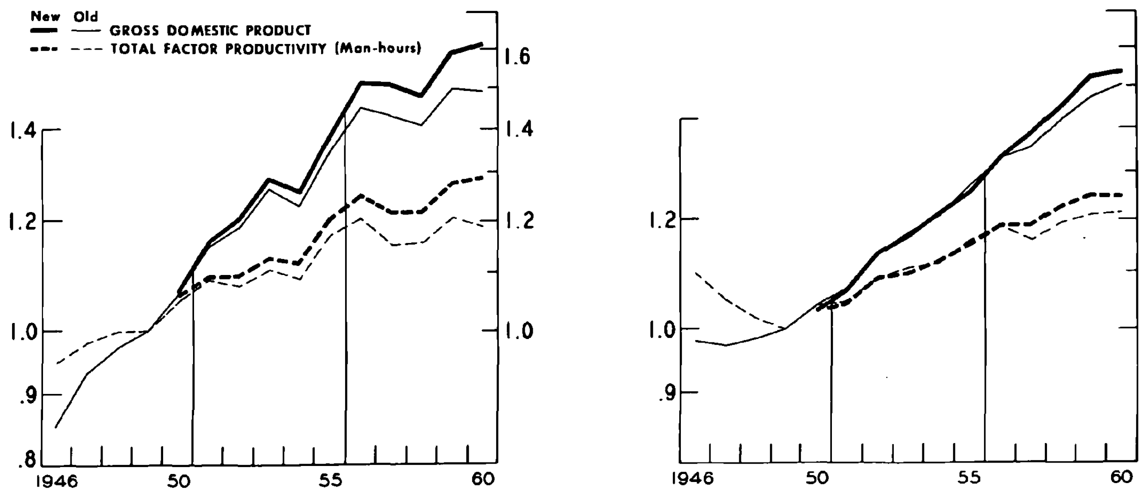


CHART SA-1 (continued)

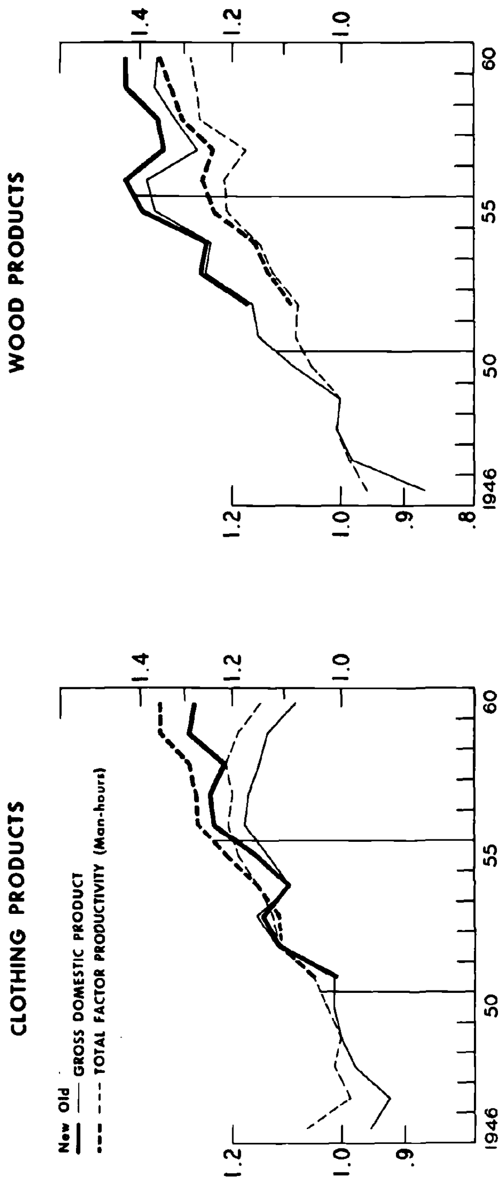


CHART SA-1 (continued)

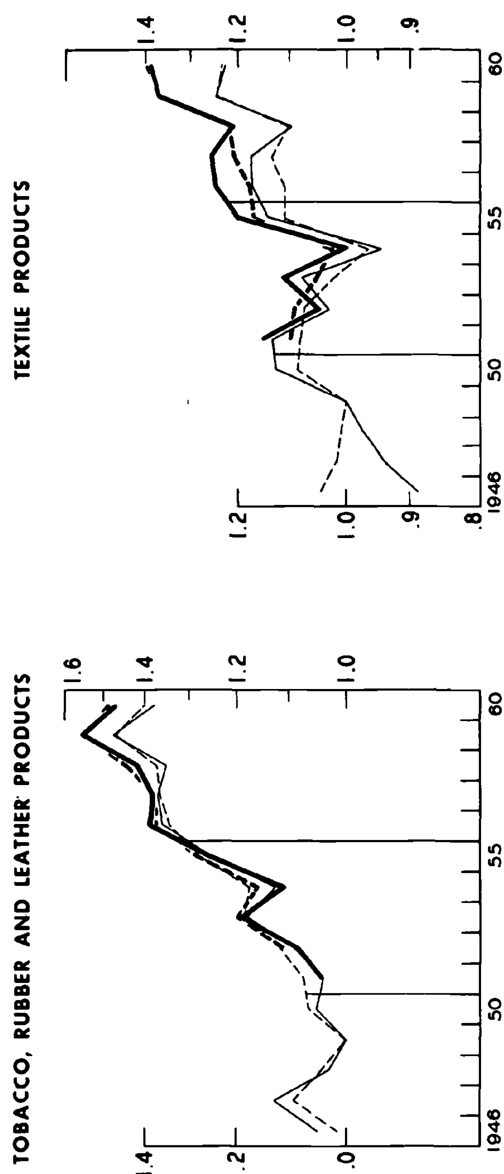


CHART SA-1 (continued)

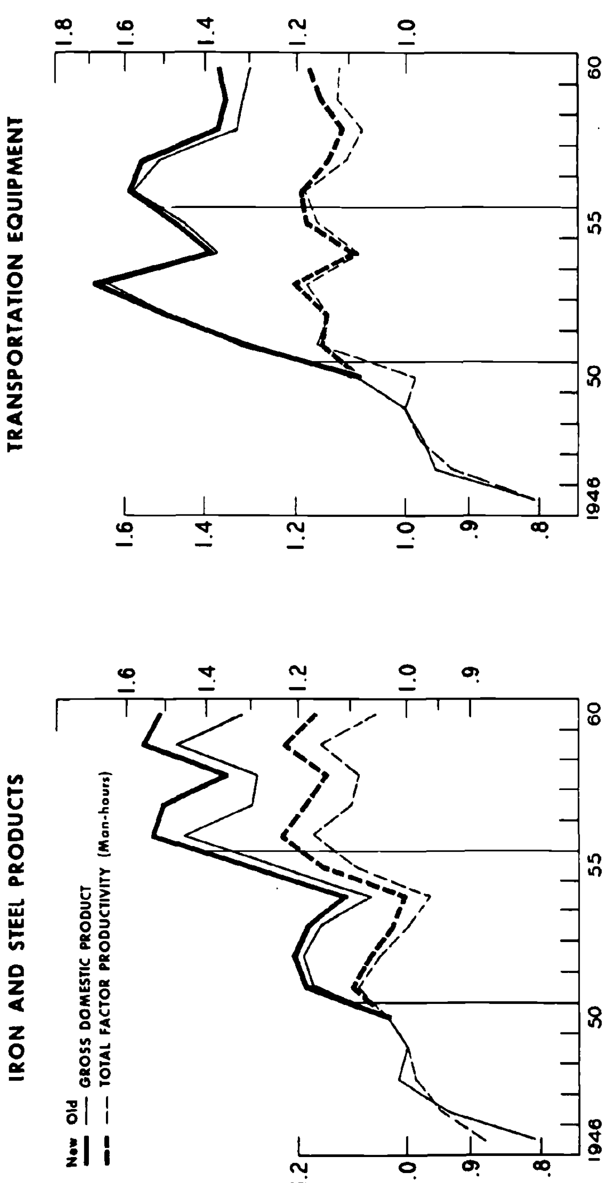


CHART SA-1 (continued)

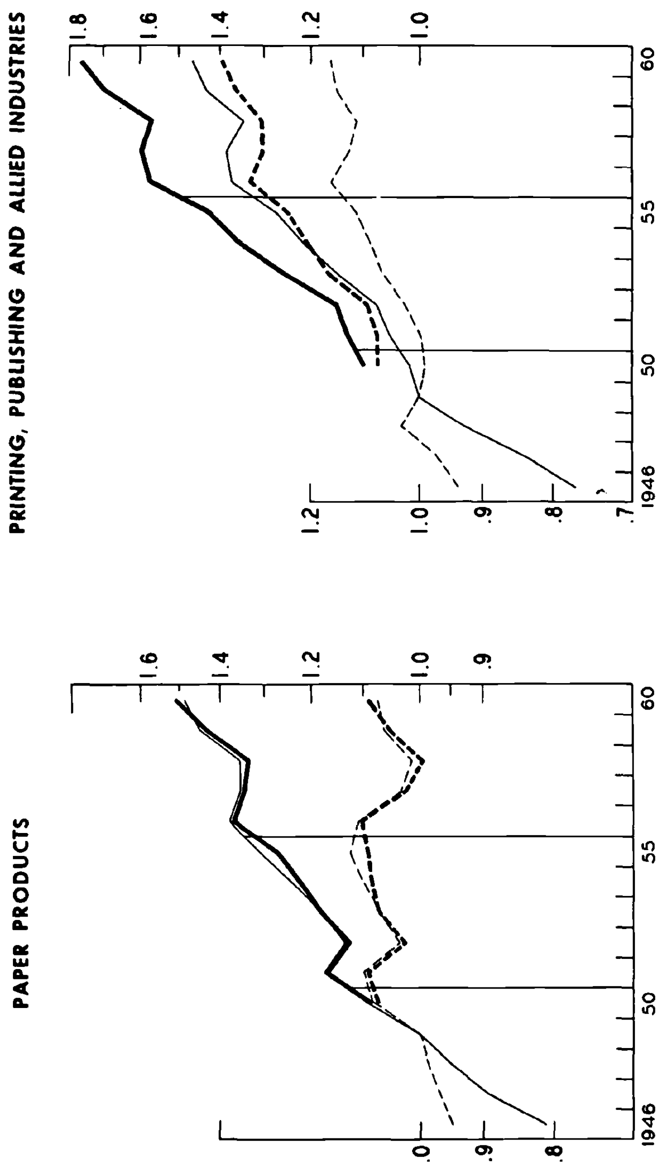


CHART SA-1 (continued)

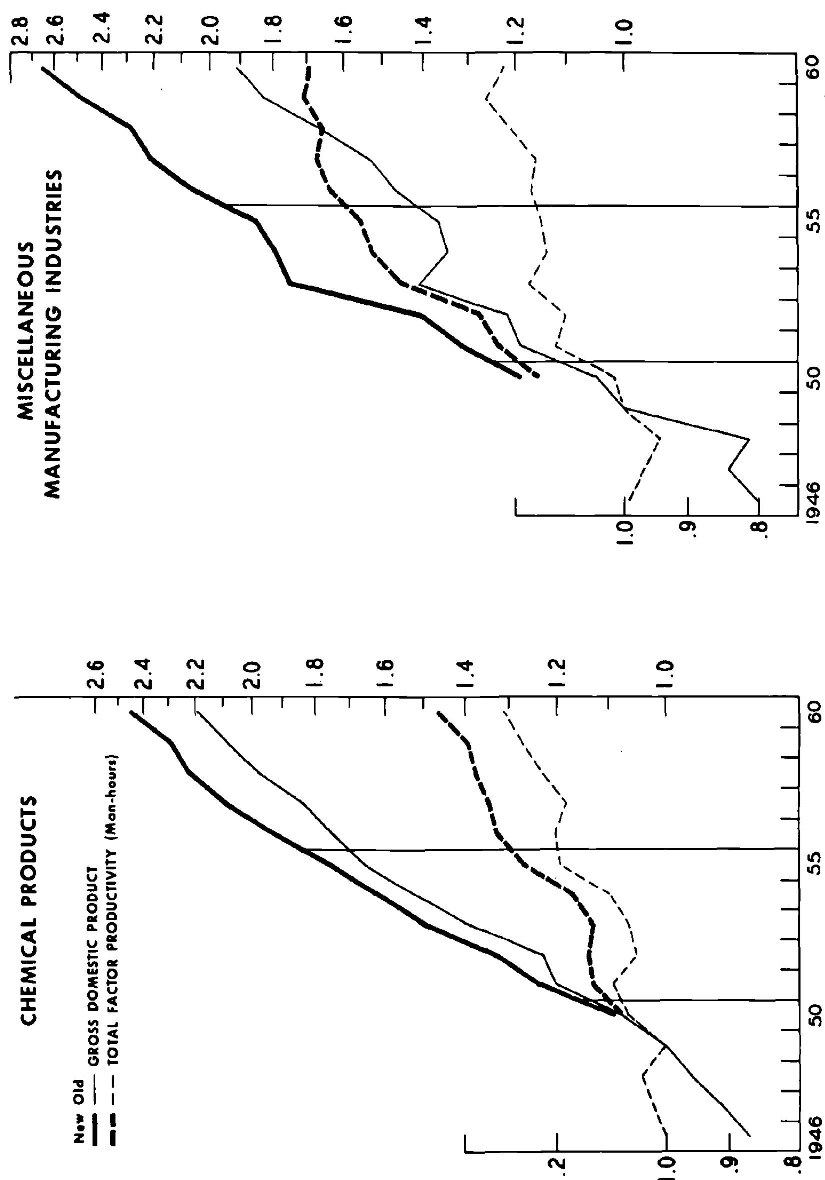
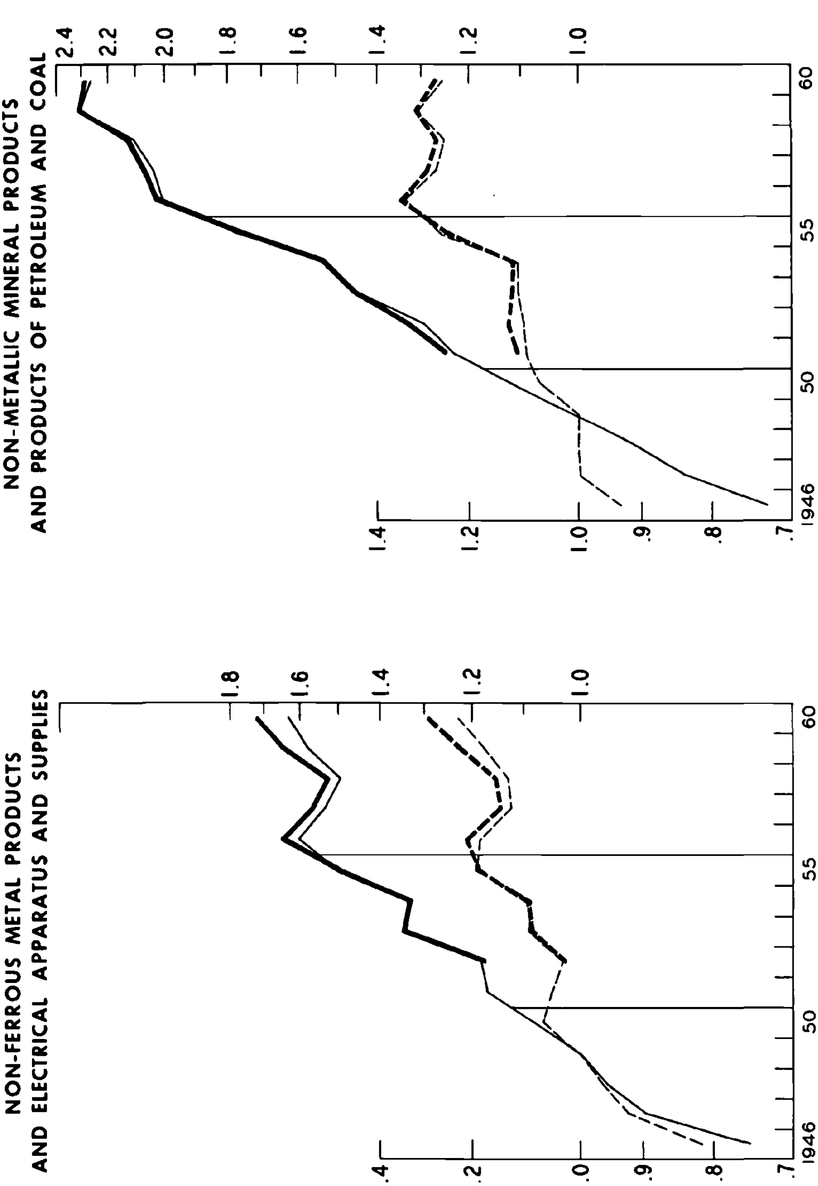


CHART SA-1 (concluded)



From the tables and Chart SA–1, it is clear that the old series seriously understates the growth of output and productivity in several of the major groups. The inexplicable decline in both output and productivity in clothing products is now reversed, and the rate of increase of these measures is substantially greater in printing, publishing, and allied industries, in chemical products, and in miscellaneous manufacturing. In the other major groups, the revisions are less substantial, but the impact on the total manufacturing measures is significant. The implications of these revisions in assessing the past performance of the Canadian economy are most important. Widespread concern about insufficient productivity growth as well as concern about the increase in unit labor costs must now be modified.

Technical Appendix

In this Technical Appendix to our paper, we set out more formally the format in which our various estimates of total measured factor productivity in Part II are presented, our reasons for the capital input measures we chose, and some comments about the various output versions of the productivity estimates presented. Finally, we make some brief comments upon the evaluation of commodity inputs (stocks and flows) in the estimation of total measured factor productivity.

Consider the social accounting *ex post* identity between the value of outputs and the value of inputs

$$1.1 \qquad \sum_i P_i Q_i \equiv \sum_j p_j q_j$$

for an activity, establishment, industry, or economy. Differentiation with respect to time yields

$$\sum_i (P_i \dot{Q}_i + Q_i \dot{P}_i) \equiv \sum_j (p_j \dot{q}_j + q_j \dot{p}_j)$$

with $\dot{Q}_i$ defined as dQ_i/dt, etc. Factoring and division by $\sum_i P_i Q_i$ yields

$$\sum_i \frac{P_i Q_i}{\sum_i P_i Q_i}\left(\frac{\dot{Q}_i}{Q_i} + \frac{\dot{P}_i}{P_i}\right) \equiv \sum_j \frac{p_j q_j}{\sum_i P_i Q_i}\left(\frac{\dot{q}_j}{q_j} + \frac{\dot{p}_j}{p_j}\right)$$

Rearrangement yields

$$1.2 \quad \sum_i \frac{P_i Q_i}{\sum_i P_i Q_i}\left(\frac{\dot{Q}_i}{Q_i}\right) - \sum_j \frac{p_j q_j}{\sum_i P_i Q_i}\left(\frac{\dot{q}_j}{q_j}\right) \equiv \sum_j \frac{p_j q_j}{\sum_i P_i Q_i}\left(\frac{\dot{p}_j}{p_j}\right) - \sum_i \frac{P_i Q_i}{\sum_i P_i Q_i}\left(\frac{\dot{P}_i}{P_i}\right)$$

Identity 1.2 expresses the weighted proportionate rates of change of output(s) less the weighted proportionate rates of change of input(s) as being identically equal to the weighted proportionate rates of change of the price(s) of input(s) less the weighted proportionate rates of change of the price(s) of output(s). Much of the estimation of total measured factor productivity has been carried out, in one guise or another, within the context of the left-hand side of identity 1.2. Less frequently attempted is the estimation of the same phenomena within the context of the right-hand side of the identity.

Define

$$\sum_i \frac{P_i Q_i}{\sum_i P_i Q_i}\left(\frac{\dot{Q}_i}{Q_i}\right) - \frac{\dot{q}_j}{q_j} \equiv \frac{\dot{\lambda}_j}{\lambda_j}$$

as the proportionate rate of change of output per unit of the *j*th input and

$$\frac{\dot{p}_j}{p_j} - \sum_i \frac{P_i Q_i}{\sum_i P_i Q_i}\left(\frac{\dot{P}_i}{P_i}\right) \equiv \frac{\dot{r}_j}{r_j}$$

as the proportionate rate of change of the "own-product" price of the *j*th input. Then, identity 1.2 may be written as

$$1.3 \quad \sum_j \frac{p_j q_j}{\sum_i P_i Q_i}\left[\sum_i \frac{P_i Q_i}{\sum_i P_i Q_i}\left(\frac{\dot{Q}_i}{Q_i}\right) - \frac{\dot{q}_j}{q_j}\right] \equiv \sum_j \frac{p_j q_j}{\sum_i P_i Q_i}\left[\frac{\dot{p}_j}{p_j} - \sum_i \frac{P_i Q_i}{\sum_i P_i Q_i}\left(\frac{\dot{P}_i}{P_i}\right)\right]$$

Identity 1.3 expresses the weighted proportionate rates of change of output(s) per unit of input(s) as being identically equal to the weighted proportionate rates of change of the own-product prices of the input(s).

It is within the context of these identities that our estimation procedures in Part II of this paper have been conducted. What are the relevant input and output measures to use? In Part II of our paper, we have been primarily concerned with the capital input(s), and the reasons for our choice of the net stock and capital consumption allowances in preference to the gross stock are now outlined.

Suppose for the moment that the output concept chosen were net domestic product at factor cost. Corresponding to our basic social accounting identity 1.1, the value of net domestic product would be identically equal, *ex post,* to the wages and salaries bill and the *net* returns to capital. That is

$$1.4 \qquad PQ \equiv WL + rP^N N$$

where PQ is the value of net domestic product, WL is the wage bill, and $rP^N N$ is the net return to capital.[1] The net returns to capital are made up of the *ex post* net rate of return to capital multiplied by the value of the *net* stock of fixed capital (the net stock in terms of quantities times the

[1] For simplicity in exposition, we assume here that net output can be unambiguously conceived as one commodity, labor is homogeneous, and the capital input is represented solely by one fixed reproducible good.

price of the net stock).[2] When the customary algebraic manipulations are performed on identity 1.4, we have, as a variant of 1.2,[3]

1.5

$$\frac{\dot{Q}}{Q} - \left[\frac{WL}{PQ}\left(\frac{\dot{L}}{L}\right) + \frac{rP^N N}{PQ}\left(\frac{\dot{N}}{N}\right)\right] \equiv \left[\frac{WL}{PQ}\left(\frac{\dot{W}}{W}\right) + \frac{rP^N N}{PQ}\left(\frac{\dot{r}}{r} + \frac{\dot{P}^N}{P^N}\right)\right] - \frac{\dot{P}}{P}$$

Within the context of the net domestic product version of estimation of total measured factor productivity, we can find no place for the gross stock of capital—a proxy for capital input that is favored by some investigators in the area. It is clearly the net stock which gives rise to the nominal net returns to capital and the value of the net stock which is associated with the net rate of return to capital. In estimates of total measured factor producivity, changes in constant-dollar estimates of the net stock of capital reflect the value which the economic system, under the conditions of the base year whose constant net stock prices are selected, would place upon the changes in the fixed assets being used. In the estimation of total measured factor productivity, this valuation, which takes into account the changing age structure of the stock, is what we wish to approximate.

If the output concept chosen were gross domestic product at factor cost, then, again corresponding to our general social accounting identity 1.2, we would have

1.6 $$PQ \equiv WL + rP^N N + P^D D$$

where PQ is now the value of gross domestic product, $P^D D$ is the value of the capital consumption allowance, and the remaining terms are defined as before.

Corresponding to identity 1.2, we would have,

1.7 $$\frac{\dot{Q}}{Q} - \left[\frac{WL}{PQ}\left(\frac{\dot{L}}{L}\right) + \frac{rP^N N}{PQ}\left(\frac{\dot{N}}{N}\right) + \frac{P^D D}{PQ}\left(\frac{\dot{D}}{D}\right)\right]$$

$$\equiv \left[\frac{WL}{PQ}\left(\frac{\dot{W}}{W}\right) + \frac{rP^N N}{PQ}\left(\frac{\dot{r}}{r} + \frac{\dot{P}^N}{P^N}\right) + \frac{P^D D}{PQ}\left(\frac{\dot{P}^D}{P^D}\right)\right] - \frac{\dot{P}}{P}$$

where the proportionate rates of change of the two capital inputs are shown —namely, the net stock and capital consumption allowances. The former would appear again as the best measure of the value which the economic system, under base-period conditions, would place upon the augmentable

[2] Even in our simplified exposition, the net stock of capital would be composed of goods of many vintages. Market prices of the various vintages making up the net stock can be conceived of which permit the unambiguous valuation of the net stock.

[3] The terms in the right-hand side of the identity are discussed later in this appendix.

resources being used or held for productive purposes by the industry, while the latter would appear as the best proxy for the value which the economic system, again under base-period conditions, would place upon the resources "used up" from the processes of physical wear and tear, obsolescence, and aging. Again, in the estimation of total measured factor productivity, we would argue that these two evaluations rather than the gross stock permit the more satisfactory evaluation of the improvements made in transforming inputs into outputs.

Some investigators have expressed a preference for the use of the gross stock measure as the correct or more meaningful proxy for capital input on the grounds that, since capital goods retain their technical efficiency substantially unimpaired over their lifetimes, a measure of the capital input is required which moves with the contribution of capital to output.[4]

Changes in the composition of the stock of fixed capital and changes in the average age of the capital goods will set in motion changes in the net stock and capital consumption different from those recorded by the gross stock.[5]

For a hypothetical major group not subject to growth and possessed of a balanced age structure of capital goods, the value of the gross stock of capital will be, in competitive equilibrium, equal to the sum of the discounted flows of expected gross surpluses which would be accruing to each component of the stock if it were new. The value of the net stock would be the market's evaluation of the discounted flow of expected gross surplus accruing to each component of the stock and would appropriately take into account the different ages of the components. If the vintage composition of the stock remained unchanged over one year, then the sum of the changes in market values of each component of the stock as each component aged one period would be the capital consumption for the stock as a whole over the year.[6]

Consider now an equilibrium to equilibrium change in the composition of the stationary stock of capital goods such that the total current-period flow of returns and capital consumption allowances increase as compared to the

[4] It is, of course, admitted that capital goods nearing the end of their economic lives may suffer a decline in technical efficiency since the marginal rate of return to repair and maintenance expenditures declines and the more efficient associated inputs will be switched to newer and better capital goods. Thus it is not necessarily the case that technical efficiency of capital goods and capital's contribution to output, gross or net, will move together.

[5] See E. F. Denison, *The Sources of Economic Growth in the United States and the Alternatives Before Us,* Washington, D.C., 1962, Appendix D.

[6] For a balanced age stationary stock with finite lives and positive rates of interest (in competitive equilibrium with perfect foresight, equivalent to the net rate of return to capital), the value of the net stock will be greater than one-half of the value of the gross stock. Over one period of time, relatively new components of the stock will decline in value by smaller amounts than similar but older components.

base period with the total flow of net returns, the gross and net stock remaining unchanged.[7]

It appears appropriate to argue that the increased gross surplus accruing to capital goods has been obtained at a cost of shifting to a composition of capital goods involving a flow of capital consumption greater than before. In our view, any estimate of total measured factor productivity must take into account the increase in capital consumption which is associated with the increase in gross output. In this case, since the net returns accruing to the stock remain unchanged, it appears reasonable for the net stock to remain unchanged. Since the gross surplus accruing to the stock has increased because of the changed composition of the stock, there would appear to be little merit in using gross stock as representative of the capital input earning net surplus or gross surplus. The use of the net stock and capital consumption allowances (or the net stock) as the relevant capital input(s) in the gross (or net) domestic product version of the estimation of total measured factor productivity would appear to be appropriate.

When the equilibrium stock's age balance is disturbed by an increase in the rate of new additions, the fall in the average age of the stock and the greater rise in the net stock compared to the gross stock indicate, correctly in our view, the increase in value which society would have placed in the base period on the resources being used had their average age been lower.

Thus, we conclude that in assessing changes in total measured factor productivity on a gross domestic product basis, the more useful representations of the capital input are the net stock of capital and capital consumption allowances; and on a net domestic product basis, the net stock alone is to be used.

It follows from our way of looking at total measured factor productivity estimation that declines in activity legitimately show up as declines in the rate of advance in productivity. Yet, a major interruption in the rate of advance in output (or an absolute decline) will so adversely affect expectations as to profitable accumulation that the attempted measurement of capital inputs (however it is to be done) over such a decline in activity may well be impossible. If we wanted to adjust the capital inputs for underutilization, how do we construct an estimate of the base-period values which the economy would have placed upon current resources if there had been similar underutilization in the base period? Such values would, of course, be disequilibrium values par excellence, and there is doubt in our minds as to the usefulness (or even possibility) of such valuations. We do not suggest that the base-period values we have used are anything but crude approximations to market equilibrium values. The interruptions which occurred in manufacturing activity after 1957 were, however, so great in our view as to

[7] Here we attempt to follow Denison's advocacy (*ibid.*) of the gross stock as the appropriate measure of the capital input.

place serious doubts on the meaning of capital measurement, expressed in constant 1949 prices, for the years following 1957.

Where the estimation total measured factor productivity is performed at the industry level of detail, there are a number of output measures which are possible. One could use net or gross domestic product in constant dollars or two measures of gross output in constant dollars. With respect to the latter, the advantage for total measured factor productivity analysis is that intermediate inputs in constant dollars are treated as input rather than as negative output, as they are in the domestic product measures. We could include in both the gross output and intermediate inputs any intra-industry consumption which takes place in the industry. It would appear preferable to use as gross output a measure of the output of the industry which is *final to the industry* in question. In this case, the industry's intermediate inputs will not include intermediate inputs which were produced by other establishments within that same industry.[8]

Let us compare the gross output and gross domestic product measures of an industry's output from the point of view of total measured factor productivity estimation. The former measures would appear to be conceptually superior.[9] It is clear that intermediate inputs used to produce gross output final to an industry are, in every sense, as meaningfully conceived as inputs in the productive processes of the industry as are the labor and capital it uses.

There are difficulties [10] associated with the constant-dollar gross domestic product measure of output which are more readily apparent when examined within the context of the identity format of total measured factor productivity with which we work.

[8] In the text, it is assumed that no indirect taxes of subsidies prevail. With indirect taxes taken into account, the value of gross output must exclude indirect taxes (include subsidies) while the value of intermediate inputs must include indirect taxes (exclude subsidies) in order for the measures of domestic product to be on a factor cost basis. Thus, for the gross output variant of total measured factor productivity constant-dollar intermediate inputs will have a constant-dollar indirect tax component just as, in the gross domestic product variant, the constant-dollar net stock and capital consumption allowances will, if indirect taxes have been levied on capital goods, have a constant-dollar indirect tax component.

[9] There are no major difficulties in aggregating gross output final to each industry over all the industries concerned. Each time industries are added together, the measures of outputs and intermediate inputs are redefined to exclude any intra-industry consumption that arises as the aggregation process proceeds. For a closed economy, the last step in the aggregation procedure leads to a measure of final gross output equal to aggregate gross domestic product with intermediate inputs disappearing. Indirect taxes require special treatment. For an open economy, correct aggregation of intermediate inputs leads to flow of imports excluding those entering directly into components of final demand (see B. J. Emery and T. K. Rymes, "Price Indexes in a Social Accounting Framework," *Conferences on Statistics, 1962 and 1963,* Asimakopulos and Henripin, ed., Toronto, 1964).

[10] See P. A. David, "The Deflation of Value Added," *Review of Economics and Statistics,* May 1962, pp. 148–55.

Again, making certain simplifications for expositional purposes, we have

$$PQ \equiv WL + rP^N N + P^D D + P^M M \tag{1.8}$$

where PQ is the value of gross output final to an industry, $P^M M$ is the value of intermediate inputs employed by the industry, and the remaining terms are defined as before.

Again, we have, as a variant of 1.2,

1.9

$$\frac{\dot{Q}}{Q} - \left[\frac{WL}{PQ}\left(\frac{\dot{L}}{L}\right) + \frac{rP^N N}{PQ}\left(\frac{\dot{N}}{N}\right) + \frac{P^D D}{PQ}\left(\frac{\dot{D}}{D}\right) + \frac{P^M M}{PQ}\left(\frac{\dot{M}}{M}\right)\right] \equiv$$
$$\left[\frac{WL}{PQ}\left(\frac{\dot{W}}{W}\right) + \frac{rP^N N}{PQ}\left(\frac{\dot{r}}{r} + \frac{\dot{P}^N}{P^N}\right) + \frac{P^D D}{PQ}\left(\frac{\dot{P}^D}{P^D}\right) + \frac{P^M M}{PQ}\left(\frac{\dot{P}^M}{P^M}\right)\right] - \frac{\dot{P}}{P}$$

where

$$\dot{W}/W,\ \dot{r}/r,\ \dot{P}^N/P^N,\ \dot{P}^D/P^D, \text{ and } \dot{P}^M/P^M$$

are the proportionate rates of changes in the money price of labor, the nominal rate of return to augmentable capital, the price of the net stock of capital, the price of capital consumption allowances, and the price of intermediate inputs. When identities 1.8 and 1.9 are transformed into the gross domestic product version we have

$$PQ - P^M M \equiv WL + rP^N N + P^D D \tag{2.0}$$

2.1

$$\frac{PQ}{PQ - P^M M}\left(\frac{\dot{Q}}{Q}\right) - \frac{P^M M}{PQ - P^M M}\left(\frac{\dot{M}}{M}\right) - \left[\frac{WL}{PQ - P^M M}\left(\frac{\dot{L}}{L}\right)\right.$$
$$\left. + \frac{rP^N N}{PQ - P^M M}\left(\frac{\dot{N}}{N}\right) + \frac{P^D D}{PQ - P^M M}\left(\frac{\dot{D}}{D}\right)\right] \equiv \left[\frac{WL}{PQ - P^M M}\left(\frac{\dot{W}}{W}\right)\right.$$
$$\left. + \frac{rP^N N}{PQ - P^M M}\left(\frac{\dot{r}}{r} + \frac{\dot{P}^N}{P^N}\right) + \frac{P^D D}{PQ - P^M M}\left(\frac{\dot{P}^D}{P^D}\right)\right]$$
$$- \left[\frac{PQ}{PQ - P^M M}\left(\frac{\dot{P}}{P}\right) - \frac{P^M M}{PQ - P^M M}\left(\frac{\dot{P}^M}{P^M}\right)\right]$$

When identity 1.9 is transformed into the output per unit of input and "own-product price" of input format of identity 1.3, it follows that the proportionate rates of change of the own-product prices of the factor inputs will, if we assume for purposes of exposition that production is being carried on under perfectly competitive equilibrium conditions, be equal to the proportionate rates of changes of the marginal physical productivities of the factor inputs. For identity 2.1 however, the resulting proportionate rates of change in the own-product price of the factor inputs are difficult to interpret. Differences between the proportionate rates of change in the prices of gross output and intermediate inputs represent changes in the commodity terms of trade between the industry under examination and other sectors of the economy supplying it with intermediate inputs. Consider the proportionate rate of change in the wage rate, or the price of a standard labor input. In nominal terms, it is significant to the supplier and demander of labor. In "real" terms, it is presumably the consumption or total final goods value of the nominal wage rate which is of interest to the supplier of labor, whereas the demander of the labor input is presumably concerned with changes in the labor's marginal physical product in the production relationship in which it is engaged, that is, in changes in labor's own-product price. For analysis of changes in such price relationships, identity 1.9 would appear to be appropriate. The proportionate rate of change of the own-product price of labor which results from the use of identity 2.1 is, in fact, some intermediate position between the proportionate rate of change in the price of labor with which the demander of labor and the supplier of labor are concerned. The same difficulties of interpretation arise for the other own-product prices in identity 2.1. On the "real" output-input side of the identity, it must always be remembered that one is discussing the proportionate rates of change in output per unit of intermediate input. The weights that are attached to the proportionate rates of change of the gross output and the intermediate inputs transform the measure to the proportionate rate of change of the contribution to aggregate gross domestic product of the industry—a measure of output which is not necessarily the most useful for examining total measured factor productivity at the particular major group or industry level of detail.

Consider an industry producing a homogeneous product, which flows directly into final demand, with homogeneous labor, reproducible capital, and intermediate inputs. Technological change occurs in the industry producing the intermediate input, relative prices of the original industry's inputs change, so that the price of labor in terms of intermediate inputs rises. We should expect a switch in existing techniques used such that the gross output per unit of labor input would rise; output per unit of capital input and per unit of capital consumption allowances would (say) remain unchanged, and output per unit of intermediate input would fall. Elasticities of substitution are assumed such that the partial elasticities of gross output with respect to the inputs remain unchanged. The recorded changes in gross domestic product per unit of labor and reproducible capital inputs will, of course, be different from the recorded changes in gross output per unit of labor, reproducible capital, and intermediate inputs. The gross domestic product version of total measured factor productivity estimation will eliminate, for the industry under discussion, the influence of technological progress in the industry supplying it with its intermediate input. If one is concerned with assessing the changing efficiency with which direct and indirect primary inputs are contributing to the increased output of the industry in question, it is not clear that a measure of output which, in its method of construction, eliminates the effects of the increased efficiency of the indirect primary inputs is a measure which would be helpful in assessing that efficiency. That is, the unchanged efficiency of the primary inputs used in the industry under examination will possibly show up as a reduction in gross domestic product at factor cost (given the weights and changes in the primary inputs) which would appear to be correct. Yet it may well be that the gross output per unit of combined primary inputs in that industry and gross output per unit of total direct and indirect primary inputs have risen, whereas total measured factor productivity estimations will show no change because no allowance is made in the estimates, as they are presently formulated, for the reduced primary input content of the gross output of the industry supplying the intermediate inputs.

While this paper is concerned primarily with empirical results, there are further difficulties associated with the concept of output and the estimation of total measured factor productivity at the disaggregated level that we should like to touch upon briefly. Consider a two-sector economy that has long been in steady state growth equilibrium. Assume further that labor is homogeneous and that a steadily rising money wage rate prevails. Industry A is a fully integrated capital goods and intermediate-inputs-producing industry, and industry B is a consumption-goods-producing industry. Both industries are subject to rates of technological advance such that the consumption goods price of capital goods and intermediate inputs remains unchanged. The same unchanging rate of return to capital prevails in both industries. Techniques of production are such that different ratios of gross output per unit of primary and intermediate input prevail in the two industries. Then under such conditions, the rate of advance in total measured factor productivity in both sectors will be equal to the proportionate rates of change of wage rates (equal in both sectors) times the respective partial elasticities of output with respect to the labor input in both industries. As the definition of output for each sector is changed from gross output to gross or net domestic product, the respective measures of the rate of advance in total measured factor productivity will, of course, alter as the measured elasticities alter.

The example could easily be such that the deployment of factors over the two industries remained constant. In this case it is a drawback of our present methods of estimating total measured productivity that the resulting measures are not invariant to aggregation over major groups or industries whether the process of aggregation is by output final to industries or on the basis of gross or net domestic product. Indeed, if in the example the output of consumption goods and capital goods were growing at the same rate and the ratios of output per unit of net stock of capital, capital consumption allowances, and intermediate inputs remained unchanged in both industries, it would be hard to defend measures of proportionate rate of change of total measured factor productivity in both industries which yielded results that differed solely because of different partial production elasticities of labor. Parenthetically, it is interesting to note that in such a model, capital (i.e., all forms of commodity input) measured in terms of Robinsonian real capital would yield measures of total measured factor productivity which were equal in the two industries and invariant to the aggregation process.[11]

Secondly, if Professor Johnson is correct [12] in asserting that pure labor is an input concept appropriate to an earlier era and that an *increasing* share of net domestic income really represents net returns to capital, then in models of steady growth,[13] when commodity capital in all its stock and flow forms are growing at the same rate as output, the proportionate rate of change of total measured factor productivity, given our measurement procedures, would approach zero—a clearly meaningless result. Again, this dilemma would be surmounted by the utilization of the Robinsonian concept of real capital.

In conclusion, in this Technical Appendix we have argued the case for net stock and capital consumption allowances as the relevant measures of the capital inputs in total measured factor productivity estimation. We have noted certain difficulties in connection with the customary gross (or net) domestic product measures of constant-dollar output measures by industry, and suggest that some of the difficulties may be overcome by the transformation of the commodity inputs (stocks and flows) into estimates of their direct and indirect primary input reproduction requirements—a device which takes into account the changing efficiency with which commodity inputs are being produced.

Finally, for the direction of the reader, our estimates of total measured factor productivity in Part II of the paper in Tables 6, 7, 8, and 12 rest on an expanded version of identity 1.7 (or 2.1); in Table 9, on identity 1.5; and in Table 11, on identity 1.9. The expansion results simply from the introduction of inventories and the various measures of the labor inputs we have been able to derive.

[11] See L. M. Read, "The Measurement of Total Factor Productivity," DBS, June 1961 (mimeo.). Read's central thesis, in his attempt to make operational a variant of Joan Robinson's real capital input, is that changes in the commodity inputs (stocks and flows) in any activity in the economic system should, in total measured factor productivity measurement, be assessed not in terms of their base-period primary input requirements under conditions of base-period technology but rather in terms of current-period primary input requirements, under *current*-period conditions of technology, evaluated at base-period primary input prices. The problem of historical regress which is involved in Joan Robinson's real capital concept (see Joan Robinson, *The Accumulation of Capital,* p. 121) is overcome by a simultaneous solution for the changing direct and indirect primary input of all commodity inputs evaluated at base-period primary input prices.

[12] H. G. Johnson, "Towards a Generalized Capital Accumulation Approach to Economic Development," *The Canadian Quandary,* Toronto, 1963.

[13] See F. H. Hahn and R. C. O. Matthews, "The Theory of Economic Growth: A Survey," *Economic Journal,* September 1964, pp. 779–902.

COMMENT

DEREK A. WHITE

Since the Lithwick-Post-Rymes paper represents, perhaps, something of a landmark on the recent Canadian economic scene, a few words of introduction concerning its background may not be inappropriate. In Canada, the measurement of productivity and the estimation of production function relationships have lagged behind developments in these areas in the United States. Indeed, until quite recently, with one notable exception, very little domestically produced material pertaining to the measurement of Canadian productivity had been published or, for that matter, even developed, although some rough estimates had been used over the years for various purposes by different government departments. The notable exception referred to was the 1957 Hood and Scott study for the Royal Commission on Canada's Economic Prospects.[1] This study developed estimates of gross domestic product per man-hour for major economic sectors, covering the years 1926 to 1955. Projection of these trends to 1980 was used, in combination with labor input projections, to derive estimates of the aggregate supply capabilities of the Canadian economy over the twenty-five-year horizon from 1955 to 1980. A by-product of this work was the computation, at the major Standard Industrial Classification group level, using the perpetual inventory technique, of estimates of the net and gross capital stocks covering the period 1926 to 1955. These were used to calculate capital-output ratios by industry, which, in turn, were projected to yield estimates of gross capital stock and investment growth to 1980.

From 1957 until 1964, although development work was under way at the Dominion Bureau of Statistics, there was little significant further published material. Last year, however, after a prolonged period of gestation, the DBS published global indexes of real output per employee and per man-hour for the commercial nonagricultural industries, covering the years 1947 to 1963.[2] Also, in December 1964 the DBS released some limited details of the capital stock estimates prepared under the

[1] William C. Hood and A. D. Scott, *Output, Labour and Capital in the Canadian Economy,* Ottawa, 1957.

[2] *Indexes of Real Output Per Person Employed and Per Man-Hour, Canada, for 1947–63, Commercial Non-Agricultural Industries,* Dominion Bureau of Statistics, Cat. No. 14-501.

Fixed Capital Stock Project designed to extend and develop the work initiated by A. D. Scott.[3] Reasonably firm estimates of the net and gross stock were available for most of the two-digit manufacturing industries, and the full set of data were made available by the DBS to interested parties pending their release in detail in the forthcoming DBS publication, *Estimates of Fixed Capital Flows and Stocks, Manufacturing, 1926–60.* In addition to the estimates pertaining to manufacturing made available by the DBS, much more preliminary and tentative estimates covering most of the remaining major industry groups were released. Early in 1965, the Economic Council of Canada published, in a staff study, the estimates of output per man-hour in the agricultural and non-agricultural sectors of the economy underlying its potential output projections.[4] Another Economic Council Staff Study used industry output estimates consistent with its global output projections, together with industry gross capital-output ratio projections, to derive estimates of equilibrium values of invesment consistent with the steady growth of the Canadian economy to its potential level by 1970.[5] Mention should also be made of as yet unpublished work undertaken by two recent royal commissions which, it is understood, employed explicit production function models, and a recent paper by Y. Kotowitz.[6] A number of additional unpublished studies have been undertaken by Canadian university economists. The Lithwick-Post-Rymes paper before this conference represents an important addition to this now growing body of Canadian empirical studies of production function relationships, and presents what I believe are the first domestically produced published estimates of "total factor productivity."

The main thread linking the three sections of the paper appears to be their use of newly available capital stock estimates. It is perhaps a rather thin thread, since the estimates of capital stock actually used in Part III of the paper were apparently those developed independently by Lithwick in connection with the Ph.D. thesis referred to there. Presumably, the Lithwick estimates for manufacturing were broadly con-

[3] DBS, *Daily Bulletin Supplement 2,* December 22, 1964.

[4] B. J. Drabble, *Potential Output, 1946 to 1970,* Staff Study No. 2, Economic Council of Canada.

[5] Derek A. White, *Business Investment to 1970,* Staff Study No. 5, Economic Council of Canada.

[6] "Capital-Labour Substitution and Technological Change in Canadian Manufacturing, 1926–61," a paper presented to the meeting of the Canadian Political Science Association, June 10–12, 1965.

sistent with those used in the other two sections of the paper, although there is no direct discussion of this point.

The relation between Part I and the other two parts of the paper seems rather loose. The authors state that their purpose is to throw light indirectly on the role of the capital stock in Canadian manufacturing by studying the capital stock adjustment process, net investment. Net investment is related to output and net capital stock variables in the first regression equation, and in most industries the estimated relations reveal the expected positive sign for output and negative sign for the net capital stock. $\bar{R}^2$ values were low, however, and, in six cases out of fourteen, not significant at the 5 per cent level. The choices of the authors in specifying alternative hypotheses, in an attempt to explain a larger part of the variation in net investment, are somewhat difficult to understand. The choice of an interest rate variable appeared highly unlikely to yield significant coefficients in view of the known heavy reliance of Canadian corporations upon internal financing and likely low sensitivity to interest rate variations.[7] Of interest and relevance in the context of their paper would have been the introduction of gross stock variables in place of the net stock variables and of values of output lagged by more than one period, the latter in view of known substantial time lags between changes in output (or sales) and realized investment. Use of the gross stock is suggested by the authors' attribution of the poor fit of the first regression equation to "too mechanical" an estimation of replacement investment, which implies that the net stock estimates would suffer from similar defects.

The second set of regressions represents a considerable improvement on the first, although one suspects that part of the improvement results from serial correlation in gross investment and correlation between gross investment and the gross capital stock of the same period. Again, it would have been of interest if the authors had used gross capital stock estimates in the computation of capacity capital-output ratios and estimated excess capacity. Further, the introduction of excess capacity variables lagged more than one period would appear to have been desirable. Also, the use of fixed income share weights in Parts II and III of

[7] J. H. Young and J. F. Helliwell, assisted by W. A. McKay, "The Effects of Monetary Policy on Corporations," Royal Commission on Banking and Finance, *Appendix Volume*, Ottawa, 1964; also D. J. Daly, "The Scope for Monetary Policy—A Synthesis," in forthcoming Economic Council of Canada publication, *Conference on Stabilization Policies*.

the paper, implying unitary elasticity of substitution, suggests that it would have been appropriate for the authors to test a log-linear form of investment equation derived from the Cobb-Douglas function. In general, however, the influence of the business cycle upon annual investment data is such that high $\bar{R}^2$ values are not to be expected without the inclusion of cyclical variables; even then, of course, the use of annual data tends to obscure cyclical relationships.

Turning now to Part II of the paper, it is clear that, in a very general way, the evidence set forth in Parts II and III provides a useful addition to what Murray Brown has referred to as "an impressive set of evidence to indicate that, quantitatively, the labour and capital input components have been over-emphasized" in reference, specifically, to the results obtained by M. Abramovitz, R. Solow, M. Brown, and J. Popkin. Part II of the paper, together with the Statistical and Technical appendixes, is central in more than one sense. Since, as we have noted, it presents the first published estimates of the growth of total factor productivity in Canadian manufacturing using the new DBS capital stock estimates, it is perhaps appropriate for the authors to devote considerable attention to evaluating the effects of the different sets of average service lives assumed by DBS upon the growth of the capital stock over time and thus upon total weighted factor inputs and measured productivity.

The authors proceed to do this with great pessimistic zeal, as befits true devotees of the "dismal science." However, since one of the coauthors was responsible for supervising the preparation of the DBS capital stock estimates, it appears reasonable to conclude that the paper could have given somewhat firmer indications as to the growth estimates most likely to be accurate, that is, those based upon the capital stock estimates incorporating the most realistic service life assumptions. The authors do state that sets III and V were in general based respectively on the longest and shortest lives assumed, but we are not given any indication of the probabilities attached to these assumptions. The implied downgrading of the standard estimates thus appears to go beyond the requirements of detached objectivity, almost to the verge of masochism. Over the longer period 1926–56, the divergences between the total factor productivity estimates based upon the three sets of life assumptions at the total manufacturing level narrow substantially, but the authors are skeptical of this result and warn of the possible influence of secular changes in average economic lives.

While perhaps rather strong, the authors' caution is not without foundation and points to the need for continuing surveys of service lives in order both to establish their average current values and to keep abreast of changes in the rates of physical and technical obsolescence. Until such a firmer foundation for them exists, the capital stock estimates and the measures based upon them will continue to be open to some justified suspicion.

The authors' concern with capital stock measurement problems appears to have diverted their attention to some extent from other potentially serious questions relating to their results covering the 1946–56 period. One of these is the adequacy of the output data underlying the productivity estimates based upon data for gross domestic product at factor cost. In a number of industries, these have not been revised to census benchmarks since 1951. Since then, extrapolation has been on the basis of monthly data. Some 40 per cent of the monthly total industrial production index is based upon man-hours data adjusted for estimated trends in productivity. Variations in industry input requirements are not reflected in such estimates and in other projectors used in the estimates of GDP at factor cost. To the extent that unit input variations have been significant, the gross domestic product and factor productivity estimates will be subject to bias. Similar qualifications apply, of course, to the output data entering the regressions of Part I.

A further question relates to the corrections to the paid worker input series to eliminate hours paid for but not worked. DBS estimates based on Census of Industry data suggest that the allowances for hours paid for but not worked incorporated in Table SA–6 are considerably higher than is appropriate, producing a downward bias in labor inputs and an upward bias in total measured factor productivity. The DBS figures in fact suggest that the use of paid worker data over the period considered would not result in serious bias in the productivity estimates.

An additional major issue relates to the appropriateness of the period selected for the analysis of total factor productivity, apart from the shortness of the period covered by the estimates in Part II. The authors note the emergence of excess capacity from 1957 on and rightly restrict their measures to the 1946–56 period in preference to the longer period 1946–60 for which data were available. In 1946, however, the existing capital stock was depreciated to very low levels by the straight-line depreciation methods underlying the net stock computation. Subsequent growth rates for the net stock were therefore very large. In general, the net capital stock estimates reveal larger percentage swings than do the corresponding gross estimates, as is indicated by the following percentage changes in capital stock in Canadian manufacturing: [8]

	Gross Stock	*Net Stock*
1931–39	−8.8	−15.3
1946–56	+54.9	+78.8

Over the period 1946–56, gross domestic product at factor cost in manufacturing grew at 4.5 per cent per annum, the gross capital stock grew at 4.5 per cent per annum, and the net stock at 6 per cent per annum. It may be noted parenthetically that 1946 was a recession year in Canada, judged by the performance of industrial production, and manufacturing output was about 8 per cent lower than in 1945 and 9 per cent lower than in 1947. This has, of course, further implications for the choice of 1946 as a base year for the total factor productivity estimates. Here, I wish merely to observe that the calculation of the 1946–56 growth rate referred to earlier is based on the substitution of the average of the 1945 and 1947 values of manufacturing production in place of the actual estimated 1946 value.

While the authors indicate a preference for the net stock measure of capital on conceptual grounds, their illustration of its superiority assumes a change in the composition of the stock which leaves the net and gross stock unchanged but alters the level of output and capital consumption allowances. Empirical evidence suggests that changes in the average age of the stock are important and that disequilibrium relationships between the net and gross stock are the rule rather than the exception. This consideration appears to be of greater practical relevance than the hypothetical example used by the authors. It is not clear to me that the analysis of growth is usefully furthered by the introduction into the empirical measures of medium-term variations in the capital variable related to changes in the average lives of the assets comprising the capital stock.

In a more positive vein, the authors are, I feel, to be commended for their disaggregated approach to productivity measurement. As Part III shows, the effects of interindustry shifts in employment upon aggregate

[8] Based on Set I lives.

total factor productivity have been significant in the Canadian case, even within industry sectors such as manufacturing. The major influence has, however, been the shift out of agriculture, which occurred somewhat later in Canada than in the United States. The recent United Nations study of growth similarly reports important shift effects in some European countries during the 1949–59 decade,[9] and there are indications that the shift out of agriculture has been a significant influence on Japanese growth.

Here I should like to disagree mildly with the authors' statement that the productivity improvement resulting from the shift out of agriculture "has been a once and for all event." The decline in the agricultural labor force is still continuing at a rate of about 3 per cent per annum. While this rate is lower than in the earlier postwar years, and the size of the agricultural labor force itself has about halved over the postwar period, some further significant productivity improvements from the shift out of agriculture appear probable. The authors' contention that the past growth rate in aggregate productivity will not easily be attained in the future also requires some qualification to take account of the improvement in the quality of labor inputs arising from the high rate of entry of young persons with considerably improved educational standards into the labor force.

A further advantage of disaggregation lies in the additional knowledge that may be brought to bear upon the analysis of the sources of productivity change. The textile industry provides an interesting example of this. The authors note that if total factor productivity in this industry were measured from 1949, instead of 1946, its growth would appear much stronger. The different performance of the industry may be rather closely identified with economic changes between the two periods: from an immediate postwar situation of strongly rising demand and prices, extended by the effects of the Korean War, to a situation of slower demand growth, rising labor costs associated with the resource development and investment boom and increased foreign competition resulting from a shift in the exchange rate from a discount to a premium with resulting lower Canadian prices for imported manufactures. The second period was marked by increased specialization within the industry. In this case, it would appear that increased competition and forced speciali-

[9] *Some Factors in Economic Growth in Europe During the 1950s,* Geneva, 1964, Table 22, Chap. 3.

zation was a ratchet producing a higher rate of productivity growth. It is unfortunate, for the purposes of this sort of analysis that, because of capital stock data problems, such dissimilar industries as nonferrous metal products and electrical apparatus and supplies had to be amalgamated in the computation of the productivity measures.

In conclusion, I feel it appropriate to draw attention to a finding of Part III of the paper which appears to be an important one. In Tables 17 and 19, the authors point to the similarity of Canadian total factor productivity growth rates by industry between 1937 and 1961 and those for comparable industries in the United States over the period 1927–57. The similarity is indeed quite striking. The authors conclude from this evidence, as we have seen, that the different growth performance of the two economies is primarily attributable to "shift" effects, with similar technological changes occurring, industry by industry, in the two countries. A further implication to be drawn, however, is that since, notwithstanding dependence on different data sources and differences in the periods covered, the two sets of computations portray an essentially similar picture in the industries which can be compared directly, the data used, despite many shortcomings, appear to afford the basis for meaningful comparison and analysis of total factor productivity growth trends. There is an important crumb of comfort in this for those engaged in the uncertain task of productivity measurement.

THOMAS A. WILSON

In this interesting paper Lithwick, Post, and Rymes have incorporated a number of applications of measures of the capital stock recently released by the Dominion Bureau of Statistics. Incidentally, the availability of these estimates is due in large part to the painstaking work of Mr. Rymes.

The paper is really three papers bound together. The first deals with investment behavior. The second presents sector by sector estimates of "total factor productivity," and examines the sensitivity of these estimates to changes in the assumptions which underlie the capital stock figures. The third focuses on the aggregative growth performance of the Canadian economy, with explicit attention to what accounts for the observed differences between Canada and the United States in the rate of technical change.

I shall therefore divide my remarks accordingly, but shall discuss these topics in reverse order, as I want to devote most of my allotted time to the section dealing with investment behavior.

Let us first look at the aggregative study. The authors find that the rate of technical change over the 1926–56 period in Canada was considerably higher than the rate of technical change over the 1929–57 period in the United States, which accounted for nearly three-quarters of the observed growth in that country.[1] Their main contribution, however, is an examination of the sources of technical change to find out what accounts for the apparently higher rate of technical advance in Canada. Two sources are examined: changes in the quality of the labor force (as measured by changes in levels of educational attainment and by changes in the age-sex structure of the labor force), and movements of labor (and capital) between sectors or industries within the economy.

Surprisingly, the first source—improved quality of the labor force—actually contributed less to economic growth in Canada than it did in the United States. Whereas Denison found that in that country education was a particularly important source of economic growth,[2] in Canada the contribution of education to growth was much smaller, and was almost completely offset by unfavorable changes in the age-sex composition of the labor force.

Intersectoral movements of labor, on the other hand, are much more important in Canada, and largely account for the observed differences between the two countries in the rate of technical change. While this finding is somewhat influenced by the period analyzed (the important outmovement from agriculture was concentrated in the 1937–61 period), it is indicative of a fundamental difference between the two economies in the past. The much greater importance of agriculture in Canada, and the consequent greater relative importance of the shift of resources from agriculture to industry explain the larger relative importance of these intersectoral shifts for economic growth in Canada.

One thing that bothers me about these (and other) calculations of

[1] Technical change (including improvements in labor quality) accounted for 70 per cent of total growth in the United States, 1929–57 (E. F. Denison, *The Sources of Economic Growth in the United States and the Alternatives Before Us*, Washington, D.C., 1962, Table 32, p. 266).

[2] Denison (*loc. cit.*) estimates that education accounted for over one-fifth of total growth. If the correction for extra days of schooling per year of school completed is eliminated, this contribution is reduced to 12 per cent (Lithwick, Post, and Rymes, Table 16).

the effects of intersectoral shifts is that they only pick up the growth consequences of moving from a disequilibrium factor market position toward an equilibrium one. Paradoxically, in an economy with high labor mobility and well-functioning markets, the measured effect of interindustry labor movements will be small, because the interindustry mobility itself prevents situations with large wage or productivity differentials from emerging.

The authors point out that the contribution to growth of this outmovement from agriculture is likely to be less in the future than in the past, due largely to the decreased relative importance of the agricultural labor force. The depressing effect on the growth rate is likely to be more than offset by several favorable developments, however. The labor force is expected to grow at a very rapid rate over the next five years. If major wars and depression, which seriously retarded the capital formation rates in the past, are avoided, the capital stock will grow at a rate faster than that achieved over the past thirty years. These two factors together make the growth prospects of the Canadian economy particularly buoyant over the next five to ten years; to the extent that the educational level of the work force is improved and to the extent that shifts of workers occur from low- to high-productivity regions, the actual growth achieved will exceed even these buoyant prospects.

The estimates of total factor productivity presented in the second part of the paper are about as detailed as those published by Kendrick [3] for the United States. Future research involving comparisons of the estimates for Canada and the U.S. and the explanation of the observed differences in growth rates of total factor productivity might shed additional light on some of the issues discussed at this conference.

The authors find that their estimates of total factor productivity are somewhat sensitive to changes in the assumed lives of plant and equipment used in constructing the capital stock series. I think they are unduly disturbed by these findings. The changes are quite small, being of the order of one-tenth of 1 per cent per year over the 1926–56 period (or 7 per cent of the estimated growth of total factor productivity).

In any case this finding would suggest that DBS consider alternatives to the fixed lives approach now used. Under the present method

[3] John W. Kendrick, *Productivity Trends in the United States,* Princeton for NBER, 1961.

of estimating the capital stock, small changes in assumed lines may lead to fairly large changes in the gross stock for an industry which experienced an investment boom at some point in the past.

These changes would be much reduced if a survival curve approach (which is more realistic) were used—i.e., if the stocks were estimated on the assumption that the expected life of a specific machine is constant, but that its actual life is a probability function of its age.

Let us now turn to the analysis of investment behavior.

The basic model used is a simple accelerator type of capital stock adjustment model, with the desired stock this year dependent on last year's output, and with no role for variables reflecting liquidity or the availability of internal or external funds. A perusal of Table 1 indicates that this model does not perform particularly well. Economists are becoming used to unexpected signs on regression coefficients and other problems arising from the collinearity of the set of possible independent variables, but to have six out of thirteen time series R^2's statistically insignificant is not usually our lot!

A proponent of the Charles River theory of investment might argue that these results simply reflect the omission of liquidity or internal funds variables. However, in connection with some work I have carried out for the Royal Commission on Taxation, I fitted accelerator–residual funds models for industries at approximately the two-digit level in Canada. These results indicate that a capital stock adjustment model which incorporates residual funds as well as accelerator effects does not perform particularly well either.

I also have fitted forecasting and realization functions using the November forecasts of investment published by DBS. The forecasts work very well. When capital goods price changes are taken into account, roughly 90 per cent of the variation of *changes* in business fixed investment is accounted for by the forecasting functions at the aggregate level. While the disaggregated results are not that good, they are quite respectable. The realization functions, on the other hand, are very good at the aggregative level, but very poor at the two-digit level. For the economy as a whole, 80 per cent of the deviation of actual investment from forecast investment can be explained by changes in retained earnings, changes in sales, and changes in capital goods prices. At the two-digit level, it is rare that any significant improvement on the forecasts can be attained by a realization function.

What accounts for the generally poorer results obtained at the two-digit level in Canada as compared with the United States? (Compare, for example, the results of Lithwick, Post, and Rymes at the two-digit level with those recently published by Hickman.) [4]

One contributing factor may be the simple lumpiness of investment decisions by individual firms. The typical Canadian manufacturing industry is dominated by a few large firms, largely because the Canadian market is smaller than the American. Even at the two-digit level the investment decisions of a few large firms can noticeably affect the series for the industry as a whole.

Much more important, I believe, is the fact that the usual type of accelerator or accelerator–residual funds model is not suitable for industries in an open economy. The openness of the Canadian economy is great in two ways. First, exports and imports are 20 to 25 per cent of total GNP, and are even more important for the manufacturing sector. Second, roughly half of manufacturing industry is owned or controlled by foreigners; the typical foreign-controlled firm is a subsidiary of a United States firm.

Under these conditions, lagged domestic output will be a poor proxy for expected sales; retained earnings and Canadian interest rates will be inadequate measures of the availability and cost of funds. If relative prices are introduced, the relative costs of producing in Canada vis-à-vis the United States will probably be more important than the relative prices of Canadian inputs.

While some improvement may be possible with better specification of the conventional models, especially if new data series become available on a quarterly basis, I think that major improvements will be achieved only when we figure out a way of modifying the accelerator–residual funds model to handle the case of a very open economy. My first candidates for variables in such a modified model would include measures of sales expectations in foreign and domestic markets (weighting each market by its relative importance for the industry concerned), the inclusion of retained earnings of parent as well as subsidiary firms, particularly for industries such as autos where foreign ownership is very important, and measures reflecting the relative costs of production north and south of the border. Obtaining even proxy measures of these vari-

[4] Bert G. Hickman, *Investment Demand and U.S. Economic Growth,* Washington, D.C., 1965, Table 4, pp. 54–55.

ables will not be easy. But surely we can improve on models which predict, for example, that the devaluation of the dollar stimulates investment after output responds rather than before.

Another alternative worth trying might be to resurrect the old-fashioned profits theory. Given the aggregate amount of North American investment, the percentage allocated north rather than south of the forty-ninth parallel may well be explained (as conventional theory would suggest) by relative rates of return on capital.

These considerations also suggest that the aggregative results, while satisfactory at first glance, need to be interpreted with some caution, particularly for purposes of policy analysis. Given the links between the Canadian and the United States economies, the aggregate variables may move closely together so that a domestic variable (for example, Canadian output) is a reasonably good proxy for the correct variable (for example, North American sales).

Finally, let me turn to two issues dealt with by the authors where the methods used are inadequate.

They attempt to test the hypothesis that technical change is embodied in concrete capital goods in two ways. The first test is the introduction of a time trend into the capital requirements model. This does not test the hypothesis that technical change must be embodied in capital goods, since new techniques may be more or less capital-intensive than old, yet may still have to be embodied in new types of capital goods. The second test is a regression of changes in output per man-hour on changes in output and on lagged investment. However, a first-difference model, which emphasizes short-run changes in output per man-hour, will not likely be a good one for testing the effects of embodiment, which are presumably longer lasting. Some kind of distributed lag approach would seem to be in order. Furthermore, it is not clear that the inclusion of changes in output is an adequate method for eliminating the effects of cyclical fluctuations in productivity.

The authors also present estimates of the desired capital stock in manufacturing. Reversing the investment demand model, they obtain estimates of the desired stock by a procedure similar to that used by Hickman [5] to obtain capacity estimates. The Lithwick-Post-Rymes estimates of desired capital stock lie persistently *above* the actual capital stock

[5] *Ibid.*, pp. 94–104.

and are the counterpart of Hickman's estimates of capacity, being substantially *below* actual output. In the light of the sluggish performance of both the United States and the Canadian economies in the six years after 1957 these results are not particularly convincing. They confirm a suspicion of mine that the coefficient of the lagged capital stock in capital stock adjustment models is typically biased toward zero because of the likely positive serial correlation in the true error terms. If the coefficient on the lagged capital stock is biased toward zero the estimates of the desired stock will typically be upwardly biased, and the estimates of capacity downwardly biased.

To put matters more simply, the biased estimates of the coefficient on the lagged capital stock mean that too sluggish an adaptation rate is assumed. In a growing economy, this means that actual capital lags persistently behind the supposed desired capital stock.

REPLY by Lithwick, Post, and Rymes

It has been pointed out that the regressions in Part I are more successful in explaining aggregate investment than the capital expenditures of some major groups. This result is perhaps not surprising, since we specified relatively simple models of investment behavior and used them for all regressions. There are a number of factors which may have contributed to the poor performance of the models we chose and applied to all the data. A considerable amount of product and process heterogeneity may exist within the major groups. The answer to this problem lies in further disaggregation. If a major group includes plants with quite different capital-output coefficients and if the demand for the output of these different plants does not move together, then the required capital stock for the entire group will not be closely related to changes in total output for the group. A second explanation is that different industries may be subject to response lags of different length. The answer to this problem would have been to specify a model with lags tailored to the typical response pattern of each major group. Although we could have obtained better results by choosing different lags and variables for each industry, space limitations prevented us from so doing.

It was suggested by Professor Wilson that the dependence of many Canadian firms on export markets might influence their investment behavior. This will be the case if a decision maker when he is forecasting output and hence the need for capital inputs has different expectations about export sales than about domestic sales. This might, for example, be the case for a firm breaking into the export market for the first time and anticipating quite different quantities and elasticities than it has experienced in the domestic market. Our model, which assumes output expectations to depend on experienced patterns of output, is not capable of handling such a break with past patterns of behavior. Nor does our model attribute any role to the availability of financial capital; so inflows of long-term capital from abroad and direct investment in branch plants in Canada are also ignored. In the branch plant case the investment decision is made outside Canada, sometimes in the light of market possibilities outside Canada. A more complete analysis would need to take cognizance of the terms and availability of financing, as suggested by the discussants.

The emphasis in Part II of our paper on the variations in estimates of total measured factor productivity which arise because of an almost complete lack of reliable knowledge on the lives of capital goods, their survival curves, and realistic depreciation functions remains valid in our view. Clearly, in a disequilibrium world no unambiguous estimates will ever be obtained, but a great deal of work in the way of capital measurement remains to be done, in our view, before much confidence can be placed on estimates of total measured factor productivity in Canadian manufacturing. The Set I lives, which were the ones primarily used in our paper, represent the lives initially developed by DBS, and the different sets of lives were introduced by them in an attempt to see how sensitive capital stock estimates are to variations in assumed economic lives. Without further investigation it is not possible to say how appropriate the initial Set I lives are, nor would the application of crude survival curves, without first obtaining greatly improved data on actual survival patterns of capital goods, result in a reduction of the possible degree of error in the estimates.

We would have thought that our discussion in the Technical Appendix of the superiority of both the net stock and capital consumption allowances as the relevant capital inputs where the average age of the capital goods changes was quite pertinent to the points Mr. White raises in this connection. As Mr. White points out, our estimates of total measured factor productivity reflect the initial and terminal years chosen, and we drew explicit attention to this in our discussion of the cyclical sensitivity of the estimates and how they would have been altered had different initial and terminal years been chosen for analysis.

Mr. White criticizes our adjustment (in Table SA-6) of the labor series, from an hours-paid to an hours-worked basis. This correction involved only vacations with pay and other paid time off, and thus the large discrepancy between our adjustment and the preliminary work at DBS is not the result of a difference in concept. In fact, we suspect the latter series has some biases, but it would be inappropriate to discuss these unpublished materials. What we do conclude is that while our source is admittedly weak and our results biased thereby, there is strong evidence that a significant difference between hours paid and hours worked does exist, and that this must be explicitly taken into account.