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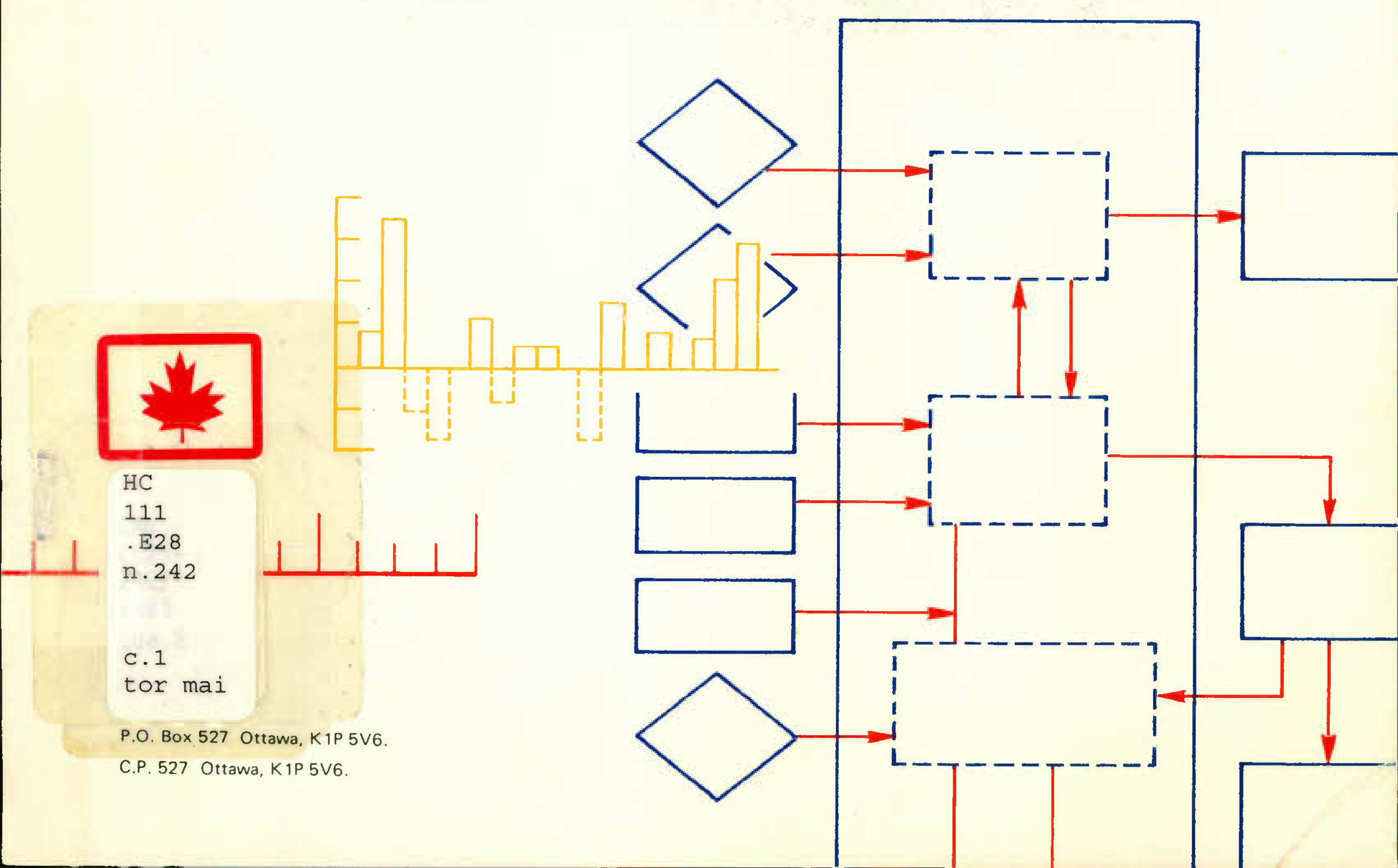

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DISCUSSION PAPER NO. 242

Inter-factor Substitution and Total Factor Productivity Growth: Evidence from Canadian Industries

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RÉSUMÉ

Les auteurs du présent document examinent les causes des variations intertemporelles de l'intensité des facteurs, ainsi que la productivité de l'ensemble des facteurs dans les industries canadiennes. A cette fin, ils ont estimé une fonction de coûts non-homothétique de type translogarithmique au niveau sectoriel; cette fonction est aussi caractérisée par un progrès technologique non neutre.

D'après nos résultats empiriques, le ralentissement de la productivité de l'ensemble des facteurs depuis 1973 est attribuable dans une proportion de 15 à 20 % à des modifications des échanges interindustriels. Le reste du ralentissement de la productivité pourrait être imputé à la baisse de la demande globale à l'échelle mondiale (occasionnant de plus bas taux d'utilisation de la capacité de production) et à l'augmentation considérable du prix relatif des produits énergétiques et des matières premières.

Abstract

This paper explores the causes of inter-temporal variations in factor intensities and total factor productivity (TFP) in Canadian industries. For this purpose, we estimated translog cost function at the sector level allowing for non-homotheticity and non-neutral technical progress.

Our empirical results suggest that about 15 to 20 per cent of the post-1973 slowdown in TFP is due to the inter-industry shifts in factor inputs. The remaining productivity slowdown could be attributed to the world wide slowdown in aggregate demand (lower capacity utilization rates) and the substantial increase in the relative price of energy and raw materials.

1. Introduction:

The performance of an economy can be assessed on both grounds of equity and efficiency. Dynamic performance, that is, inter-temporal change in equity and efficiency, is an issue that affects laymen, public officials and economists alike. Since World War II Canada has made progress in both of these areas. We have learned to combine all of our resources in increasingly efficient ways, resulting in a social dividend which was used collectively to bring about a more equitable or just society. Recently gains in efficiency have become increasingly difficult to obtain, especially after international oil prices began to increase in 1973. By using careful methods to measure the rate of growth of inputs and the rate of growth of outputs we can identify the magnitude of inter-temporal changes in efficiency which economists refer to as the index of total factor productivity (TFP).

Output per man-hour or output per person employed represents an individual's command over goods and services. As a performance measure its major shortcoming is, of course, that output is produced with capital, land, energy, materials and management and other human skills as well as with labour. Hence, changes in output per man-hour or output per person employed reflect not only improvements in technology but also could represent the substitution of other inputs for labour in response to changing market conditions (relative prices and demand). This could lead to confusion as to the reasons for movement in output per man-hour or output per person employed. In contrast, TFP reflects the contributions of all inputs. Its advantage is that it allows measurement of the influence that all factors of production have on output.

Furthermore, output per unit of labour input and TPF are inter-related. The rate of growth of output per man-hour is equal to the rate of growth of TPF plus a weighted sum of the rates of growth of other inputs (for example, capital, energy, and materials) in relation to man-hours, where the weights are the shares of each factor of production in total output [Berndt and Watkins (1982)].

When analysing inter-temporal changes in efficiency, it is important to distinguish between changes at the aggregate level and changes at the sectoral level. At the aggregate level the appropriate output concept is value added, a measure of the value of output produced by primary inputs (labour and capital) only. At the sectoral level, value added should not be used. Here value added plus the value of intermediate inputs (materials) should be employed as the output measure, since the use of value added will bias the estimate of TFP upward (except in those sectors in which intermediate input content is zero)[1].

This apparent methodological inconsistency between sectoral measurement and aggregate measurement has been dealt with by Hulten (1978). In the absence of inter-industry shifts in factor inputs, Hulten establishes an exact relationship between aggregate measures and sectoral measures. He also demonstrates that if inter-industry shifts do occur in factor inputs, differences can occur between aggregate measures and sectoral measures [Jorgenson (1980), Nordhaus (1972)].

In the post-oil embargo period, the rate of growth of output per man-hour declined dramatically in many industrial nations[2]. In Canada, improvements in aggregate output per man-hour declined from an average annual rate of 3.40 per cent per annum for the period 1967-73 to 1.05 per cent per annum for the period 1974-79. Similarly, aggregate TFP growth declined from an annual rate of 2.23 per cent for the period 1967-73 to -0.03 per cent for the period 1974-79. Almost all of the decline in output per man-hour can be traced to a decline in the rate of growth of TFP. This performance has created an upsurge of interest in the measurement and analysis of inter-temporal changes in efficiency.[3]

Even though there is a broad consensus among economists about the extent of the slowdown, there seems to be no agreement about what caused the slowdown and thus little agreement on remedies. In the Seventeenth Annual Review, the Economic Council of Canada examined the causes of the slowdown in output per man-hour. The analysis indicated that a large part of the slowdown at the sectoral level was caused by a reduction in the rate of growth of capital and intermediate inputs in relation to labour input and a slowdown in TFP growth. These findings in turn have raised the following questions:

1) Given that we can reconcile the use of gross output at the sectoral level with value added at the aggregate level, what is the contribution of inter-industry shifts to the decline in TFP growth at the aggregate level?

2) What are the causes of the slowdown in TFP at the sector level?

3) What are the factors behind the substitution of labour for capital, energy and materials at the sector level?

4) What role did energy prices play in the TFP slowdown? Is the industrial demand for energy price elastic and has this elasticity increased in the post-1973 period?

5) What role did aggregate demand play in the slowdown in TFP growth?

The objective of this paper is to analyse the causes of inter-temporal variation in factor intensities and TFP in Canadian industries. For this purpose, we estimate translog cost functions at the sector level allowing for non-homotheticity and non-neutral technical progress. Within this framework, variations in both factor intensities and TFP can be influenced by changing market conditions (factor prices and output levels).

The paper is organized as follows: Section II gives an overview of trends in output, output per man-hour, factor intensities, factor prices and TFP for the sub-periods 1958-66, 1967-73 and 1974-79. It also integrates sector information on TFP with that of aggregate TFP, reconciling the use of gross output at the industry level with value added at the aggregate level. Theoretical aspects of the translog cost function are discussed in Section III. Empirical results are discussed in Section IV. The last section explores some of the policy implications of our findings.

2. Trends in Output Per Man-hour, Total Factor Productivity and Factor Prices

One of the more striking features of economic performance in the recent past is the remarkable diversity between sectors, and within sectors between years. In this section, we present an overview of trends in output, output per man-hour, factor intensities, factor prices and TFP during the last two decades in Canadian industry. We also present detail on energy use in the manufacturing sector for purposes of identifying energy intensive industries. We concentrate our analysis on these energy intensive manufacturing industries when exploring the energy related questions posed in the introduction.

Aggregate Performance

To analyze the sharp decline in TFP growth in the Canadian economy during the period 1973-79, we develop data on TFP growth for individual sectors. As indicated in the introduction, for TFP analysis, at the sectoral level, the appropriate output concept is gross output, that is, value added plus the value of intermediate inputs -- energy and materials. However, at the aggregate level, the production and consumption of intermediate goods nets out, unless they are imported from abroad, implying that one should use net output (Gross Domestic

Product) to compute aggregate TFP. We resolve this methodological inconsistency between measures of sectoral and aggregate TFP growth by using the approach suggested by Hulten (1978) and Jorgenson (1980). Using Hulten's aggregation rule, aggregate TFP growth can be approximated by:

$$\frac{\dot{A}}{A} \simeq \sum_{i=1}^{N} \frac{Q_i}{Y} \frac{\dot{A}_i}{A_i} + \pi \qquad (2.1)$$

where

$\frac{\dot{A}}{A}$ = aggregate TFP growth

Q_i = gross output of the i-th sector

Y = total net output of the economy

$\frac{\dot{A}_i}{A_i}$ = TFP growth of the i-th sector

N = total number of sectors.

π = contribution of inter-industry shifts in primary inputs.

The first component of equation (2.1) is a weighted sum of TFP growth rates for individual sectors. The weights are the ratios of gross output (Q_i) in each sector to total output of the economy (Y). The sum of the weights exceeds unity, since

$$\sum_{i=1}^{N} Q_i > Y \qquad (2.2)$$

The intuitive reason for this procedure is straightforward. An increase in TFP at the sector level supports, in general, additional output, both final demand and intermediate deliveries. The increase in intermediate deliveries further increases output in those sectors using the intermediate good, and this further increases output and final demand. Because of these indirect effects, the direct plus indirect impact on aggregate TFP of sectoral TFP change will be greater than the direct effect $\frac{\dot{A}_i}{A_i}$. This is reflected in the weighting scheme of (2.1). The second component of (2.1) represents the contribution of inter-industry shifts in primary inputs to aggregate TFP growth[4].

The results of the aggregation exercise are presented in Table 1. During the period 1967-73, aggregate output per man-hour and TFP increased by 3.40, and 2.23 per cent per annum, respectively. This in turn implies that about 66 per cent of the improvement in output per man-hour was due to an increase in TFP with capital contributing the remainder[5]. Improvements in sectoral TFP account for about 80 per cent of the increase in aggregate TFP. The remaining 20 per cent is due to favourable shifts in primary inputs among sectors.

In contrast to this, during the post-1973 period, output per man-hour increased by only 1.05 per cent per annum -- a reduction of 2.34 per cent per annum between the two sub-periods. More than 95 per cent of the slowdown in this aggregate (output per man-hour) is associated with the slowdown in aggregate TFP. The remaining 5 per cent or so can be attributabled to a reduction in the rate of growth of the capital-labour ratio[6]. As seen from Table 1, aggregate TFP growth declined from 2.23 per cent per annum for the period 1967-73 to -0.03 per cent per annum during the period 1974-79. This implies that about 85 per cent of the slowdown in aggregate TFP was due to the slowdown in sectoral TFP. The remaining 15 per cent of the slowdown is associated with inter-industry (labour and capital) shifts from the goods producing sector to the service sector.[7]

In the post-1973 period, the rate of growth of output declined considerably in almost all of the industries. For example, total output of the durable manufacturing increased by a mere 1.60 per cent per annum during the period 1974-80 compared to 6.4 per cent in the period 1967-73. There is a similar slowdown for the nondurable manufacturing and other industries in the post-1973 period. Similarly, the rate of growth of output per man-hour and TFP also declined dramatically in the post-1973 period in almost all of the industries (see Table 2). An industry by industry analysis of movements in output and productivity suggests a strong positive correlation. Industries that experienced large reductions in output growth have also experienced large reductions in productivity growth. However, the causal direction is not clear. In theory causation could run either from variations in aggregate demand to changes in productivity growth or exogenous supply-side shifts in productivity growth to changes in output growth. In all probability both directions of causation do occur and reinforce each other in virtuous or vicious circles but it is important to try to establish which direction of causation predominates. However, in the medium run, one can probably conclude that reductions in productivity growth would be caused by falling output growth (not vice-versa), especially in fixed or quasi-fixed inputs were installed in the expectation of rises in output.

In all of the industries, the rates of growth of capital, energy and material inputs in relation to labour input have slowed considerably in the post-1973 period. An examination of movements in factor prices suggest that a large part of the slowdown in energy-labour, material-labour and capital-labour ratios might have been caused by changes in relative factor prices, that is the prices of energy, materials and capital in relation to labour have increased dramatically during the post-oil embargo period.[7]

In summary, our analysis indicate that about 95 per cent of the post-1973 slowdown in aggregate output per man-hour is due to a reduction in aggregate TFP growth. The contribution of the capital-labour ratio is marginal.[9] However, at the sector level, the contribution of capital and intermediate inputs to the slowdown in output per man-hour is large. Inter-industry shifts in primary inputs account for about 15 per cent of the slowdown in aggregate TFP.[10] The remainder is caused by a slowdown in sectoral TFP.

In the next section, we outline the translog cost function framework[11], based on the principles of duality developed by Samuelson (1947), Shepard (1953), Uzawa (1962) and Diewert (1971). The objective is to estimate the parameters of the translog cost function, at the sector level, allowing for biased technical change and non homotheticity[12]. This will enable us to test whether relative factor prices and output levels have influenced factor intensities and TFP growth at the sector level.

3. The Translog Model

We assume that the production surface for each industrial sector can be characterized by a twice differentiable production function relating gross output (Q_i) to the services of capital, labour, energy and material inputs:

$$Q_i = F_i\,(K_i, L_i, E_i, M_i, T) \qquad (3.1)$$

Where Q_i = gross output of the i-th industry

K_i = capital input in the i-th industry

L_i = labour input in the i-th industry

M_i = material input in the i-th industry

T = time trend - a proxy for technical change

If we assume that factor prices and output are exogenous and that firms are cost-minimizers, the theory of duality implies that associated with the production function (3.1) is a cost function of the form:

$$C_i = g_i(P_{Ki}, P_{Li}, P_{Ei}, P_{Mi}, Q_i, T) \qquad (3.2)$$

where C_i is the total cost of the i-th industry and P_{Ki}, P_{Li}, P_{Ei} and P_{Mi} are the prices of capital, labour, energy, and materials inputs for the i-th industry, respectively.

To estimate the parameters of the cost function, requires us to choose a parametric form for (3.2). We chose the transcendental logarithmic (translog) form originally proposed by Christensen, Jorgenson and Lau (1970), for three reasons.[13] First, it can be regarded as a second-order approximation to any arbritrary cost function. Second, it permits direct estimation of substitution elasticities, own- and cross-price elasticities, returns to scale and technical progress. Third, it requires no restrictions on the parameters of the cost function.

A translog functional form (general) for equation (3.2) is as follows:

$$\ln C = \alpha_O + \alpha_Q \ln Q + (1/2)\alpha_{QQ}(\ln Q)^2 + \alpha_{QT} T \ln Q + \alpha_T T + (1/2)\alpha_{TT} T^2$$
$$+ \sum_{i=1}^{4} \alpha_i \ln P_i + (1/2) \sum_{i=1}^{4} \sum_{j=1}^{4} \alpha_{ij} \ln P_i \ln P_j + \sum_{i=1}^{4} \alpha_{Qi} \ln Q \ln P_i$$
$$+ \sum_{i=1}^{4} \alpha_{Ti} \ln P_i T \qquad (3.3)$$

The underlying production structure in (3.3) is homothetic if $\alpha_{Qi} = 0$ for all i. It is linear homogeneous (constant returns to scale) if $\alpha_{QQ} = \alpha_{QT} = 0$ and $\alpha_Q = 1$. As pointed out earlier in this paper, if the production function is homothetic, factor proportions depend only on factor-price ratios (the slope of the isocost curve) and are independent of the level of output. In contrast, if the production function is nonhomothetic, pure scale changes (increases or decreases in the level of output) would alter relative marginal products and thus affect factor proportions and factor shares independent of factor prices. Consequently, the expansion path will not be a straight line, except for the Gorman polar forms.

Using Shephard's lemma, we derive the cost-minimizing quantity demanded for the i-th input. $\partial C/\partial P_i = X_i$ [Diewert (1971)]. For the translog this implies the following:

$$\frac{\partial \ln C}{\partial \ln P_i} = P_i X_i \;/\; C = S_i^*$$

or

$$S_i^* = \alpha_i + \sum_{j=1} \alpha_{ij} \ln P_j + \alpha_{Qi} \ln Q + \alpha_{Ti} T$$

$$i = K, L, E, M \qquad (3.4)$$

where

S_i^* is the cost share for the i-th input.

In order that the share equations in (3.4) satisfy adding up

($\sum_{i=1} S_i^* = 1$, since $C = \sum_{i=1} P_i X_i$) and the properties of a well-

behaved production function, the following parameter restrictions are required [see Christensen, Jorgenson and Lau (1970)]

$$\sum_{i=1} \alpha_i = 1, \quad \sum_{i=1} \alpha_{Qi} = \sum_{i=1} \alpha_{Ti} = \sum_j \alpha_{ij} = \sum_i \alpha_{ji} = 0 \qquad (3.5)$$

$i, j = K, L, E, M$ (adding up restrictions)

and

$$\frac{\partial^2 \ln C}{\partial \ln P_i \partial \ln P_j} = \alpha_{ij} = \alpha_{ji} \quad \text{for } i \neq j \tag{3.6}$$

$i, j = K, L, E, M$ (symmetry restrictions)

In addition we must test for two other conditions (monotonicity and concavity) because the translog function need not be well behaved for all input price combinations, increases in an input price must lead to an increase in total cost. Therefore, from (3.4) the predicted cost shares must be non negative at each data point (monotonicity or positivity). In addition, if the cost function is well behaved, it must be concave in input prices, which requires that the Hessian matrix be negative semidefinite (the characteristic roots must be non positive).[14]

The observed factor shares could deviate from their optimal (cost-minimizing) level in the presence of lags in responding to changes in output and factor prices. Thus, the observed share (S_i) will have a disturbance term:

$$S_i = S_i^* + e_i \tag{3.7}$$

and

$$\sum_{i=1} e_i = 0, \; i = K, L, E, M \tag{3.8}$$

Substituting equations (3.4) in to (3.7), we can write the stochastic share equations as follows:

$$S_i = \alpha_i + \sum_{j=1}^{4} \alpha_{ij} \ln P_j + \alpha_{Qi} \ln Q + \alpha_{Ti} T + e_i$$

$$i = j = K,\ L,\ E,\ M \qquad (3.9)$$

The parameters of the translog cost function in (3.3) for each industry are estimated using a two-step procedure. In the first step, using the iterative Zellner estimation procedure, coefficients of the four share equations in (3.9) are estimated, subject to the restrictions given in (3.6). In the second step, using the estimates derived from the first step the remaining parameters of the cost function in (3.3) are estimated. Since data on total costs by industry are not available, we have used the value of gross output as a proxy for total cost. This can be justified if we assume that the output price in each industry is a constant mark-up over unit cost. [See Fuss (1977).]

Using the estimated parameters of the translog cost function (3.3), we can derive estimates for the Allen-Uzawa partial elasticities of substitution (σ_{ij}) own- and cross-price elasticities of the demand, for each of the four factors of production (ε_{ij}), returns to scale (RTS), and the technical change (TP) parameter. For the translog cost function these measures are computed as follows [Berndt and Wood (1975) and Pindyck (1979)].

$$\sigma_{ij} = (\alpha_{ij}/S_i S_j) + 1 \quad i, j = K, L, E, M, \text{ for } i \neq j \qquad (3.10)$$

$$\sigma_{ii} = (\alpha_{ii} + S_i^2 - S_i)/S_i^2 \quad i = K, L, E, M, \text{ for all } i \qquad (3.11)$$

$$\varepsilon_{ii} = S_i\ \sigma_{ii} \qquad (3.12)$$

$$\varepsilon_{ij} = S_j \sigma_{ij} \qquad (3.13)$$

$$RTS = 1/\frac{\partial \ln C}{\partial \ln Q} = 1/(\alpha_Q + \alpha_{QQ}\ln Q + \alpha_{QT}T$$

$$+ \sum_{i=1} \alpha_{Qi}\ln P_i) \qquad (3.14)$$

$i = K, L, E, M$

$$TP = -\frac{\partial \ln C}{\partial T} = -(\alpha_T + \alpha_{QT}\ln Q + \sum_{i=1} \alpha_{Ti}\ln P_i + \alpha_{TT}T) \qquad (3.15)$$

$i = K, L, E, M$

where, coefficients with a are estimates.

Note that the returns to scale parameter (RTS) in (3.14) is not a constant but varies in response to changing output levels. Pure scale changes affect this parameter, both directly and indirectly. Indirect impacts come through the coefficients of output in the share equations (α_{Qi}) - nonhomotheticity. For a nonhomothetic cost structure, changes in output level affect factor proportions by altering relative marginal products independent of price changes. Such changes could be either "factor using" or "factor saving"; hence there are no a priori expectations concerning the signs of α_{Qi}, however, the restriction $\Sigma\ \alpha_{Qi} = 0$ always applies. If RTS is greater (less) than unity, there are increasing (decreasing) returns to scale. Constant returns to scale prevails, if RTS is equal to unity.

The rate of growth of technical change (TP) in (3.15) not only varies over time, but variations in output level and factor prices also influence (TP). Factor prices influence technical change through α_{Ti} -- biased technical progress. If $\alpha_{Ti} = 0$ for all i -- the coefficient of the trend is zero in all four factor share equations, technical change is neutral. Technical change could be classified as 'factor using' in the i-th input if $\alpha_{Ti} > 0$ and 'factor saving' if $\alpha_{Ti} < 0$.[15] For example, technical change is labour using, if an increase in the price of labour increases total cost and it is labour saving if an increase in the price of labour reduces total cost. Alternatively, technical change is labour using (biased toward labour), if changes in the index T result in an increase in the share of labour input in the value of output holding all input prices constant. The converse is true for 'labour saving' technical change. Similarly, biases in the growth of capital, energy and material inputs that give rise to changes in the shares of capital, energy and material inputs can arise from changes in the level of technology. Since the shares of all four inputs -- capital, labour, energy and materials -- sum to unity, technical change that 'uses' or 'saves' all four inputs is impossible. In fact, the sum of the bias associated with all inputs must be zero, since the changes in all four shares must sum to zero.

4. Empirical Results

We now summarize the empirical results for both manufacturing and non-manufacturing. Since data on energy consumption for the non-manufacturing industries are not readily available, for these industries the translog cost function is estimated using only three inputs -- capital, labour and intermediate inputs (energy and materials). The estimated parameters of the translog cost function for the manufacturing and non-manufacturing industries are recorded in Tables 3 and 4, respectively. These results are interesting for several reasons. First, despite the cross-equation restrictions, for most industries, more than 98 per cent of the variation in total cost is explained by the variation in relative factor prices and output levels. Second, for every industry the estimated cost function meets the monotonicity and concavity restrictions outlined in the previous section. Third, for almost all industries the assumption of homotheticity is not supported.[16] Finally, we reject the assumption of neutral technical change.

Manufacturing Industries

In manufacturing about 80 per cent of the energy use is concentrated in just seven industries. In an effort to check the robustness of the relationship between energy and the other factors of production, particularly capital, we not only estimated translog functions for the durable and the nondurable aggregates, but also estimated translog functions for each of the energy intensive industries in manufacturing (Table 9).

Inter-factor Substitution

(a) For each industry, the results support the nonhomotheticity assumption -- the coefficients associated with the output variable in the factor share equations are highly significant. In all the manufacturing industries, output growth is "labour saving" -- an increase in output reduces the share of labour in total costs (Table 3). In contrast output growth is 'capital using'. The results also imply that output growth is 'energy saving' for durable manufacturing and 'neutral' for nondurable manufacturing industries. Our results in general imply that the share of materials in total cost is invariant to changes in the level of output.[17]

(b) For all manufacturing industries, own price elasticities are negative and statistically significant (Table 5). With the exception of iron and steel, for each industry, the price elasticity of capital is well above unity and uniformly higher than the other input price elasticities. The results also suggest that the demand for labour, energy and materials is price inelastic.

(c) The estimates for the own-price elasticity of energy are in the upper range of the estimates reported in earlier studies [OECD (1982)]. Moreover, the increase in the magnitude of this elasticity in the post-1973 period is encouraging. It provides support for a certain degree of 'elasticity optimism'.[18]

(d) Although the cross-price elasticities are generally much smaller than the own-price elasticities, most of them are statistically significant (Table 5). This implies that the input mix in manufacturing is reponsive to changes in relative prices.

(e) In general our results indicate substitution among all four factors of production.[19] In particular, our results support substitutability between energy and capital in manufacturing industries.[20]

Returns to Scale and Technical Progress[21]

(a) In both durable and nondurable manufacturing the returns to scale parameter is slightly below unity for the sub-period 1967-73, implying slightly diminishing or constant returns to scale (Table 6).[22]

With the exception of food and beverages, the energy intensive manufacturing industries also reveal slightly diminishing or constant returns to scale.[23]

(b) For all manufacturing industries the assumption of neutral technical change is rejected.

(c) Technical change is 'capital saving' in each of the nine manufacturing industries (Table 7). As mentioned in Section 3, capital saving technical change reduces the share of capital in the value of total output, holding all input prices constant. In a translog cost function framework this implies that an increase in the relative price of capital will reduce the total cost of production (increases efficiency).[24]

(d) In general, technical change appears to be neutral with respect to labour in manufacturing industries.[25]

(e) As in Jorgenson (1980), our results in general suggest that in manufacturing technical change is 'energy using' -- an increase in the price of energy reduces TFP growth.[26] Similarly, technical progress is also the 'material using' type.[27]

(f) For each manufacturing industry, when compared to the period 1967-73, the estimated values of both returns to scale and technical change are smaller during the period 1974-79. This suggests that the observed slowdown in TFP in these industries is caused by declines in these two key factors. As shown in Section 3, in the translog cost function framework, variations in both RTS and TP are influenced by output levels and factor prices, which suggest that the post-1973 slowdown in TFP is associated with the slowdown in world aggregate demand and increases in the relative price of energy and raw materials.[28]

Non-manufacturing Industries

As seen from Table 4, with the exception of agriculture, and utilities, in all the non-manufacturing industries more than 99 per cent of the variation in total costs is explained by variation in output and relative factor prices. Like the manufacturing industries, the homotheticity assumption is also rejected for non-manufacturing. In five of the eight non-manufacturing industries, the assumption of neutral technical change is also rejected (the coefficient of the time trend in the share equations is statistically significant).

Inter-factor Substitution

(a) In each of the non-manufacturing industries, all three own-price elasticities are negative and statistically significant.[29] However, in most cases the estimated elasticities are less than unity.[30]

(b) The results in general suggest that capital and labour are good substitutes in non-manufacturing industries (Table 7).[31]

(c) In five out of eight non-manufacturing industries the results indicate significant substitution between labour and intermediate inputs. For the remaining industries, complementarity between labour and intermediate inputs is suggested.[32]

(d) Our results imply that capital and intermediate inputs are good substitutes.[33]

Returns to Scale and Technical Progress

(a) In general, slightly increasing returns to scale are indicated for the non-manufacturing industries (Table 6).[34]

(b) For three of the eight non-manufacturing industries, technical change is the 'capital using' type -- an increase in the price of capital relative to other input prices reduces TFP growth (Table 7).[35] In contrast, technical change is 'capital saving' for agriculture, forestry and trade [36]

(c) In agriculture, forestry, construction, and transportation and communications technical change is neutral with respect to labour. The results suggest 'labour using' technical change for finance, insurance and real estate, trade and utilities. In contrast, for the mining industry our results indicate labour 'saving' technical change.

(d) Technical change seems to be 'materials using' in agriculture, forestry and construction.[37] In contrast, for transportation and communications, finance, insurance and real estate, and utilities the results imply 'materials saving' technical progress.

(e) Like the manufacturing industries, the estimated value for returns to scale and technical change are also much smaller for the post-1973 period in all the non-manufacturing industries, suggesting that the recent slowdown in total factor productivity growth is primarily caused by the world wide slowdown in aggregate demand and increases in the relative price of capital and intermediate inputs.

5. Conclusions

What are the implications of these results for future improvements in TFP and output per man-hour in Canada? What are the policy implications of these results? Our analysis indicated about 15 per cent of the post-1973 slowdown in TFP is due to a migration of resources (labour, capital and natural resources) from the goods-producing industries to the service industries. This suggests that high rates of saving and capital accumulation *per se* will not necessarily lead to improvements in TFP, if capital and, of course, other resources continue to move to low productivity sectors. This could continue for the following reasons: (a) market distortions, (b) persistent slowdown in the aggregate demand growth and (c) changes in individual tastes.

If the movement of resources from high productivity to low productivity sectors and or lack of movement of resources from 'sunset' to 'sunrise' industries is caused by market distortions (eg., the tax system, regulation, subsidies, and various regional, trade and industrial policies) we should make efforts to remove such distortions. However, if the movements of resources to the service sector has been caused by a change in individual tastes and/or demographic shifts, it is less clear what can be done, if anything. Since the response of the goods producing sector to recessions (slowdown in aggregate demand) is much more severe than the response of the service sector, a persistent slowdown in aggregate demand could increase the share of the service sector in total resource use. Here monetary and fiscal policy can play a role in the short to medium run.

One of the more significant results is the suggestion of slightly diminishing or constant returns to scale in manufacturing. This contradicts the popular view and raises some major questions for future Canadian industrial policy. If there are no economies of scale to be captured, then we should be less concerned with the expansion of markets and more concerned with increasing domestic competition.

Our results in general indicate substitution among all four factors of production. If capital is a substitute for both energy and raw materials as our results indicate, the effect of increasing energy and raw material prices will be increased capital accumulation. This in turn will partly offset any reduction in output per man-hour via reduced TFP growth. Moreover, our results imply that the own-price elasticity of energy is an increasing function of the real (relative) price of energy. Thus, higher domestic energy prices perhaps at the limit of world prices would foster structural adjustment via increased price sensitivity.

The results suggest that the recent slowdown in TFP at the sectoral level is linked to the world-wide slowdown in aggregate demand (lower capacity utilization rates) and the substantial increase in the relative price of energy, raw materials and capital.[38] Moreover, for a majority of industries technical change is biased towards the use of capital, energy and raw materials -- an increase in the price of these inputs relative to labour costs will lead to lower TFP growth. These results in turn suggest that quick and easy-to-implement remedies which will improve output per man-hour and TFP at the sectoral level are not numerous. High on any list of priorities should be alternative ways (effective incomes policies and/or a social contract) to fight inflation which do not 'squeeze' aggregate demand. Important but less effective in the short run would be deregulation of prices (a slow process) and moving the price structure via taxation (eg., reducing the cost of capital) in such a way as to encourage capital formation.

In summary, the results suggests that the outlook for improvements in both output per man-hour and TFP at the aggregate level at best are not favourable unless trends in inflation and real aggregate demand growth are reversed. If this is not the case it implies a lean outlook for macro-economic performance -- the standard of living, international competitiveness, and unemployment -- in the years ahead.

Table 1

Anatomy of Aggregate Labour Productivity Growth for the Canadian Economy 1958-1980 (per cent per annum)

	1958-66	1967-73	1974-80
Improvements in Output per Man-hour	3.40	3.40	1.05
Contribution of Capital-labour Ratio	1.23	1.17	1.09
Aggregate Total Factor Productivity Growth	2.17	2.23	-0.03
Sectoral Total Factor Productivity Growth (weighted sum of sector TFP growth rates)	1.37	1.79	-0.10
Inter-industry Shifts of Productive Inputs	0.80	0.44	0.07

Table 2

Trends in Output and Productivity 1967-1980 (per cent per annum)

Industry	Output Growth		Output per Man-hour		TFP	
	1967-73	1974-80	1967-73	1974-80	1967-73	1974-80
Agriculture	1.14	2.56	4.65	3.04	-0.78	-1.96
Construction	3.05	1.08	2.80	-0.57	0.70	-0.82
Communication & Transport.	7.48	4.24	5.08	2.49	3.09	1.49
Finance, Insur. & Real Estate	7.37	5.05	3.33	0.05	-0.20	-1.23
Forestry	10.68	0.96	11.62	0.92	5.05	-0.19
Mfg.-Durables	6.44	1.57	4.91	0.64	1.23	0.17
Mfg.-Nondur.	5.05	2.49	4.33	1.04	0.88	0.14
Mining	7.97	0.40	8.55	-5.60	1.44	-3.48
Trade	5.94	3.82	4.39	0.90	2.55	0.75
Services	7.14	4.29	2.02	0.15	1.04	0.03
Utilities	9.56	4.82	6.66	2.73	1.14	0.73

Table 3

Coefficients of the Translog Cost Function:
Manufacturing Industries - 1957-1979

Coefficient (T-Ratio)	Industry			
	Mfg-Durables	Mfg-Nondurables	Wood	Iron & Steel
α_Q	1.2759 (29.27)	1.2110 (11.58)	1.7924 (13.37)	1.2912 (32.61)
α_{QT}	0.0060 (2.41)	0.0082 (2.46)	0.0100 (3.35)	0.0071 (2.57)
α_T	-0.0812 (3.14)	-0.1071 (3.01)	-0.1116 (4.86)	-0.0845 (3.83)
α_{LL}	0.1180 (7.90)	0.1190 (8.42)	0.1421 (7.28)	0.1970 (15.12)
α_{KK}	-0.0534 (3.48)	-0.0168 (0.53)	-0.1383 (3.17)	0.0287 (0.82)
α_{EE}	0.0072 (7.22)	0.0190 (10.47)	0.0084 (8.85)	0.0078 (0.37)
α_{MM}	0.0616 (3.89)	0.1294 (7.32)	0.0329 (1.24)	0.1275 (3.49)
α_{LK}	0.0003 (0.03)	0.0096 (0.61)	0.0055 (0.19)	-0.0374 (1.70)
α_{EK}	-0.0014 (1.10)	0.0034 (0.25)	0.0077 (2.41)	-0.0065 (0.53)
α_{MK}	0.0545 (4.96)	0.0038 (0.16)	0.1251 (3.81)	0.0152 (0.62)
α_{LE}	-0.0040 (1.76)	-0.0044 (1.33)	-0.0029 (0.94)	-0.0091 (1.14)
α_{LM}	-0.1143 (9.08)	-0.1204 (9.44)	-0.1448 (7.54)	-0.1505 (9.52)
α_{EM}	-0.0018 (0.66)	-0.0174 (4.48)	-0.0132 (4.11)	0.0078 (0.37)
α_{LQ}	-0.0958 (8.83)	-0.0678 (2.97)	-0.1107 (2.12)	-0.1312 (7.67)
α_{KQ}	0.0995 (5.72)	0.1380 (2.84)	0.1979 (1.80)	0.1370 (3.64)
α_{EQ}	-0.0124 (7.21)	0.0046 (0.69)	0.0067 (1.20)	-0.0133 (1.38)
α_{MQ}	0.0087 (0.64)	-0.0526 (1.24)	-0.0939 (1.45)	0.0075 (0.25)
α_{LT}	-0.0002 (0.30)	-0.0011 (1.01)	0.0011 (0.52)	0.0022 (2.49)
α_{KT}	-0.0046 (14.67)	-0.0081 (11.44)	-0.0059 (4.20)	-0.0101 (17.28)
α_{ET}	0.0007 (5.90)	-0.0001 (0.25)	0.0000 (0.10)	0.0017 (2.37)
α_{MT}	0.0041 (5.10)	0.0080 (4.31)	0.0048 (1.77)	0.0061 (3.74)
$\bar{R}^2$	1.000	0.998	0.994	0.997
SEE	0.009	0.011	0.025	0.015

Table 3 (Cont'd.)

Coefficients of the Translog Cost Function:
Manufacturing Industries - 1957-1979

Coef. (T-Ratio)	Industry				
	Nonferrous Metals	Nonmetallic Mineral Prod	Food and Beverages	Paper and Allied Prod	Chem & Chem Prod
α_Q	1.1400 (12.45)	1.3247 (24.56)	0.9747 (4.45)	0.9964 (6.32)	1.3258 (13.84)
α_{QT}	0.0170 (3.13)	0.0036 (1.50)	--	0.0104 (1.34)	0.0077 (2.21)
α_T	-0.1401 (3.41)	-0.0506 (2.78)	-0.0054 (0.70)	-0.0948 (1.50)	-0.0950 (3.36)
α_{LL}	0.1061 (4.22)	0.1528 (4.87)	0.0953 (10.13)	0.1395 (7.80)	0.0936 (10.30)
α_{KK}	-0.0007 (1.10)	-0.0513 (1.60)	-0.0065 (0.30)	-0.1352 (2.40)	-0.0699 (2.11)
α_{EE}	0.0059 (1.20)	0.0525 (27.20)	0.0070 (10.98)	0.0594 (13.02)	0.0288 (5.42)
α_{MM}	0.2171 (6.36)	0.1429 (7.22)	0.1025 (6.52)	0.1663 (5.20)	0.1601 (5.03)
α_{LK}	0.0286 (0.90)	0.0126 (0.45)	0.0037 (0.30)	0.0377 (1.88)	0.0425 (3.13)
α_{EK}	0.0045 (0.45)	0.6012 (0.20)	0.0007 (2.54)	0.0059 (0.56)	-0.0023 (0.20)
α_{MK}	-0.0325 (1.03)	0.0376 (2.41)	0.0021 (0.12)	0.0916 (1.75)	0.0297 (1.10)
α_{LE}	0.0198 (2.66)	-0.0193 (3.97)	-0.0011 (0.80)	0.0077 (1.30)	0.0136 (3.15)
α_{ML}	-0.1544 (6.34)	-0.1460 (8.01)	-0.0979 (11.70)	-0.1849 (10.14)	-0.1498 (15.30)
α_{EM}	-0.0302 (3.32)	-0.0344 (&.93)	-0.0066 (5.47)	-0.0730 (9.14)	-0.0401 (3.80)
α_{LQ}	-0.0843 (2.24)	-0.1044 (2.76)	-0.0801 (3.36)	-0.0946 (3.37)	-0.1351 (8.27)
α_{KQ}	0.0791 (1.60)	0.1137 (2.90)	0.1514 (1.90)	0.0352 (0.40)	0.1467 (2.98)
α_{EQ}	-0.0363 (3.10)	-0.0170 (3.03)	0.0035 (0.80)	-0.0018 (0.20)	-0.0487 (2.90)
α_{MQ}	0.0414 (0.90)	0.0078 (0.36)	-0.0749 (0.97)	0.0613 (1.00)	0.0371 (0.80)
α_{LT}	-0.0011 (0.72)	0.0008 (0.50)	0.0004 (0.50)	-0.0002 (0.20)	0.0022 (2.23)
α_{KT}	-0.0030 (3.70)	-0.0056 (11.10)	-0.0071 (8.23)	-0.0020 (1.45)	-0.0099 (26.73)
α_{ET}	0.0006 (1.10)	0.0014 (5.77)	-0.0002 (1.43)	0.0003 (0.70)	0.0029 (2.90)
α_{MT}	0.0035 (1.90)	0.0034 (3.53)	0.0069 (2.62)	0.0019 (0.74)	0.0048 (1.70)
$\bar{R}^2$	1.00	1.00	0.98	0.99	1.00
SEE	0.02	0.01	0.03	0.03	0.01

Table 4

Coefficients of the Translog Cost Function:
Non-manufacturing Industries - 1957-1979

Coef. (T-Ratio)	Agriculture	Forestry	Construction	Mining
α_Q	1.2129 (5.06)	0.7475 (10.12)	0.7042 (6.12)	0.1522 (0.83)
α_{QT}	--	0.0353 (12.83)	0.0162 (2.20)	0.0393 (4.20)
α_T	-0.0121 (1.68)	-0.2792 (14.11)	-0.1552 (2.22)	-0.2983 (3.72)
α_{LL}	0.0477 (3.49)	0.0910 (1.70)	0.1662 (6.80)	-0.0317 (1.94)
α_{KK}	0.0022 (0.04)	-0.0114 (0.23)	0.9212 (.)	0.0433 (1.20)
α_{MM}	-0.0345 (0.71)	0.1886 (8.90)	0.0463 (1.62)	0.1361 (3.83)
α_{LK}	-0.0422 (1.82)	0.0545 (1.16)	-0.1060 (.)	0.0623 (3.43)
α_{MK}	0.0400 (0.65)	-0.0431 (2.92)	0.0139 (.)	-0.1056 (3.26)
α_{ML}	-0.0055 (0.30)	-0.1455 (7.30)	-0.0602 (3.31)	-0.0305 (1.60)
α_{LQ}	-0.0819 (2.11)	-0.2584 (5.40)	0.0006 (0.01)	-0.0015 (0.03)
α_{KQ}	0.2047 (1.50)	-0.0179 (0.49)	-0.0204 (.)	-0.0795 (0.78)
α_{MQ}	-0.1228 (1.20)	0.2763 (5.38)	0.0199 (0.60)	0.0810 (1.15)
α_{LT}	0.0001 (0.10)	-0.0005 (0.15)	-0.0011 (0.80)	-0.0043 (2.00)
α_{KT}	-0.0030 (1.00)	-0.0030 (1.28)	-0.0005 (.)	0.0062 (1.73)
α_{MT}	0.0029 (1.00)	0.0035 (1.10)	0.0016 (1.33)	-0.0019 (0.55)
$\bar{R}^2$	0.842	0.993	0.992	0.990
SEE	0.059	0.028	0.017	0.043

Table 4 (Cont'd.)

Coefficients of the Translog Cost Function:
Non-manufacturing Industries - 1957-1979

Coef. (T-Ratio)	Industry: Transportation & Communication	Finance, Insurance and Real Estate	Trade	Utilities
α_Q	0.4399 (2.50)	0.6193 (3.49)	1.3563 (10.38)	0.2450 (0.66)
α_{QT}	--	0.0130 (3.77)	0.0096 (2.10)	0.0128 (2.21)
α_T	-0.0147 (1.40)	-0.1094 (4.15)	-0.1483 (3.43)	-0.0943 (1.53)
α_{LL}	0.0468 (1.10)	0.1482 (6.11)	0.1270 (5.76)	0.0740 (4.45)
α_{KK}	-0.0925 (1.65)	0.0389 (0.68)	-0.0875 (2.18)	-0.0154 (0.54)
α_{MM}	0.0701 (4.58)	0.2585 (7.03)	0.1384 (6.11)	0.2120 (11.88)
α_{LK}	0.0579 (1.10)	0.0357 (0.98)	0.0494 (1.86)	0.0768 (3.94)
α_{MK}	0.0346 (1.79)	-0.0746 (1.71)	0.0381 (1.27)	-0.0614 (3.00)
α_{ML}	-0.1047 (5.48)	-0.1839 (6.96)	-0.1765 (11.81)	-0.1508 (14.78)
α_{LQ}	-0.0621 (0.72)	-0.2939 (8.23)	-0.2892 (8.99)	-0.3744 (6.82)
α_{KQ}	-0.1149 (1.02)	-0.0279 (0.40)	0.119 (2.60)	-0.2757 (2.78)
α_{MQ}	0.1770 (5.54)	0.3218 (5.83)	0.1172 (2.54)	0.6502 (7.10)
α_{LT}	-0.0021 (0.40)	0.0131 (7.24)	0.0132 (7.61)	0.0204 (4.98)
α_{KT}	0.0077 (1.43)	-0.0003 (0.19)	-0.0136 (12.25)	0.0139 (1.73)
α_{MT}	-0.0056 (2.96)	-0.0128 (4.51)	0.0004 (0.18)	-0.0343 (5.03)
$\bar{R}^2$	0.994	0.995	0.990	0.841
SEE	0.022	0.026	0.017	0.059

Table 5

Own and Cross-price Elasticities: Manufacturing Industries

Elasticity	Industry					
	Manufacturing -durables		Manufacturing -nondurables		Iron and Steel	
	1971	1979	1971	1979	1971	1979
ε_{KK}	-1.44	-1.43	-1.03	-1.08	-0.63	-0.53
ε_{LL}	-0.27	-0.23	-0.28	-0.21	-0.05	0.02
ε_{EE}	-0.51	-0.60	0.10	-0.22	-0.74	-0.79
ε_{MM}	-0.26	-0.24	-0.15	-0.11	-0.22	-0.17
ε_{LK}	0.10	0.10	0.13	0.13	-0.00	-0.07
ε_{LE}	-0.00	-0.00	-0.00	-0.00	0.01	0.01
ε_{LM}	0.18	0.12	0.12	0.06	0.06	0.04
ε_{EK}	0.01	0.03	0.31*	0.23*	-0.08*	-0.06*
ε_{EM}	0.52	0.58	-0.39*	-0.01*	0.77	0.78
ε_{KM}	1.19	1.21	0.69	0.74	0.69	0.83

* Statistically insignificant

Table 5 (cont'd.)

Own and Cross-price Elasticities: Manufacturing Industries

Elasticity	Industry					
	Wood		Nonferrous Metals		Nonmetallic Minerals	
	1971	1979	1971	1979	1971	1979
ε_{KK}	-2.52	-1.83	-0.90	-0.92	-1.12	-1.14
ε_{LL}	-0.20	-0.15	-0.29	-0.25	-0.16	-0.13
ε_{EE}	-0.50	-0.56	-0.82	-0.82	0.12	-0.23
ε_{MM}	-0.32	-0.34	-0.02	-0.00	-0.21	-0.21
ε_{LK}	0.08	0.17	0.21	0.30	0.24	0.21
ε_{LE}	0.01	0.01	0.14	0.15	-0.02	-0.00
ε_{LM}	0.08	-0.02	-0.08	-0.15	-0.04	-0.08
ε_{EK}	0.53	0.53	0.21	0.20	0.20	0.18
ε_{EM}	- 0.13	-0.05*	-0.04	-0.03	-0.20	0.06
ε_{KM}	2.08	1.49	0.31	0.32	0.72	0.73

* Statistically insignificant

Table 5 (cont'd.)

Own and Cross-price Elasticities: Manufacturing Industries

Elasticity	Industry: Food and Beverages 1971	1979	Paper and Allied Prod. 1971	1979	Chemical and Chemical Prod. 1971	1979
ε_{KK}	-0.95	-0.99	-2.0	-1.90	-1.36	-1.41
ε_{LL}	-0.21	-0.16	-0.21	-0.19	-0.34	-0.25
ε_{EE}	-0.31	-0.40	0.16	-0.15	-0.15	-0.35
ε_{MM}	-0.13	-0.10	-0.14	-0.15	-0.12	-0.09
ε_{LK}	0.13	0.11	0.22	0.30	0.34	0.40
ε_{LE}	0.00	0.00	0.08	0.11	0.10	0.13
ε_{LM}	0.07	0.04	-0.13	-0.20	-0.12	-0.28
ε_{EK}	0.18	0.15	0.23	0.21	0.08*	0.08*
ε_{EM}	0.08	0.21	-0.81	-0.41	-0.51	-0.18*
ε_{KM}	0.75	0.79	1.34	1.25	0.83	0.89*

* Statistically insignificant

Table 6

Estimated Values for Returns to Scale and Technical Progress

Industry	Returns to Scale Parameter 1967-73	Returns to Scale Parameter 1974-79	Technical Progress (Average Annual per cent growth) 1967-73	Technical Progress (Average Annual per cent growth) 1974-79
Manufacturing Durables	0.93	0.91	1.90	1.86
Manufacturing Nondurables	0.98	0.94	1.08	0.81
Wood	0.67	0.66	2.34	1.98
Iron & Steel	1.01	0.98	1.21	0.84
Nonferrous Metals	0.88	0.81	0.71	0.53
Nonmetallic Minerals	0.94	0.94	1.44	1.28
Food & Bev.	1.58	1.64	-0.68	-0.77
Paper & Allied Products	1.05	0.99	0.52	0.32
Chemical & Chem. Prod.	0.98	0.96	1.42	1.03
Agriculture	1.03	1.06	0.74	0.74
Forestry	1.03	0.86	1.77	0.52
Construction	1.04	0.93	0.40	0.05
Mining	1.22	0.91	-2.24	-2.90
Transportation & Comm.	1.86	1.94	0.06	0.00
Fin., Insurance & Real Estate	2.34	2.24	-2.89	-3.74
Trade	1.07	1.03	2.37	1.96
Utilities	3.57	2.00	-1.70	-1.62

Table 6

Classification of Industries by Bias

Industry	Pattern of Bias in TP			
	Capital	Labour	Energy	Materials
Manufacturing Durables	Saving*	Saving	Using*	Using*
Manufacturing Nondurables	Saving*	Saving	Saving	Using*
Wood	Saving*	Using	Using	Using*
Iron and Steel	Saving*	Using*	Using*	Using*
Nonferrous Metals	Saving*	Saving	Using*	Using*
Nonmetallic Minerals	Saving*	Using	Using*	Using*
Food & Beverages	Saving*	Using	Saving**	Using*
Paper and Allied Product	Saving**	Saving	Using**	Using
Chemcial & Chem. Products	Saving*	Using*	Using*	Using**
Agriculture	Saving**	Using	--	Using**
Forestry	Saving**	Saving	--	Using**
Construction	Saving	Saving	--	Using**
Mining	Using*	Saving*	--	Saving
Transportation & Comm.	Using**	Saving	--	Saving*
Fin. & Insurance & Real Estate	Saving	Using*	--	Saving*
Trade	Saving*	Using*	--	Using
Utilities	Using**	Using*	--	Saving*

* Significant at 99% confidence level.
** Significant at 90% confidence level.

Table 7

Own and Cross-price Elasticities: Non-manufacturing Industries

Elasticity	Industry					
	Agriculture		Forestry		Construction	
	1971	1979	1971	1979	1971	1979
ε_{KK}	-0.51	-0.52	-1.13	-1.32	0.00	-0.10
ε_{LL}	-0.30	-0.36	-0.39	-0.39	-0.17	-0.15
ε_{MM}	-0.64	-0.64	-0.09	-0.04	-0.37	-0.35
ε_{LK}	-0.04	-0.00	0.22	0.25	-0.20	-0.22
ε_{LM}	0.37	0.38	0.17	0.16	0.37	0.38
ε_{KM}	0.52	0.52	-0.12	-0.62	0.68	0.69

Table 7 (Cont'd.)
Own and Cross-price Elasticities: Non-manufacturing Industries

Elasticity	Industry					
	Mining		Transportation & Communications		Finance, Insurance and Real Estate	
	1971	1979	1971	1979	1971	1979
ε_{KK}	-0.52	-0.52	-1.17	-1.14	-0.55	-0.55
ε_{LL}	-0.94	-1.04	-0.47	-0.49	-0.16	-0.20
ε_{MM}	-0.25	-0.24	-0.45	-0.44	0.04	0.06
ε_{LK}	0.59	0.81	0.40	0.48	0.47	0.49
ε_{LM}	0.28	0.29	0.10	0.10	-0.30	-0.26
ε_{KM}	0.14	0.19	0.50	0.51	0.19	0.16

Table 7 (Cont'd.)
Own and Cross-price Elasticities: Non-manufacturing Industries

Elasticity	Industry			
	Trade		Utilities	
	1971	1979	1971	1979
ε_{KK}	-1.19	-1.35	-0.57	-0.63
ε_{LL}	-0.26	-0.26	-0.46	-0.43
ε_{MM}	-0.25	-0.26	0.07	-0.07
ε_{LK}	0.31	0.31	0.75	0.76
ε_{LM}	-0.06	-0.01	-0.28	-0.35
ε_{KM}	0.49	0.60	0.13	0.24

DATA APPENDIX

The current and constant dollar gross output data for the manufacturing industries were obtained from the Industry Product Division, Statistics Canada. This data is for the period 1957-1979. The price of gross output is obtained by dividing the current dollar output by constant dollar output. The data on current and constant dollar intermediate inputs (materials + energy) for the manufacturing industries, for the period 1957-1979, is from the Industry Product Division of Statistics Canada. For all the manufacturing industries, data on current dollar energy consumption is taken directly from Statistics Canada Publication: General Review of the Manufacturing Industries of Canada, Catalogue No. 31-203. To obtain constant dollar estimates of consumption of energy, we require time series on energy prices by industry. Since this data is not readily available, we constructed energy price indices by making use of the data on gross output price of the following industries: coal mining, crude petroleum and natural gas, petroleum and coal products and utilities. First, we obtained the deliveries of these industries to each manufacturing industry from the 1971 input-output tables. This total is approximately equal to the energy and fuel consumption given by the census of manufacturing. This data is used to construct weights and these in turn are used to construct a weighted energy price index by industry:

$$P_{Eit} = \alpha_{cli}P_{clt} + \alpha_{cpi}P_{cpt} + \alpha_{pci}P_{pct} + \alpha_{ui}P_{ut} \quad i = 1,\ldots,22$$

where P_{Eit} is the price index of energy for i-th industry at time t. α_{cli}, α_{cpi}, α_{pci}, and α_{ui} are the shares of coal, crude petroleum, and natural gas, petroleum and coal products, and utilities used by the i-th industry, respectively, and P_{clt}, P_{cpt}, P_{pct} and P_{ut} are the gross output price indices of coal, crude petroleum and natural gas mining, petroleum and coal products and utilities, respectively. For the manufacturing industries, data on material inputs (current and constant dollars) is obtained by subtracting energy input from total intermediate inputs. In the case of manufacturing and mining data on average hourly earnings (price of labour) and total wagebill (labour income) is taken from the CANDIDE 2.0 databank. For a detailed description of primary data series for the individual manufacturing industries, see Rao [1979]. For the manufacturing and mining industries, data on the user cost of capital is taken from the CANDIDE 2.0 databank. For a detailed description of the construction of these data series, see CANDIDE 2.0 Model Description, Vol. 1, Section 28.

FOOTNOTES

1 Value added data will result in an overestimate of TFP growth in industries for which the share of intermediate inputs is large. For example Star (1974) has shown the relationship between the two procedures is as follows:

$\dot{A}/A \simeq \beta \, \dot{A}^*/A^*$ where $\dot{A}/A$ and $\dot{A}^*/A^*$ are estimates of TFP growth based on gross and net output (value added) respectively and β is the share of primary inputs (capital and labour) in gross output. This implies that the correct index ($\dot{A}/A$) is less than an index ($\dot{A}^*/A^*$) developed using value added as output.

For details, see Star (1974) and Rao (1979)

2 OECD Economic Outlook (1982).

3 See Rao (1978, 1979), Ostry and, Rao (1980), Economic Council of Canada (1980), C.D. Howe Research Institute (1980), Sims and Stanton (1980), Stuber (1981, 1982), Jarrett and Selody (1982).

4 The importance of shifts in factor inputs among sectors is obvious. For example, if both capital and labour move from low to high productivity sectors, total output increases even though the total quantity of inputs for the economy as a whole remains unchanged.

5 In the aggregate, the rate of growth of output per man-hour is equal to the rate of growth of total factor productivity plus a contribution from the capital-labour ratio. The contribution of capital is computed by multiplying the rate of growth of the capital-labour ratio by the share of capital in the total value of production in the economy [see Jorgenson (1980)].

6 After 1973 the capital-labour ratio increases by about 3.0 per cent per annum, compared to an annual growth rate of 3.11 per cent during the period 1967-73.

7 The share of man-hours in the goods producing sector declined from 37 per cent in 1973 to 33 per in 1980. These results on inter-industry shifts are in line with the findings of other researchers. [See Stuber (1982), Economic Council of Canada (1980), and Sharpe (1981)].

8 The price of labour includes gross pay (before deductions for personal taxes including unemployment insurance contributions, etc.), and supplementary labour income such as contributions to unemployment insurance, medical plans, and workmen's compensation. It also includes imputations for the value of room and board, compensation in kind, travel expense and employee-owned tools and equipment.

9 We are aware that the measured capital stock series might overestimate the effective input of capital services, especially after the first energy shock. During the post shock period increased energy prices might have rendered some existing capital either obsolete and/or reduced in quality. This in turn could result in an underestimate of improvements in TFP and bias downward the role of capital in the slowdown of output per man-hour.

10 In computing the aggregate TFP, we should also take into account the terms of trade effect, especially for an open economy like Canada. Since the terms of trade improvements also disappeared in the post-1973 period, part of the productivity slowdown attributed to the inter-industry shifts might actually accounted for any deterioration in the terms of trade effect.

11 We could also estimate the substitution elasticities, returns to scale and technical progress using a production function framework rather than a cost function framework. However, in this study we choose a cost function framework since it is more appropriate to take input prices as exogenous rather than input quantities.

12 For a detailed discussion on biased technical change and non-hometheticity, see Binswanger (1974), Jorgenson (1980) and OECD (1982).

13 Examples of translog function can be found in Berndt/Christenson (1973), Berndt and Wood (1975), Hudson/Jorgenson (1974), Fuss (1977), Fuss/Waverman (1975), Pyndyck (1979), Griffin/Gregory (1976), and Humphrey/Morney (1975).

14 For details see, Conrad/Jorgenson (1977).

15 For a thorough discussion of biased technical change, see Binswanger (1974) and Jorgenson (1980).

16 This result is in line with the findings of earlier reseachers [Pindyck (1979), Fuss (1977) and Rao (1981)].

17 This result contrasts with the findings of Rao (1981). However, this apparent conflicting evidence could be due to differences in the specification employed -- in Rao (1981), neutral technical change was assumed.

18 Our results imply that the own-price elasticity of energy is a positive function of the level of real (relative) energy prices [see Mittelstadt and Hall (1981)].

19 Our aggregate results suggest that in manufacturing labour and energy are complements. However, the size of the cross-price elasticity for both durable and nondurable manufacturing is close to zero. Moreover, in six of the seven energy intensive industries, the substitution elasticity between labour and energy is positive and significant, implying substitution between energy and labour. Therefore, the evidence is somewhat inconclusive.

20 While this result is in contrast to the earlier time-series evidence of strong complementarity [Berndt and Wood (1975) and Hudson and Jorgenson (1974)], it supports more recent evidence for both Canada and other industrial countries, implying energy and capital are substitutes [OECD (1982)].

21 As outlined in Section 3, (Equation 3.14 and 3.15), using the estimated parameters of the translog cost function, we are able to compute both returns to scale and technical change parameters for each manufacturing industry for the sub-periods 1967-73 and 1974-79.

22 These results are in line with the earlier findings of Rao (1979). However, the finding of slightly diminishing or constant returns to scale is contrary to the popular view that increasing returns to scale exist in the manufacturing sector. These results do not suggest that there are vast untapped gains to be made from product specialization [Daly (1980)].

23 In the food and beverages industry the returns to scale parameter is 1.6, implying increasing returns to scale. However, the estimated technical change parameter is negative, which in turn suggests that our estimation procedure might have assigned some or all of the improvements in technical change to the returns to scale parameter, resulting in an upward biased estimate for RTS and a downward biased estimate for the technical change parameter.

24 This result is in contrast to the findings of Jorgenson (1980) -- for most industries Jorgenson found 'capital using' technical change. However, aside from differences in country data this discrepancy could be due to to Jorgenson's assumption of homotheticity.

25 Only for iron and steel do the results imply biased technical change which respect to labour -- 'labour using' type.

26 For food and beverags the coefficient associated with the time trend in the energy share equation is negative and significant, implying 'energy saving' technical change.

27 For U.S. manufacturing, Jorgenson found 'material saving' technical change. This apparent discepancy between Canadian and U.S. results could again be attributable to the differences in model specification -- homotheticity vs non-homotheticity.

28 As the world wide adoption of restrictive aggregate demand policies was in direct response to the increase in inflation rates induced by adverse supply shocks (increases in energy and other raw material prices), the slowdown in world aggregate demand is indirectly the result of the energy crisis and its aftermath.

29 As mentioned before, due to the lack of data on separate energy inputs for these industries, the translog cost function is estimated with only three inputs: capital, labour and intermediate inputs (energy + materials).

30 In contrast to the manufacturing industries, the capital price elasticity is not consistently bigger than the other two input price elasticities. However, in most of the non-manufacturing industries the capital price elasticity has an increasing trend.

31 In agriculture and construction, the cross-price elasticity between labour and capital is negative and significant, implying complementarity. However, in agriculture the size of the elasticity is very close to zero.

32 In finance, insurance and real estate, trade and utilities the cross-price elasticity is negative and significant.

33 For forestry the estimated cross-price elasticity indicates complementarity.

34 In mining, transportation and communication, finance, insurance and real estate, and utilities the returns to scale parameter is well above unity, implying a substantial decrease in unit costs in response to an increase in the size of operations. However, for these industries, the estimated technical change parameter is well below the measured increases in total factor productivity and in some cases negative (Tables 4 and 15), which suggests that our estimation procedure might have assigned all of the improvements in technical change to returns to scale, thereby resulting in upward biased estimates of RTS.

35 Mining, transportation and communication and utilities.

36 In the remaining two industries -- construction and finance, insurance and real estate, technical progress is neutral with respect to capital input.

37 Here materials refer to intermediate inputs (energy + other materials).

38 Bruno's study (1982), using international data comes to similar conclusions. According to Bruno, high raw material prices explain about 60 per cent of the world productivity slowdown in manufacturing, and the resulting 'demand squeeze' explains the remaining 40 per cent.

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