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PRODUCTIVITY AND TECHNICAL CHANGE IN CANADIAN FOOD AND BEVERAGE INDUSTRIES: 1961-1982

(Working Paper 2/87)

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SUMMARY

An industry's economic performance is the outcome of general market conditions interacting with technological and organizational factors specific to its constituent firms. Productivity growth is a prime determinant of vitality and commercial competitiveness of industries, both domestically and in international markets.

This study concerns the analysis and measurement of productivity performance of the 17 constituent industries of the Canadian food and beverage sector and the sector as a whole. The results are useful in assessing current and future cost competitiveness of industries in domestic and international markets and evaluating the need for, or the success of, policies aimed at improving performance. To investigate the impact of technical and organizational change on their performance, we have measured each industry's labour productivity and total factor productivity growth (technical progress) over the period 1961-1982. We have estimated the trend of total factor productivity (TFP) growth for each industry and statistically tested whether and to what extent it has been declining (or increasing). Labour productivity growth, which results from the interaction of all factor inputs as well as technical progress, is broken down into the contributions of its ultimate sources. For greater clarity in identifying growth changes, the above analysis is presented for four sub-periods as well as the study period.

The theoretical and empirical methods adopted in this study are explained in Sections 2 and 3. Briefly, we take each industry's production process

to be represented by a generalized Cobb-Douglas function with gross output determined by four factors of production (capital, labour, energy and material inputs) and the extent of plant and equipment utilization. The estimated functions allow for both non-constant returns-to-scale and non-neutral (biased) technical progress. A constrained estimation procedure is used to estimate parameters of returns-to-scale, neutral or biased technical progress, and the effects of plant and equipment utilization on labour productivity. Technical progress is computed as the partial elasticity of gross output with respect to time using the estimated parameters. Before being used for computation, the null hypothesis was tested for parameters determining technical progress as well as returns-to-scale.

All quantitative information on industries' inputs and outputs were obtained from Statistics Canada while series on plant and equipment utilization are those of the Bank of Canada. Price and quantity data on industries' factor inputs were aggregated using the Fisher Ideal index formulation. These procedures and data sources are explained in the Appendices.

Table 1 provides a summary of productivity gains estimated for the study period as well as the most recent six years together with a ranking of industries according to their performance in each period. By far the best performing industries in terms of techincal progress (or total factor productivity growth) were the Breweries and Fruit and Vegetable Processors. Although they both displayed sharply declining TFP gains, their average annual growth rate surpassed all other industries both in the last six years and over the whole study period. In terms of labour productivity, however, both industries showed relatively low growth rates and ranked at or below the median growth rate.

Over the study period, the Fish Products industry had the lowest average annual TFP gains as well as the lowest labour productivity growth. Over tha last six years (1977-82), however, Vegetable Oil Mills showed the lowest productivity growth rate.

The Food and Beverage Sector taken as one industry experienced declining productivity gains over the study period. On average, its total factor productivity gains were approximately 0.36% per year though over the last six years it only gained about 0.16% per year. The sectors' labour productivity index grew at an average annual rate of 3.3%, about 11% of which was due to technical progress. By far the most significant source of labour productivity gains was found to be the materials-labour ratio. Changes in this ratio accounted for about 77% of changes in labour productivity.

Table 2 presents industry returns-to-scale parameters estimated over the 1961-82 period and the industries' technical progress bias wherever present. Three industries -- Biscuit Manufacturers, Distilleries and Wineries -- were found to have constant returns-to-scale while Vegetable Oil Mills displayed mildly increasing returns. All other industries were found to operate under decreasing returns-to-scale. A direct implication of these findings is that, with the possible exception of Vegetable Oil Mills, expanding industry production through expanding the market size or some other means will not result in lower average industry costs or prices. For most industries, expansion results in increasing unit costs and, unless compensated by gains through technical progress, leads to higher average prices.

TABLE 1

INDUSTRY PRODUCTIVITY CHANGES

(percent per year)

S.I.C.	INDUSTRY	T.F.P. GROWTH 1962-82	RANK	T.F.P. GROWTH 1977-82	RANK	L.P. GROWTH 1962-82	RANK	L.P. GROWTH 1977-82	RANK
1011	SLAUGHTERING & MEAT	0.46	5	0.28	5	3.39	7	2.25	7
1012	POULTRY	-0.24	16	-0.13	12	2.68	10	3.26	5
1020	FISH	-0.27	17	-0.21	14	1.06	17	3.02	6
1030	FRUIT & VEGETABLE	1.02	2	0.43	2	2.79	9	1.57	11
1040	DAIRY PRODUCTS	0.08	12	-0.09	11	3.40	6	2.07	8
1050	FLOUR & B. CEREAL	-0.01	13	-0.18	13	1.55	16	0.59	14
1060	FEED	0.29	9	-0.30	15	4.55	2	3.92	3
1071	BISCUIT MFR'S	0.30	7	0.15	8	2.40	13	-0.72	16
1072	BAKERIES	0.21	11	0.05	9	1.81	14	-0.99	17
1081	CONFECTIONERY MFR'S	0.30	8	0.15	7	2.51	12	0.66	13
1082	CANE & BEET SUGAR	0.38	6	0.36	4	3.41	5	3.66	4
1083	VEGETABLE OIL MILLS	-0.12	14	-0.81	17	3.18	8	1.50	12
1089	MISCELLANEOUS FOOD	0.24	10	0.41	3	1.79	15	1.94	9
1091	SOFT DRINK MRF'S	-0.23	15	-0.34	16	5.07	1	4.26	2
1092	DISTILLERIES	0.87	3	0.01	10	4.29	3	-0.18	15
1093	BREWERIES	1.12	1	0.51	1	2.67	11	1.59	10
1094	WINERIES	0.82	4	0.21	6	3.95	4	5.34	1
FOOD AND BEVERAGE SECTOR		0.36		0.15		3.28		2.20	

TABLE 2

INDUSTRY	ESTIMATED RETURNS-TO-SCALE*	MEASURED TECHNICAL PROGRESS BIAS**	
SLAUGHTERING & MEAT	0.91	Materials-using	
POULTRY	0.90		
FISH	0.90	Materials-using	
FRUIT & VEGETABLE	0.86	Capital-using	Materials-saving
DAIRY PRODUCTS	0.93	Materials-using	
FLOUR & B. CEREAL	0.92	Capital-using	
FEED	0.94		
BISCUIT MFR'S	1.00	Capital-using	Energy-using
		Materials-saving	
BAKERIES	0.74		
CONFECTIONERY MFR'S	0.83	Capital-using	Materials-saving
CANE & BEET SUGAR	0.77	Capital-saving	Energy-saving
		Materials-using	
VEGETABLE OIL MILLS	1.05		
MISCELLANEOUS FOOD	0.88		
SOFT DRINK MRF'S	0.73	Materials-using	
DISTILLERIES	1.00	Capital-saving (61-76)	
		Materials-using & Capital-using (77-82)	
BREWERIES	0.86		
WINERIES	1.00		
FOOD AND BEVERAGE SECTOR	0.86		

* This parameter indicates the percentage increase in gross industry production which results from a one percent increase in the use of all factors of production, e.g., increasing all inputs by 10% in the Dairy Products industry will increase production by only 9.3%, all else the same.

** Materials-using (-saving) technical progress indicates that the percentage change in industry output resulting from a change in the amount of materials and supplies used, other things equal, increased (decreased) over time making this factor more (less) important for industry productivity.

INTRODUCTION

The productive efficiency of Canadian food processing and beverage industries is an important determinant of their ability to compete with foreign firms in domestic and export markets. Knowledge of productivity growth rates and an understanding of the factors affecting them are powerful instruments in assessing the vitality and competitive position of Canadian industries. Such information is clearly useful in negotiations for freer trade, both with the U.S. and multilaterally. They may also be useful in identifying the need for changes in policy in areas such as research and development, investment and agricultural supply.

More generally, knowledge of productivity change is of interest because of its importance to growth in real per capita incomes and in understanding an apparent slowdown in productivity growth throughout the economy.

Productivity research focuses on the supply or production side of the market to measure and analyze technical and ogranizational performance of economic units. Specifically, a total factor productivity (TFP) index can be constructed to express the relationship between the volume of products and services produced and all associated purchased inputs in real, physical terms. An increase in TFP from one period to the next indicates enhanced efficiency of the economic unit in transforming all inputs into its outputs of products and services. TFP growth measures increases in output which are not accounted for by increases in the aggregate of all inputs but are due to greater technical or organizational efficiency, what is termed technical progress. Since an increase in TFP indicates that a given aggregate output is produced with less of some or all factor inputs, it implies a diminution in the unit cost of output for given levels of production and unit prices of factor inputs.

To obtain estimates of total factor productivity growth (technical progress) for each industry, we estimate parameters of industry production functions allowing for non-constant returns-to-scale and non-neutral (biased) technical progress. These estimated parameters allow us to measure TFP growth for each industry and, more importantly, to test the hypothesis that TFP growth has declined (or increased) over the study period and to measure the extent of this change.

A second productivity measure presented and analyzed is labour productivity (LP) or the index of output produced per "unit" of labour input. To measure combined labour input, the Fisher Ideal index formulation is used to aggregate the hours worked by production workers and the number of administrative employees employed per year. The ultimate sources of labour productivity change are measured in terms of the contributions of technical progress (estimated in this study), capital, energy (fuel and electricity), intermediate materials and services, returns-to-scale and the rate of utilization of plant and equipment capacity.

To obtain greater focus on changes in TFP growth and LP growth, the studys' results are presented for 4 sub-periods as well as for the whole study period. Our estimates of factor-saving and factor-using technical progress, where applicable, present measures of the disproportionality of the contributions of various inputs to total factor productivity growth.

2 METHODOLOGY

In this section we discuss the theoretical underpinnings of the methods of productivity measurement followed in this study and present the model and the estimation procedure used to obtain the reported results.

2.1 General

This study is concerned with two measures: labour productivity and total factor productivity. Labour productivity (LP) over a given unit of time is defined in this study (and elsewhere) as output produced per unit of labour input (however measured). Total factor productivity, by contrast, is the ratio of output to an optimally chosen combination of all productive factors employed in production. As such, it is a measure of productivity of the collectivity of inputs used.

The fundamental importance of labour productivity as a measure of economic performance is its implication for per capita real incomes. A higher level of output for the amount of labour used indicates that a greater volume of production is made available for consumption or investment purposes. Labour productivity is thus a measure of gains in productive efficiency. It is, however, an imperfect and at times misleading indicator (see Daly and Rao 1985, p. 207).

For any production process, the volume of output depends not only on labour effort and quality but also on other productive factors such as capital, energy, intermediate materials, managerial talent as well as the regulatory environment, the scale of production, general economic conditions and the state of technology. Increased labour productivity, then, may originate from efficient substitutions between productive factors rather than any gains in efficiency. If relative price changes induce a substitution away from labour and toward energy and intermediate materials, output per unit of labour may rise while costs also rise. In situations such as these, labour productivity shows an improvement when there have been no gains in productive efficiency. Similarly, we may note a fall in labour productivity during short-term cyclical declines in demand. Since enterprises respond to the fixed (e.g. training) as well as the variable costs of labour employment, they often find it efficient not to lay off and rehire labour during stages of the business cycle. With lower demand and output but unchanged flow of labour services, labour productivity shows a decline though productive efficiency may not have decreased. It is therefore crucial to go beyond mere measurement and identify the sources of labour productivity changes.

Our analysis attempts to identify these sources of labour productivity change and measure their individual contributions. This requires that we measure, among other things, changes over time of the technical efficiency of the production process, what is termed technical progress. Apart from technical improvements embodied in material inputs, perhaps the most empirically significant source of gains in labour productivity is technical progress or increased total factor productivity. Changes in output relative to <u>total</u> factor input, i.e. changes in total factor productivity (TFP), indicate only those changes in output which have resulted from shifts in the production function. In arriving at estimates of TFP we employ data to separate those changes which represent movements along the production hyper-surface from shifts of the hyper-surface itself. By making this separation, movements of TFP represent changes which are neither the result of changes in optimal factor ratios nor increases in the quantities of all factors together.

The ultimate source of productivity change is not a subject of controversy. Certainly, productivity improvements (LP or TFP) experienced since the turn of the century and the accompanying per capita real income gains have their origin in evolution of our technology or state of knowledge. Total factor productivity growth is, for this reason, often termed technical progress. Improvements in our state of knowledge effect productivity changes by improving the productive potentials of agents of production, e.g., through greater and more specialized human capital, more effective and/or less costly machinery and equipment, etc. Each agent, depending on its own productive improvement, contributes differently toward the gains in output which we term productivity. In most empirical work, however, it is not feasible to measure quantities of factor inputs so as to fully account for such enhancements. Since most such attributes of inputs are not objectively measurable, data is most often collected on physical or observable quantities. Labour services, for instance, are of necessity measured in hours, days or the number of employees regardless of the quality of work produced, effort exerted or skills used. But if we measured all productive agents in some efficiency units which account fully for productive attributes TFP would vanish. To state the point obversely, TFP measures the collectivity of improvements in efficiency of all productive agents, including those which can neither be objectively measured nor directly observed.

Technical progress is classified as neutral or biased. Specifically, Hicks-neutral technical progress occurs when improvements in all factors' productivities are equiproportional. When the technology of production is such that technical progress is Hicks-neutral, neither the proportions in which factors are used nor their relative returns change overtime, other things equal. When neutrality does not hold, differing factor productivity improvements among factors lead to intertemporal changes in factor proportions, since with unchanged factor prices less of the more productive factor(s) will be needed relative to other factors. The possibilities of non-neutral or factor-saving(-using) technical change must then be explored in our productivity measurement.

An additional consideration in productivity measurement is economies (or diseconomies) of scale at the industry level. When increasing returns-to-scale prevails, an increase in industry output from one period to the next is technically attainable with less than a proportional increase in the quantity of technical factors (with the same mix). If, with no change in technical efficiency, production on a larger scale allows better organization or utilization of resources such that inputs need not be increased by the same proportion, the gains should not be attributed to increased productive efficiency. Our labour productivity measure - output per unit of labour - will clearly include gains in output from this source and we need to measure its contribution. In measuring TFP gains, scale economy gains (or losses) must be identified and isolated to obtain a measure of efficiency improvement separate from gains (losses) to the industry from operating on a larger (smaller) scale.

In the next section, we will deal with all of the above considerations in detail and propose a methodology and an econometric model specification to appropriately treat them in our measurement of labour and total factor productivity.

2.2 Model Specification

The measurement of TFP and its rate of growth can be accomplished in a number of ways. All, however, have peculiar merits and shortcomings making them appropriate to particular sets of conditions. These conditions include the structure of available data series, the level of aggregation (firm, industry, etc.), the aggregation procedures necessary or possible, our knowledge of industry environment and history, the nature of the results desired and many others. It is a crucial part of the researchers' function to construct and specify a model which optimizes the quantity and quality of results subject to the above constraints and the costs of the procedures necessary. We shall, with this in mind, outline the major theoretical and empirical issues related to our choice of data aggregation and model specification. This may clarify the precise nature of the measures and estimates obtained and, as in any social scientific endeavor, qualify the results for evaluation and interpretation.

Beginning with labour productivity, it is simply the ratio of "output" to "labour input",

$$LP_i = Q_i/L_i \qquad i = 1, \ldots 18 \qquad (2.2.1)$$

with i referring to the individual industry or sector and Q and L referring to quantities of output and labour input. This equation is not necessarily derived from any other more fundamental relation. We are interested in LP because its growth rate is a prime determinant of real per capita income growth. For the industries studied, this is an indicator of their contribution to economy-wide improvements in living standards. Growth rates are defined by

$$\dot{LP}_i = 1/LP_i \,.\, dLP_i/dt$$
$$\dot{Q}_i = 1/Q_i \,.\, dQ_i/dt$$
$$\dot{L}_i = 1/L_i \,.\, dL_i/dt \,. \qquad (2.2.2)$$

Taking natural logarithms of (2.2.1) and differentiating with respect to time gives our labour productivity growth relation

$$\dot{LP}_i = \dot{Q}_i - \dot{L}_i \qquad i = 1, \ldots 18 \qquad (2.2.3)$$

The outputs of our industries, however, are not composed of a single, homogeneous good and neither are labour inputs. Our output data are constant 1971 dollar values of gross output and current dollar values of gross output. To construct a proxy for output quantity from these series, we have constructed an output index as the ratio of the constant dollar series to a base year. To see that this gives us a <u>quantity</u> index (rather than a value-of-output index) we may note that the ratio of the dollar values of any two baskets of goods is identical to the ratio of the aggregates of the goods involved when the prices used to obtain dollar values are the same. The aggregate quantities are, in this case, price weighted sums of the individual products comprising the industry's output. When price indices are used to deflate current dollar output value series, such as in our data, the remaining changes are only due to quantities and measurement error.

Our series on labour input must also be transformed to produce a proxy for aggregate labour L. The series on labour input are for person-hours worked by production workers, the number of salaried employees employed each year and two series on compensation paid to each category of labour in current dollars. A traditional method of obtaining an aggregate labour series from two or more input series is to simply sum them if the series are expressed in the same units (e.g., hours per year). When units differ, quantities of different types of labour may be aggregated by measuring one type in terms of another. Assuming a competitive labour market, wage rates equal marginal productivities and these can be used to convert quantities of one labour type into another to obtain the sum of the two types. It can be shown, however, that these methods of aggregation reflect (assume) an underlying production technology for which the two types of labour are perfect substitutes and the function is additively separable. Such restrictive conditions are rarely, if ever, realized as casual observation shows: Labour services of production workers and those of administrative employees are not perfect substitutes in the production process. We have arrived at a fundamental problem of empirical work, namely producing aggregates of some set of components such that they are not subject to exceedingly restrictive assumptions and obey certain optimality conditions. Robert Solow (1955-6, p. 103) brought out this point most succinctly. Assuming that we wish to aggregate two types of capital, C_1 and C_2, into K using an aggregator or index function ϕ before entering them into the production function F, he points out that:

> "It could be that the process of production described by F should have two stages such that <u>first</u> something called K is literally manufactured out of C_1 and C_2 alone, and <u>then</u> this substance K is combined with labour to manufacture the final output Q. In this case the index function ϕ is actually a production function itself" (original italics).

Labour input components - hours worked by production workers and number of non-production employees - must be aggregated to form a measure of composite labour services used in production. To do this, we can assume a particular functional form for the aggregator function (e.g., Cobb-Douglas) and obtain the aggregate using appropriate marginal conditions (cost minimization). Without prior knowledge of the underlying technology, however, our choice is quite arbitrary.

To perform this operation more simply, we can employ an index number (Fisher, 1922). An index number Q taken for any two periods t_0, t_1, represents the relative change in that period of the magnitude of the aggregate we are interested in measuring. Let $f(L_1, L_2)$ be the aggregator function for the two types of labour discussed above. Using an index, we have for the two periods

$$Q = f_1(L_1, L_2)/f_0(L_1, L_2). \qquad (2.2.4)$$

If we assume our aggregator function f(.) is a linear homogeneous Cobb-Douglas, for instance, we can employ the Vartia index formulation which corresponds to it (see Diewert, 1978) and provides a discrete approximation to the continuous Divisia index. Research in functional forms and the theory of index numbers (see, for instance, Diewert 1976, 1977, 1978 and Caves, Christensen and Diewert, 1982) has developed rigourously the properties of various index numbers, including their optimality properties and the underlying technology of the aggregator function to which they each correspond (for which they are "exact"). Should we employ a Laspeyres index for our aggregation, we would be proceeding on the assumption that the aggregator function is linear with perfect substitutability among inputs. Among index number formulations, Diewert (1976, 1977) indentifies "superlative" indices as those which are exact for (correspond to) aggregator functions with flexible functional forms. A flexible functional form for the aggregator function f implies that this function can approximate to the second order an abritrary twice differentiable homogeneous aggregator function. Employing such index numbers, we will be placing the least restrictive set of conditions (first degree homogeneity and cost minimization) on the production technology of the industries under study. The Tornqvist (1936) index and the Fisher (1922) ideal index are both superlative indices; the Tornqvist index is exact for a homogeneous translog function and the Fisher index is exact for a quadratic aggregator function and both are "flexible" in the above sense. Since the Tornqvist index has a logarithmic form and the logarithm of zero is not defined, a Tornqvist quantity index is not well defined when the quantities of some inputs are zero - a condition present in our input data series (Diewert, 1977 p.21, 106-108). This restriction and advantages of the Fisher ideal index (Diewert, 1976 pp. 136-8) led us to use the latter index in aggregating our range of input components into categories of capital, labour, energy and material inputs. The derivations of Fisher price and quantity indices (and details of data tranformations) appear in Appendices.

As pointed out at the beginning of Appendix 2, we are primarily interested in discovering and measuring the effects of various groups of productive inputs on output and productivity; in particular capital, labour, energy and mareria1 inputs. Such aggregation, however, is only permissible under certain assumptions about the overall production technology of the industries studied (Solow, 1956). Only when the aggregate production technology is separable, as in the Cobb-Douglas form, will the aggregation procedure result in no loss of information contained in our set of input data. In brief, the separability requirement is satisfied when the marginal rates of substitution between the set of inputs to be aggregated are independent of the quantities used of other inputs (Berndt and Christensen, 1973). Alternatively, aggregation is appropriate when the elasticities of substitution between each of the components to be aggregated and other inputs are equal. We have no prior information on the substitutability of factor inputs in the industries being studied. Most econometric studies of the productivity of industries in the manufacturing sector assume this condition to approximately hold (see, inter alia, Rao 1979, 1978; Zohar, 1982; Rao and Ostry, 1980; Brown and Medoff, 1978). There is strong evidence, however, that the necessary conditions do hold. Berndt and Christensen (1973) reached this conclusion for capital using a translog production function for the U.S. manufacturing industry. Later, Berndt and Christensen (1974) tested the separability conditions for labour in the same industry. They found that placing separability restrictions on productive technology produced very high correlations between the actual and predicted factor shares (0.9999 for linear and 0.9994 for non-linear constraints (pp. 399-400)). These measures suggest the absence of information loss due to aggregation.

Having discussed aggregation and indexing of data into output, capital, labour, energy and material inputs categories (Q,K,L,E and M respectively), we can proceed to obtain our next productivity measure, TFP or technical progress. We assume that for each industry there exists an aggregate homogeneous production function and that, for the moment, technical change is Hicks neutral:

$$Q_{it} = a_i\,(t)\;.\;Q_i\,(K_{it},\;L_{it},\;E_{it},\;M_{it})\;. \tag{2.2.5}$$

Here a_i is ith industrys' efficiency parameter and is a function of time. More specifically, we employ a Cobb-Douglas form for the production function and an exponential form for the efficiency parameter:

$$Q = A\;.\;e^{\lambda t}.\;\;K^{\alpha}.\;\;E^{\beta}.\;\;M^{\gamma}.\;\;L^{\delta}. \tag{2.2.6}$$

where time and industry subscripts have been omitted. Since the function is homogeneous, its degree of homogeneity can be found by multiplying all inputs by (1/L) and observing the proportional change in output

$$Q(1/L)^{\rho} = A.\ e^{\lambda t}\ .\ (K/L)^{\alpha}.\ (E/L)^{\beta}\ .\ (M/L)^{\gamma}.\ (i)^{\delta} \qquad (2.2.7)$$

where ρ is the degree of homogeneity of the production function. To obtain output-per-labour input as a function of K, E and M, we divide both sides by L and move $(1/L)^{\rho}$ to the right-hand-side

$$q = A.\ e^{\lambda t}.\ k^{\alpha}.\ e^{\beta}.\ m^{\gamma}.\ L^{\rho-1} \qquad (2.2.8)$$

expressing the ratios of output, capital, energy and material inputs to labour by lower case letters. To see that the exponent of L is our returns-to-scale parameter, we find that under constant returns-to-scale or first degree homogeneity

$$\alpha + \beta + \gamma + \delta = \rho = 1 \qquad (2.2.9)$$

holds for exponents of the original function (2.2.6). Hence under constant, increasing and decreasing returns-to-scale respectively, the exponent of L will take the following values:

$$\phi = \rho - 1 = 0 \qquad \text{(constant)}$$
$$\phi = \rho - 1 > 0 \qquad \text{(increasing)}$$
$$\phi = \rho - 1 < 0 \qquad \text{(decreasing)} \qquad (2.2.10)$$

As ϕ will be estimated along with other parameters, we can interpret a ϕ which is statistically not significantly different from zero to indicate constant returns and, significant positive and negative ϕ as increasing and decreasing returns respectively where ϕ is the returns-to-scale parameter (for an equivalent derivation of ϕ see Brown and Medoff, 1978).

A number of studies have reported that returns-to-scale are not constant for the food and beverage sector as a whole. For instance, Zohar (1982) estimated a returns-to-scale parameter of 1.5429 using a C.E.S. production function and 0.5605 using a translog function. Rao (1979) used a Cobb-Douglas form and found non-constant returns-to-scale with several different specifications of his estimation equation. Rao and Preston (1983) found a similar result using a translog functional form. Our specification will explore this problem and attempt to estimate aggregate scale economies (diseconomies) for the less aggregate 3- and 4-digit level industries.

Most studies of the manufacturing industry have made note of short term fluctuations in industries' output rates. As pointed out in Section 2.1, these fluctuations in the utilization of plant and equipment capacity affect the values of factor shares. Furthermore, if producers find it a cost-minimizing strategy not to adjust their employment of labour to short term fluctuations in demand, labour productivity rates themselves will be affected by capacity utilization. We can isolate the effects of these fluctuations upon the left-hand-side of equation (2.2.8) by adding an index of capacity utilization to our estimating equation (see Rao, 1979, p.24).

$$q = A.\ e^{\lambda t}\ k^{\alpha}.\ e^{\beta}.\ m^{\gamma}.\ L^{\phi}\ e^{\eta c}. \qquad (2.2.11)$$

Should we estimate the parameters of this labour productivity equation, the results may be interpreted as cycle-corrected estimates: λ will be an estimate of cycle-corrected technical progress or TFP growth.

The parameters of (2.2.11) can be estimated using Least Squares procedures when it is expressed in log-linear form. Taking natural logarithms of both sides and writing it in stochastic form we have

$$\ln q = \ln A + \lambda t + \alpha \ln k + \beta \ln e + \gamma$$
$$\ln m + \eta c + \phi \ln L + \varepsilon \qquad (2.2.12)$$

where ε is a random error term.

Given a Cobb-Douglas specification for the production function (2.2.11), we cannot obtain consistent estimates of its parameters by direct estimation (Nerlove, 1965 Ch. 4 ; Walters, 1963; Bodkin and Klein, 1967). Following Klein (1953) and Solow (1957) we can obtain consistent estimates of the parameters of this function using constrained estimation or the "factor shares method" (see Nerlove, 1965 pp.61-67; Walters, 1963, p.21). With cost minimization by industry members and competitive factor markets, the value-marginal-product of each factor input equals its real return. Differentiating equation (2.2.6) with respect to each input we find

$$\begin{aligned}\partial Q/\partial K &= \alpha Q/K\\ \partial Q/\partial E &= \beta Q/E\\ \partial Q/\partial M &= \gamma Q/M\\ \partial Q/\partial L &= \delta Q/L\end{aligned} \tag{2.2.13}$$

Multiplying both sides of these equations by the unit price of output (to find respective value-marginal-products on the left-hand-side) and solving for the unknown parameters we find

$$\begin{aligned}\alpha &= VMPK.K/P.Q\\ \beta &= VMPE.E/P.Q\\ \gamma &= VMPM.M/P.Q\\ \delta &= VMPL.L/P.Q\end{aligned} \tag{2.2.14}$$

With cost minimization, the numerator of each equation is equal to the industry's current expenditure on that factor and P.Q is the value in current dollars of the industry's output. Following Wold (1938), our time series on factor shares can be taken as a sample realization of a stochastic process. When equation (2.2.14) is written with independent, normally distributed, zero-mean random error terms, the best linear unbiased estimators of the parameters α, β, γ, δ are the sample means of the ratios of expenditure on each input to the value of output in current dollars (Larson, 1974, pp.263-4). We therefore obtain the following parameter estimates using Kleins' (1953) method (see Walters, 1963, pp.14-22)

$$\hat{\delta} = \text{MEAN}\ ((\text{VPW\_} + \text{VNPW\_})\ /\ \text{VGO\_C}),$$

$$\hat{\beta} = \text{MEAN}\ (\text{VFE\_}\ /\ \text{VGO\_C}),$$

$$\hat{\gamma} = \text{MEAN}\ (\text{VMA\_C}\ /\ \text{VGO\_C}),$$

$$\hat{\alpha} = 1-\hat{\beta}-\hat{\gamma}-\hat{\delta} \qquad (2.2.15)$$

where Mean refers to arithmetic mean taken over the 1961-1982 period.

The last equation, finding the parameter for capital residually, follows the assumption that over the sample period (in the long run), payments to productive factors exhaust the revenues from sale of output so that profits are zero. More precisely, let v_{it} denote current dollar payments to (costs of) each factor of production i=K, L, E, M, during period t=1 ... 22 and S_{it} denote the share of this value in the value of total output $(P.Q)_t$. Our parameter estimates (2.2.15) then imply

$$1 = S_{1t} + S_{2t} + S_{3t} + S_{4t} + U_t \qquad (2.2.16)$$

where U_t is a random error term with $E(U_t) = 0$. Taking expectations of this equation gives

$$1 = E(S_1) + E(S_2) + E(S_3) + E(S_4) + 0 \qquad (2.2.17)$$

which is identical to the last equation in (2.2.15). Multiplying both sides of (2.2.16) by E(P.Q) we have

$$E(PQ) = E(PQ) \,.\, (\, E(S_1) + E(S_2) + E(S_3) + E(S_4)\,). \qquad (2.2.18)$$

Noting that factor shares are assumed to be independent of the value of output (neutral technical progress), we can write

$E(PQ).\ E(S_i) = E(V_i)$. Thus

$$E(PQ) = E(V_1) + E(V_2) + E(V_3) + E(V_4) \qquad (2.2.19)$$

which is consistent with

$$PQ_t = V_{1t} + V_{2t} + V_{3t} + V_{4t} + e_t \qquad (2.2.20)$$

where $E(e_t) = 0$.

We may note that equations (2.2.15) and (2.2.19) are not inconsistent with existence of cyclical changes in capacity utilization and non-constant returns-to-scale whose effects on labour productivity are captured by their respective coefficients. The above derivation of factor-share for capital, rather than any other factor, can also be rationalized as follows. It avoids the complex and often arbitrary operations (e.g., choice of the discount rate) required to compute the values of capital service flows (see Christensen and Jorgenson, 1969) and attributes the residual of revenues over other factor costs to investors who are in fact "residual claimants".

Before completing the model we may note that the usual specification of the form of technical progress, that used in equations (2.2.6) or (2.2.12) for instance, is rather restrictive -- it assumes that Hicks neutral technical progress occurs at a constant annual rate through time. We can relax this assumption and estimate the trend rate of technical progress--the growth rate of TFP for each year--by changing the specification of the technical progress term in (2.2.12) to read $\lambda t + \Lambda t^2$. Should these coefficients be statistically significant, technical progress will be a linear function of time with intercept λ and slope 2Λ. With this specification, we will be better equipped to examine whether and to what extent the industries studied have experienced a slowdown in TFP growth.

We can now complete the model by substituting the set of equations (2.2.15) into (2.2.12) and adding the above trend term to obtain

$$\ln q = \ln A + \lambda t + \Lambda t^2 + \hat{\alpha} \ln k + \hat{\beta} \ln e + \hat{\gamma} \ln m + \eta c + \phi \ln L + \varepsilon. \qquad (2.2.21)$$

Moving all dependent variables of the regression to the left-hand-side, we form the final equation

$$\ln q - \hat{\alpha}\ln k - \hat{\beta}\ln e - \hat{\gamma}\ln m = \ln A + \lambda t + \Lambda t^2 + \phi \ln L + \eta c + \varepsilon \qquad (2.2.22)$$

where the left-hand-side is regressed on ln A and the coefficients of the time trend, time squared, capacity utilization and labour (returns-to-scale proxy) and ε is an independently distributed random variable with zero mean.

On the left-hand-side of (2.2.22) the variables are ratios to a Fisher ideal quantity index of labour services. These variables are Q, a quantity index of output; K, a Fisher quantity index of capital; E, a Fisher quantity index of purchased fuel and electricity; and M, a quantity index of material inputs obtained from constant dollar expenditure data (see Appendix 2). The right-hand-side of (2.2.22) comprises the following: A, an industry-specific constant or intercept term; λt and Λt^2, where lambdas are used to compute the rate of technical progress or the (instantaneous) annual growth rate of total factor productivity estimated over the relevant period; c, an index of capacity utilization (see Appendix 2) which supports our use of an aggregate capital stock index as a proxy for capital service flows; and L which is the Fisher index of labour used to test for (and capture the effects of) scale economies. The estimated coefficient of L is the elasticity of output with respect to proportional changes in the quantities of all inputs (see equations (2.2.8) through (2.2.10) and Layard and Walters, 1978, pp.399-400).

The model represented by equations (2.2.21) or (2.2.11) is constructed on the assumption of Hicks neutrality of technical progress. As pointed out in (2.1) above, we must explore the possibility that, at least for some of the industries considered, technical change is non-neutral. Under these conditions, the coefficients of productive factors in (2.2.11) will not be constant over time indicating a bias in technical progress. Modifying Binswanger's (1974, p. 964) definition of the bias slightly, we define the bias in the rate of technical change of each productive input, α', β' and γ' by the time derivative of the elasticity of output with respect to each productive input

$$\alpha' = \partial(\partial Q/\partial K \,.\, K/Q)/\partial T,$$

$$\beta' = \partial(\partial Q/\partial E \,.\, E/Q)/\partial T, \text{ and}$$

$$\gamma' = \partial(\partial Q/\partial M \,.\, M/Q)/\partial T. \tag{2.2.23}$$

To obtain an estimate of these rates of bias, we must modify equation (2.2.11) and its logarithmic equivalent (2.2.21) to allow the coefficients of inputs to vary with time. Modifying equation (2.2.6) following Denny (1978), it becomes

$$Q = Ae^{\lambda t + \Delta t^2} K^{\alpha + \alpha' t} E^{\beta + \beta' t} M^{\gamma + \gamma' t} L^{\delta}. \tag{2.2.24}$$

Since equation (2.2.9) must hold, our productivity equation now becomes

$$q = Ae^{\lambda t+\Lambda t^2}k^{\alpha} \quad e^{\beta} \quad m^{\gamma} \quad K^{\alpha' t} \quad E^{\beta' t} \quad M^{\gamma' t} \quad L^{\phi} \quad e^{\eta c} \tag{2.2.25}$$

and its logarithmic equivalent is

$$\ln q-\alpha \ln k-\beta \ln e-\gamma \ln m = \ln A$$
$$+\lambda t+\Lambda t^2+\alpha' t\ln K+\beta' t\ln E+\gamma' t\ln M+\eta c+\phi \ln L+\varepsilon \tag{2.2.26}$$

where ε is, as before, a zero mean, independently distributed random error term. When technical change is Hicks neutral, this equation is identical to (2.2.21) and the coefficients of factor inputs are given by (2.2.16), otherwise they are given by (2.2.16) and (2.2.23) above.

When technical change is biased, the factor(s) of production in question make an additional positive (or negative) contribution to overall technical progress and this contribution depends on the level of the input used each period. Total technical progress, therefore, is found as the derivative of the right-hand-side of (2.2.26) with respect to time or

$$\text{Technical Progress} = \lambda+\Lambda 2t+\alpha' \ln K+\beta' \ln E+\gamma' \ln M. \tag{2.2.27}$$

When parameters of factor input bias terms are not statistically significant, technical progress is Hicks neutral and is given by the first two terms of (2.2.27). Positive (negative) significant factor input bias parameters indicate factor using (saving) technical change in production for the input in question.

2.3 Sources of Productivity Growth

In the preceding discussion, labour productivity was given by equation (2.2.1) and its rate of growth by (2.2.3) involving quantity indices of output and labour services. Having estimated the parameters of equation (2.2.22) and in particular the technical progress parameter, our next objective is to identify the sources of labour productivity growth (2.2.3) within the framework of exogenous factors represented in (2.2.22) and measure their contributions to the observed growth in labour productivity.

We obtain the rate of growth of labour productivity as a function of the exogenous factors postulated by differentiating (2.2.21) with respect to time

$$\partial/\partial t(\ln q)=\partial/\partial t(\lambda t)+\partial/\partial t(\Delta t^2)+\partial/\partial t(\alpha \ln k)+\partial/\partial t(\beta \ln e)+\partial/\partial t(\gamma \ln m)+\partial/\partial t(\eta c)+\partial/\partial t(\phi \ln L)+R \tag{2.3.1}$$

where R is the residual growth rate associated with errors of measurement of growth rates and ommitted factors. This equation can be written in terms of growth rates of the variables (denoted with a dot)

$$\dot{q} = \lambda + \Lambda 2t + \alpha \dot{k} + \beta \dot{e} + \gamma \dot{m} + \eta d/dt(c) + \phi \dot{L} + R \ . \qquad (2.3.2)$$

This equation presents the observed labour productivity growth values for any sub-period as well as the study period (1961 - 1982) as the sum of the weighted rates of growth of its determining variables. Labour productivity growth originates from Hicks neutral technical progress (growth in TFP) amounting to $\lambda + 2\Lambda t$;from increased use of capital relative to labour contributing $\alpha \dot{k}$ to this magnitude; from increased ratio of energy and material inputs to labour contributing to $\dot{q}$ by $\beta \dot{e}$ and $\gamma \dot{m}$ respectively; from changes in capacity utilization given by the product of η and the time derivative of c; and from economies of scale computed by $\phi \dot{L}$. Having estimated the parameters of (2.2.22) using factor shares and least squares estimation methods, all of the parameters of (2.3.2) are replaced by their estimates which results in a productivity growth accounting framework when growth rates of the variables have been computed.

To allow for non-neutral technical change, we must modify this framework slightly to account for changing factor input parameters. We can obtain the growth rate of labour productivity as a function of factor inputs without the Hicks neutrality restriction by taking the logarithm of equation (2.2.25) and differentiating with respect to time

$$\dot{q} = \lambda + \Lambda 2t + \alpha' \ln K + \beta' \ln E + \gamma' \ln M + \hat{\alpha}\dot{k} + \hat{\beta}\dot{e} + \hat{\gamma}\dot{m} +$$
$$\phi\dot{L} + \eta\, d/dt(c) + \alpha' t\dot{K} + \beta' t\dot{E} + \gamma' t\dot{M} + R' . \qquad (2.3.3)$$

Once again dots indicate growth rates of variables and R' is the residual. When parameters of this equation are estimated using (2.2.26), it allows us to account for changes in labour productivity in terms of the underlying changes in factor to labour ratios, biased technical change and total factor productivity growth.

3. EMPIRICAL RESULTS

3.1 Food and Beverage Sector

For the Food and Beverage Sector, comprising 9 industries at the 3-digit level of S.I.C., our empirical results are summarized in Table 3.1.1. As with other industries, we have estimated the parameters of both equations (2.2.22) and (2.2.26) using aggregate data discussed in Appendices 1 and 2. The results of alternative estimations of this equation appear in Table 3.1.2.

The estimated equation, used to obtain other empirical results for this industry, is

$$
\begin{aligned}
d(\ln q) &= 0.109868 * d(\ln k) + 0.011665 * d(\ln e) + 0.748254 * d(\ln m) + \\
&\quad \underset{(5.14)}{0.006551} * d(t) \underset{(2.69)}{-\,0.000135} * d(t^2) \underset{(22.54)}{+\,0.00245} * d(c) \underset{(7.51)}{-\,0.141791} * d(\ln L)
\end{aligned}
$$

$R^2=0.970188$ D.W.=1.37645 S.E.R.=0.001061 Rho:0.715096
Condition Number: 3.25774

This equation is the first-difference of equation (2.2.22) and obtains estimated coefficients for the two time trend terms, the effect of capacity utililzation on labour productivity q, (or the ratio of the index of output to that of aggregate labour input) and the coefficient of aggregate labour input which measures the degree of homogeneity of the production function. Since autocorrelation persisted in our earlier estimation, the

Cochrane-Orcutt procedure was employed for its correction and the Prais-Winsten procedure was used to avoid losing the first set of observations. All coefficients are significant at the 99% level or better (brackets indicate t ratios). The Condition Number assures the absence of multicollinearity problems in our estimation.

The above estimated results suggest that the aggregate production surface is homothetic and that technical progress in the food and beverage sector is Hicks neutral. According to the coefficient of labour, the industry operates under decreasing returns-to-scale conditions: returns-to-scale (unity plus the labour coefficient) is approximately 0.858.

The two coefficients of the time trend indicate that technical change has the intercept 0.6551% per year and has declined at the rate of 0.027% per year over the study period. This means that in 1982, the last year for which complete data was attainable, technical progress occured at the rate of 0.0881% per year compared to 0.6551% twenty one years earlier.

Having obtained the above estimates, we can now analyse the causes of the observed changes in labour productivity growth using the framework represented by equation (2.3.2). The growth accounting framework, summarized in Table 3.1.1, suggests a distinct pattern of change over the study period. During the 1962-66 period labour productivity grew at the average rate of 3.326% per year and increased in the subsequent period (1967-71) to 3.903%. However, over the next 5 years, productivity growth declined by almost 2 percentage points to 2.915% and suffered a further, though less substantial, decline during the next 6 years as it fell to 2.201%. This pattern of rising growth during the 1962-71 period and of slowly falling growth thereafter (1972-82) is closely matched by changes in the underlying sources of labour productivity growth. With the exception of capacity utilization, all sources of growth display this pattern with the largest contribution coming from growth in the ratio of intermediate materials to labour. The next largest contributor is technical change followed by growth in the capital-labour ratio.

To summarize, the observed improvement in labour productivity growth over the first 10 years of the study period originated largely in the growing materials-labour ratio -- it accounts for more than 70% of labour productivity growth. Other contributors (capital-labour ratio, energy-labour ratio and returns-to-scale) had a substantially smaller role: the contribution of capital-labour ratio more than doubled over this period (from 0.307% to 0.629% per year) while that of energy remained almost constant. As aggregate labour input grew during the first 5 years but declined over the subsequent 5 years (1967-71) and the industry operates under decreasing returns-to-scale, the contribution of returns-to-scale to rising labour productivity growth was significant and approximately matched that of capital-labour ratio.

During the 1972-76 and 1977-82 sub-periods, labour productivity growth declined from 2.915% to 2.201% per year. The largest contributors to this decline were the materials-labour ratio and falling capacity utilization followed by declining technical progress. Although the contribution of energy-labour ratio fell to half its value from 1972-76 to 1977-82, it accounted for a very small portion of the decline in labour productivity growth.

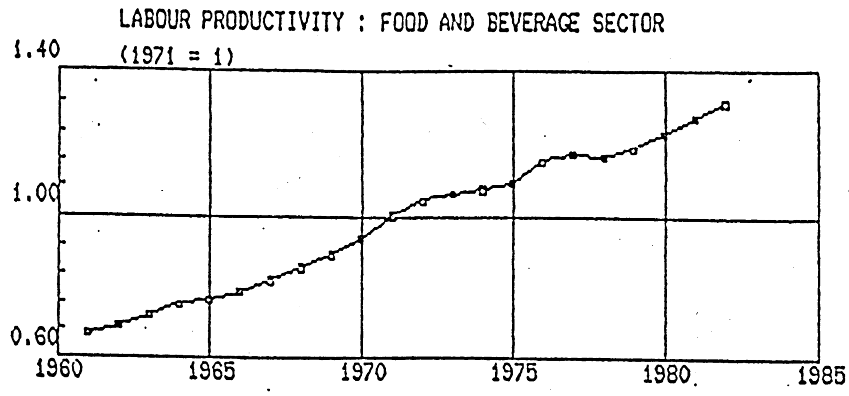
TABLE 3.1.1

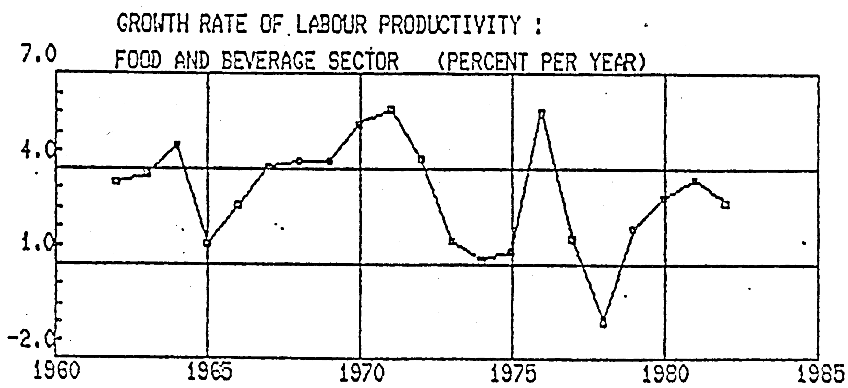
FOOD & BEVERAGE SECTOR

SOURCES OF LABOUR PRODUCTIVITY GROWTH: 1961-1982

(PERCENT PER YEAR)

	1962-66	1967-71	1972-76	1977-82	1962-1982
LABOUR PRODUCTIVITY GROWTH	3.326	4.903	2.915	2.201	3.282
TECHNICAL PROGRESS (T.F.P. GROWTH)	0.574	0.439	0.304	0.155	0.358
CAPITAL	0.307	0.629	0.355	0.261	0.382
ENERGY	0.031	0.031	0.009	0.004	0.018
MATERIAL INPUTS	2.424	3.610	2.245	1.945	2.527
UTILIZATION OF CAPACITY	0.187	-0.095	0.046	-0.140	-0.007
RETURNS-TO-SCALE	-0.202	0.173	0.019	-0.017	-0.006
RESIDUAL GROWTH	0.049	0.048	-0.072	-0.026	-0.001


LABOUR PRODUCTIVITY : FOOD AND BEVERAGE SECTOR
(1971 = 1)
1.40
1.00
0.60
1960
1965
1970
1975
1980
1985


GROWTH RATE OF LABOUR PRODUCTIVITY :
FOOD AND BEVERAGE SECTOR (PERCENT PER YEAR)
7.0
4.0
1.0
-2.0
1960
1965
1970
1975
1980
1985

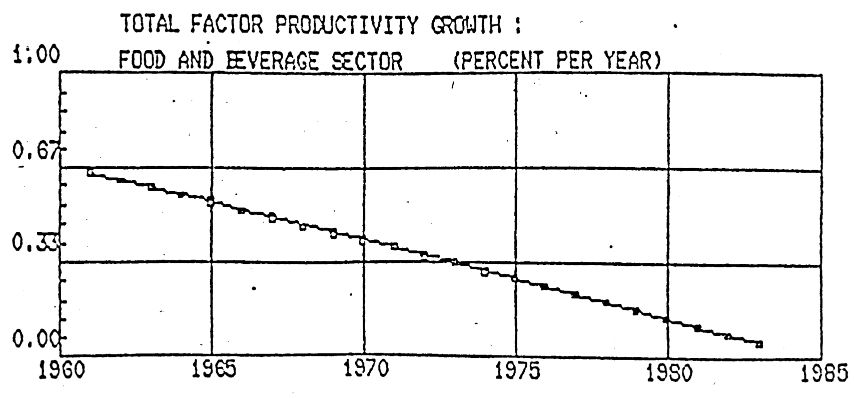

TOTAL FACTOR PRODUCTIVITY GROWTH :
FOOD AND BEVERAGE SECTOR (PERCENT PER YEAR)
1.00
0.67
0.33
0.00
1960
1965
1970
1975
1980
1985

TABLE 3.1.2

FOOD & BEVERAGE SECTOR (S.I.C. 10)

Alternative Regression Results

$\ln q = \ln A + a_1 * \ln k + a_2 * \ln e + a_3 * \ln m + a_4 * t + a_5 * t^2 + a_6 * c + a_7 * \ln L + a_8 * t * \ln K + a_9 * t * \ln E + a_{10} * t * \ln M$

a1=0.1098 a2=0.0116 a3=0.7482

Estimation Method	ln A	a4	a5	a6	a7	a8	a9	a10	R^2	D.W.	Rho	Cond.No.
OLS	0.8110 (5.63)	0.0383 (4.86)	--	0.0016 (3.54)	-0.2237 (7.83)	-0.0117 (2.23)	0.0008 (0.39)	0.0038 (0.85)	0.994	1.02	--	2500
GLS First Diff	--	-0.0175 (1.18)	-0.0003 (2.82)	0.0027 (14.43)	-0.1469 (9.66)	0.0095 (2.04)	-0.0014 (2.33)	-0.0024 (1.12)	0.985	1.23	0.865	52
GLS First Diff	--	-0.0120 (0.84)	-0.0002 (2.59)	0.0025 (25.55)	-0.1466 (9.52)	0.0054 (1.78)	-0.011 (2.03)	--	0.983	1.24	0.854	37
GLS First Diff	--	--	-0.0001 (3.32)	0.0025 (29.50)	-0.1460 (9.55)	0.0029 (4.98)	-0.0013 (2.74)	--	0.982	1.25	0.818	6
OLS	0.5666 (6.91)	-0.0075 (27.98)	-0.0001 (15.55)	0.0020 (6.45)	-0.1774 (8.58)	--	--	--	0.995	0.64	--	650
GLS	0.5349 (5.96)	0.0070 (15.64)	-0.0001 (8.15)	0.0023 (12.85)	-0.1771 (8.66)	--	--	--	0.982	0.97	0.818	210
OLS First Diff	--	0.0069 (11.42)	-0.0001 (6.27)	0.0023 (13.48)	-0.1753 (8.62)	--	--	--	0.959	1.00	--	3
GLS First Diff	--	0.0065 (11.42)	-0.0001 (6.27)	0.0024 (13.48)	-0.1417 (8.62)	--	--	--	0.970	1.37	0.715	3

3.2 Fish Products Industry

Most of the empirical results obtained for this industry have been summarized in Table 3.2.1. These results are based on econometric estimation of equation (2.2.26) using aggregate input and other data on Fish Products industry described in Appendices. Although equation (2.2.22) based on the assumption of Hicks neutral technical progress was also estimated, it is clear from Table 3.2.2 that this assumption is not supported by empirical evidence. Our estimating equation, which accounts for biased technical progress, is

$$d(\ln q)=0.091332^{*}\, d(\ln k)+0.012562^{*}\, d(\ln e)+0.74052^{*}\, d(\ln m) -$$

$$\underset{(2.82)}{0.011515^{*}}\, d(t)+\underset{(22.05)}{0.002415^{*}}d(c)-\underset{(5.90)}{0.105709}\, {}^{*}d(\ln L)+\underset{(2.50)}{0.001897^{*}}$$

$$d(t^{*}(\ln M))$$

R^2=0.97566   D.W.=1.87016   S.E.R.=0.004048   Rho:0.514189
Condition Number: 5.01055

The above estimating equation is the first-difference of equation (2.2.26) and obtains estimated coefficients for the time trend, the effect of capacity utilization on labour productivity, q, and for aggregate labour input which, in this formulation, measures returns-to-scale. Due to autocorrelation in an earlier estimation of this equation the Cochrane-Orcutt procedure was used in the final estimation. The Durbin-Watson statistic assures the absence of autocorrelation at the 5% level.

To avoid losing the first observation, the Prais-Winsten procedure was used along with Cochrane-Orcutt. The Condition Number, furthermore, indicates the absence of serious multicollinearity problems. All estimated coefficients are significant at the 98% level or better, while the coefficient of the interaction of material inputs and time is significant at the 97% level.

Our final results indicate that technical progress is not Hicks neutral for this industry but rather biased in favour of material inputs (materials-using). For other productive inputs (energy and capital), the hypothesis that their estimated interaction coefficients were equal to zero could not be rejected and the variables were dropped from the estimating equation (see Table 3.2.2). Similarly, the coefficient of time-squared or the trend of technical progress was dropped. According to the coefficient of labour, the industry operates under decreasing returns-to-scale conditions: returns-to-scale (unity plus the labour coefficient) is approximately 0.895. Since technical change is biased, its magnitude is given by equation (2.2.27) and varies over the study period. As Table 3.2.1 indicates, overall technical change, though negative throughout the study period, rose consistently and averaged -0.268% per year between 1962 and 1982.

With the above results and the growth accounting framework represented by equation (2.3.2), Table 3.2.1 analyses the sources of labour productivity growth and the changes it displayed over the study period. Labour productivity grew at the average annual rate of 0.729% per year during the 1962-66 period but this rate more than doubled over the next five years. This improved performance appears to have originated mainly from falling (aggregate) labour employment (negative labour input growth) during the 1967-71 period: the contribution of returns-to-scale (alternatively, the contribution of labour employment to labour productivity) increased by about 0.72 percentage points from its average in the first five years to the next. Rapidly growing capital-labour ratio also contributed to this improvement: its contribution to labour productivity growth rose from an average of 0.391% per year during the first five years to 0.933% over the next five years. The contribution of energy-labour growth, though rather small, more than doubled during the same period. Technical progress (negative throughout the study period) showed a small improvement over the 1962-1971 period.

During the third sub-period studied (1972-76) labour productivity growth declined quite sharply; it <u>contracted</u>, on the average, by 1.395% per year. Our analysis suggests that this occurred as a result of a sharply declining growth in the material inputs-labour ratio -- the latter fell by more than 2 percentage points from its average in the last five years (1967-71). Other causes of this decline appear to be the falling growth in the capital-labour ratio and, to a much smaller extent, increasing growth in (aggregate) labour employment. These declining trends were completely reversed during the next five years, 1977-82. Labour productivity growth climbed very sharply to 3.019% per year during this period. Once again, our analysis finds the primary source of this improvement in the increased growth of the materials-labour ratio and greater utilization of capacity. Improvements in technical progress also contributed to this remarkably enhanced labour productivity growth, while declining capital-labour and energy-labour ratios and growing employment only partially offset the effects of the productivity enhancing factors.

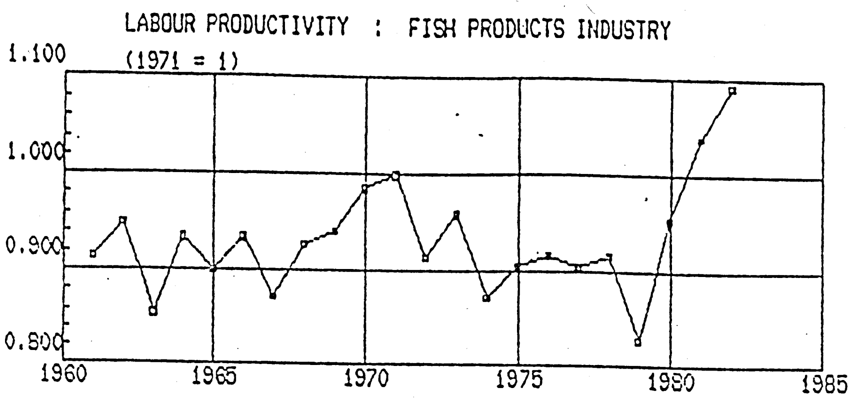
TABLE 3.2.1

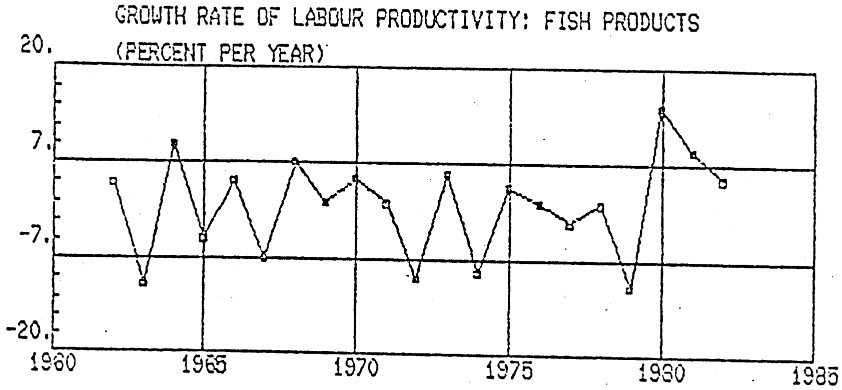
FISH PRODUCTS INDUSTRY

SOURCES OF LABOUR PRODUCTIVITY GROWTH: 1961-1982

(PERCENT PER YEAR)

	1962-66	1967-71	1972-76	1977-82	1962-1982
LABOUR PRODUCTIVITY GROWTH	0.729	1.499	-1.395	3.019	1.060
TECHNICAL PROGRESS (T.F.P. GROWTH)	-0.305	-0.276	-0.287	-0.215	-0.268
CAPITAL	0.391	0.933	0.279	-0.031	0.373
ENERGY	0.029	0.053	0.016	-0.025	0.016
MATERIAL INPUTS	1.047	0.952	-1.263	3.489	1.172
UTILIZATION OF CAPACITY	0.024	-0.688	-0.029	0.848	0.077
RETURNS-TO-SCALE	-0.603	0.117	-0.229	-0.496	-0.311
RESIDUAL GROWTH	0.144	0.407	0.118	-0.549	0.002


LABOUR PRODUCTIVITY : FISH PRODUCTS INDUSTRY
(1971 = 1)
1.100
1.000
0.900
0.800
1960
1965
1970
1975
1980
1985


GROWTH RATE OF LABOUR PRODUCTIVITY: FISH PRODUCTS
(PERCENT PER YEAR)
20.
7.
-7.
-20.
1960
1965
1970
1975
1980
1985

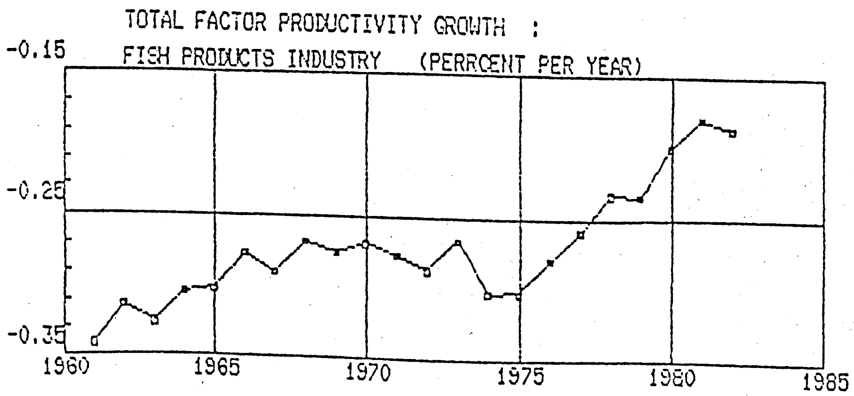

TOTAL FACTOR PRODUCTIVITY GROWTH :
FISH PRODUCTS INDUSTRY (PERRCENT PER YEAR)
-0.15
-0.25
-0.35
1960
1965
1970
1975
1980
1985

TABLE 3.2.2
FISH PRODUCTS INDUSTRY (SIC 1020)

Alternative Regression Results

$\ln q = \ln A + a_1 * \ln k + a_2 * \ln e + a_3 * \ln m + a_4 * t + a_5 * t^2 + a_6 * c + a_7 * \ln L + a_8 * t * \ln K + a_9 * t * \ln E + a_{10} * t * \ln M$

a1=0.0913   a2=0.0125   a3=0.7405

Estimation Method	lnA	a4	a5	a6	a7	a8	a9	a10	R^2	D.W.	Rho	Cond.No.
OLS	0.4717 (2.65)	-0.0007 (0.11)	-- (10.00)	0.0019 (3.27)	-0.1349 (1.31)	-0.0037 (0.54)	0.0010 (1.66)	0.0027 --	0.974 --	1.180 --	--	640
OLS First Diff	--	-0.0396 (2.81)	-0.0004 (2.41)	0.0025 (15.5)	-0.1062 (3.87)	0.0090 (2.15)	-0.0010 (0.80)	0.0012 (0.88)	0.968 --	1.319 --	--	65 --
OLS First Diff	--	-0.0388 (2.79)	-0.0004 (2.33)	0.0025 (15.90)	-0.1219 (6.35)	0.0070 (2.09)	--	0.0020 (2.09)	0.967	1.27	--	48
GLS First Diff	--	-0.0365 (2.51)	-0.0002 (1.54)	0.0025 (19.53)	-0.1095 (5.99)	0.0065 (1.83)	--	0.0016 (1.98)	0.978	1.77	0.439	30
GLS First Diff	--	-0.0343 (2.43)	--	0.0025 (23.8)	-0.0992 (6.03)	0.0048 (1.67)	--	0.0015 (2.22)	0.983	2.04	0.746	11
GLS First Diff	--	-0.0115 (2.82)	--	0.0024 (22.0)	-0.1057 (5.90)	--	--	0.0018 (2.50)	0.975	1.87	0.514	5
OLS	0.2690 (3.35)	-0.0006 (0.47)	-0.0004 (0.80)	0.0020 (9.32)	-0.0920 (4.48)	--	--	--	0.968	0.906	--	190
GLS	0.2906 (3.31)	-0.0012 (0.68)	-0.0001 (0.18)	0.0023 (14.5)	-0.1014 (4.70)	--	--	--	0.950	1.45	0.762	72
GLS	0.2876 (3.42)	-0.0015 (2.16)	--	0.0023 (16.0)	-0.1004 (4.93)	--	--	--	0.950	1.45	0.780	60

3.3 Fruit and Vegetable Processing Industry

Most of the empirical results obtained for this industry have been summarized in Table 3.3.1. They are based on econometric estimation of equation (2.2.26) using aggregate input and other data discussed in Appendices 1 and 2. Equation (2.2.22), based on Hicks neutrality of technical change was also estimated but, as Table 3.3.2 shows, this assumption could not be maintained. The estimating equation, which accounts also for biased technical progress, is

$$\begin{aligned} d(\ln q) = {} & 0.114669 * d(\ln k) + 0.012779 * d(\ln e) + 0.724681 * d(\ln m) - \underset{(6.61)}{0.000471} * \\ & d(t^2) + \underset{(24.88)}{0.002846} * d(c) - \underset{(11.59)}{0.140785} * d(\ln L) + \underset{(3.18)}{0.004421} * d(t * (\ln K)) - \\ & \underset{(1.30)}{0.001715} * d(t * (\ln M)) \end{aligned}$$

$R^2 = 0.982883$ D.W.=1.54004 S.E.R. = 0.001662 Rho = 0.55082
Condition Number: 20.3

This equation is the first-difference of equation (2.2.26) and obtains estimated coefficients for the square of the time trend, the effect of capacity utilization on labour productivity, q, the aggregate labour input which, in this formulation, measures returns-to-scale and for the interaction terms of capital and material inputs with time. Due to autocorrelation in our earlier estimations of this equation, the Cochrane-Orcutt procedure was used in the final estimation along with the Prais-Winsten procedure to avoid losing the first set of observations. The Durbin-Watson statistic is 1.54, which is less than the upper significance point of 1.55, and falls in the indetermiante region. The Condition Number does not indicate the presence of a serious multicollinearity problem. All estimated coefficients are statistically significant at the 99% level or better, though that of the interaction of time and material inputs is only significant at the 78% level.

Our results indicate that technical progress is not Hicks neutral, but is rather biased toward capital (capital-using) and against material inputs (materials-saving), although the latter bias is not statisticaly significant. As Table 3.3.2 suggests, the hypothesis that the coefficient of the interaction of time and energy input is zero could not be rejected and the variable was not included in the final estimation. The time trend variable was similarly dropped. According to the coefficient of labour, the industry operates under decreasing returns-to-scale conditions: returns-to-scale (unity plus the labour coefficient) is approximately 0.859. Since technical change is biased, its magnitude varies over the study period and is given by equation (2.2.27). As Table 3.3.1 indicates, overall technical change declined over the study period and averaged 1.021% per year.

Using the growth accounting framework of equation (2.3.2) and the above econometric results we can now analyse the sources of the slowdown in labour productivity growth shown in Table 3.3.1. Labour productivity grew at an average annual rate of 2.794% per year between 1961 and 1982. It showed a substantial improvement, however, between 1967 and 1971 over the previous five years. Our analysis suggests that most of this improvement originated from faster growth of the materials-labour ratio: the contribution of this source increased by more than 1.2 percentage points. The next major source was declining (aggregate) labour employment (negative labour growth rate) whose contribution to labour productivity growth increased by more than 0.76 percentage points. Other sources include improved capacity utilization and higher capital-labour ratio.

Over the following five years, 1972-76, although capacity utilization as well as the contribution of capital-labour ratio increased, labour productivity growth declined drastically: it fell by more than 2.8 percentage points below the previous five years' average to 1.938% per year. The largest source of this decline was the contribution of the materials-labour ratio which fell by more than 2.3 percentage points below its value in the previous five years. As labour employment grew during this period, the contribution of this source to labour productivity growth also declined.

During the last five years of the study, 1977 to 1982, labour productivity growth continued to decline. This occured in spite of a reversal in the trend just discussed: the contribution of materials-labour ratio increased and aggregate labour employment declined. The principal cause of the falling labour productivity growth during this period appears to be a sharp decline in capacity utilization and slower growth of the capital-labour ratio and energy-labour ratio. Technical progress, which occured at less than half its average annual rate in the previous five years, also made a substantial contribution to the observed decline in labour productivity growth.

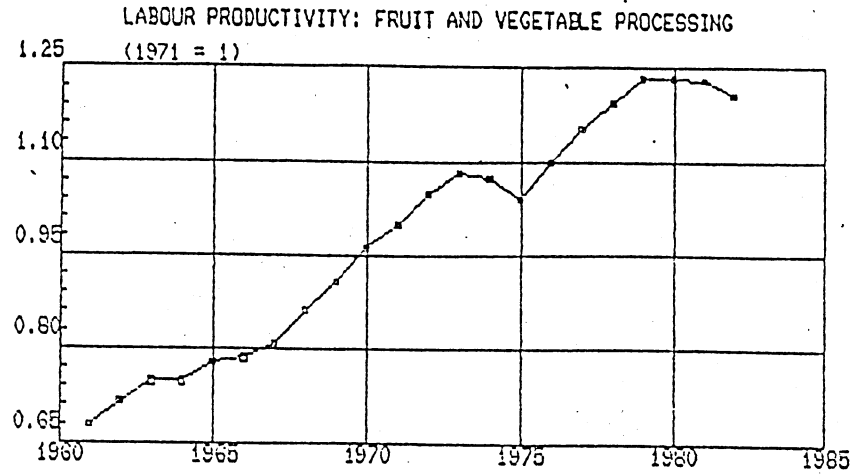
TABLE 3.3.1

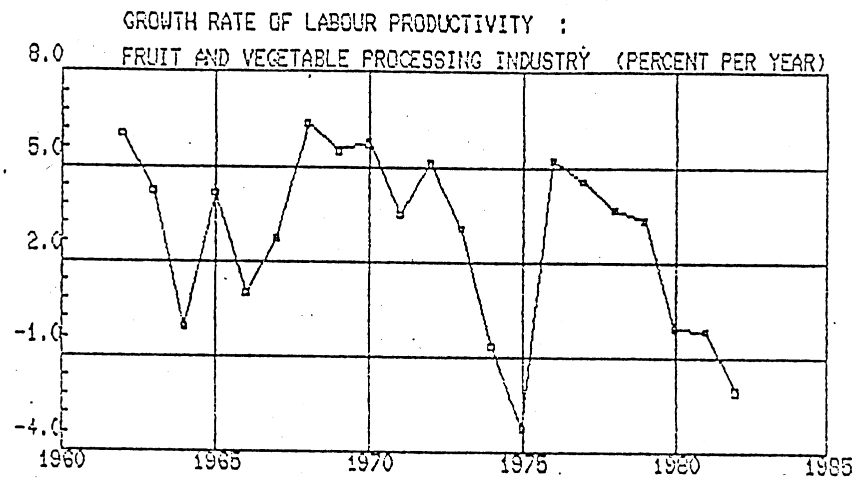
FRUIT & VEGETABLE PROCESSING INDUSTRY

SOURCES OF LABOUR PRODUCTIVITY GROWTH: 1961-1982

(PERCENT PER YEAR)

	1962-66	1967-71	1972-76	1977-82	1962-1982
LABOUR PRODUCTIVITY GROWTH	3.100	4.815	1.938	1.566	2.794
TECHNICAL PROGRESS (T.F.P. GROWTH)	1.642	1.253	0.874	0.431	1.021
CAPITAL	0.503	0.716	0.743	0.683	0.662
ENERGY	0.032	0.029	0.033	0.026	0.030
MATERIAL INPUTS	2.082	3.321	0.951	1.417	1.918
UTILIZATION OF CAPACITY	-0.052	0.169	0.243	-0.432	-0.037
RETURNS-TO-SCALE	-0.440	0.327	-0.062	0.247	0.028
RESIDUAL GROWTH	-0.668	-1.002	-0.844	-0.808	-0.829


LABOUR PRODUCTIVITY: FRUIT AND VEGETABLE PROCESSING
(1971 = 1)
1.25
1.10
0.95
0.80
0.65
1960
1965
1970
1975
1980
1985


GROWTH RATE OF LABOUR PRODUCTIVITY :
FRUIT AND VEGETABLE PROCESSING INDUSTRY (PERCENT PER YEAR)
8.0
5.0
2.0
-1.0
-4.0
1960
1965
1970
1975
1980
1985

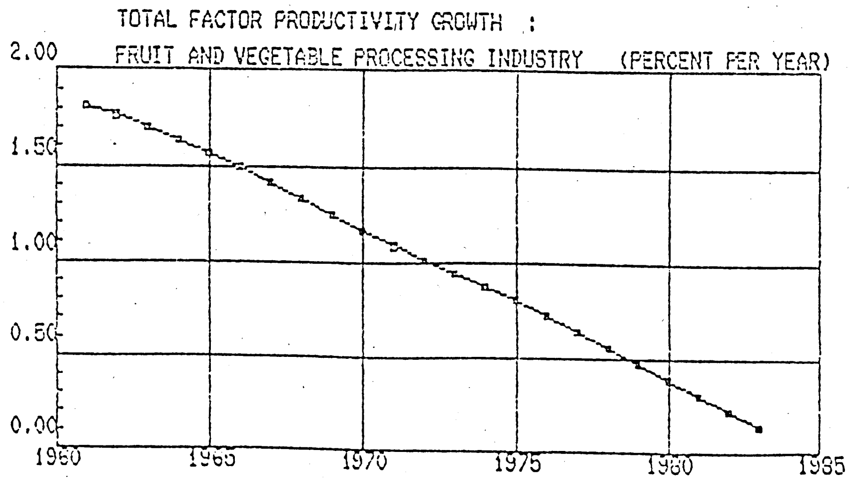

TOTAL FACTOR PRODUCTIVITY GROWTH :
FRUIT AND VEGETABLE PROCESSING INDUSTRY (PERCENT PER YEAR)
2.00
1.50
1.00
0.50
0.00
1960
1965
1970
1975
1980
1985

TABLE 3.3.2

FRUIT & VEGETABLE PROCESSING INDUSTRY (SIC 1030)

Alternative Regression Results

$$\ln q = \ln A + a_1 * \ln k + a_2 * \ln e + a_3 * \ln m + a_4 * t + a_5 * t^2 + a_6 * c + a_7 * \ln L + a_8 * t * \ln K + a_9 * t * \ln E + a_{10} * t * \ln M$$

a1=0.114669 a2=0.012779 a3=0.724681

Estimation Method	lnA	a4	a5	a6	a7	a8	a9	a10	R^2	D.W.	Rho	Cond.No.
OLS	0.0958	0.0365	--	0.0027	-0.0932	-0.079	0.01	0.0013	0.984	0.51	--	790
	(0.54)	(2.89)		(5.55)	(2.67)	(3.50)	(0.02)	(0.30)				
GLS	0.1639	0.0506	--	0.0026	-0.1049	-0.0084	-0.0010	0.0000	0.960	0.94	0.87	120
	(1.63)	(5.08)		(11.02)	(4.80)	(4.71)	(0.63)	(.000)				
OLS First Diff	--	0.0040	-0.0004	0.0028	-0.1259	0.0041	-0.0007	-0.0017	0.973	0.99	--	106
		(0.28)	(3.88)	(16.20)	(7.72)	(1.19)	(0.71)	(1.04)				
GLS First Diff	--	0.0001	-0.0004	0.0028	-0.1393	0.0044	-0.0002	-0.0015	0.982	1.52	0.54	73
		(0.01)	(3.47)	(21.61)	(9.76)	(1.08)	(0.39)	(1.04)				
GLS First Diff	--	--	-0.0004	0.0028	-0.1407	0.0044	--	-0.0017	0.982	1.54	0.55	20
			(6.61)	(24.88)	(11.59)	(3.18)		(1.30)				
GLS First Diff	--	--	-0.0004	0.0027	-0.1446	0.0026	--	--	0.981	1.45	0.58	4
			(6.30)	(29.06)	(12.10)	(7.68)						
OLS	-0.4879	0.0044	--	0.0037	0.0154	--	--	--	0.950	1.07	--	270
	(2.93)	(13.16)		(7.17)	(0.43)							
GLS	0.0929	0.0038	--	0.0026	-0.0902	--	--	--	0.845	0.76	--	18
	(0.70)	(4.52)		(9.12)								
OLS First Diff	--	0.0105	-0.0003	0.0026	-0.1286	--	--	--	0.968	0.89	--	4
		(11.21)	(8.07)	(19.54)	(8.72)							
GLS First Diff	--	0.0115	-0.0003	0.0027	-0.1414	--	--	--	0.980	1.51	0.55	3
		(7.66)	(5.90)	(27.57)	(11.47)							

3.4 Dairy Products Industry

Table 3.3.1 summarizes most of the empirical results obtained for this industry. They are based on econometric estimation of equation (2.2.26) using aggregate data on inputs and other variables discussed in Appendices 1 and 2. Equation (2.2.22), based on Hicks neutrality of technical progress was also estimated but, as Table 3.4.2 shows, this assumption could not be maintained. The estimating equation, which accounts also for biased technical progress, is

$$\underset{}{d(\ln q)=0.075724*d(\ln k)+0.013668*d(\ln e)+0.802762*d(\ln m)}-\underset{(2.19)}{0.000118}*$$
$$d(t^2)+\underset{(5.12)}{0.001511}*d(c)-\underset{(2.69)}{0.074933}*d(\ln L)+\underset{(2.54)}{0.000731}*d(t*(\ln M))$$

$R^2 = 0.752657$ D.W. = 1.51352 S.E.R. = 0.002766
Condition Number: 4.632

This equation is the first-difference of equation (2.2.26) and obtains estimated coefficients for the square of the time trend, the effect of capacity utilization on labour productivity, q, the aggregate labour input which, in this formulation, measures returns-to-scale and for the interaction of time and material inputs. The Durbin-Watson statistic is slightly below the upper significance point of 1.55 and, therefore, falls in the indeterminate region. The Condition Number assures us that no serious multicollinearity exists among independent variables of this regression. All estimated coefficients are significant at the 95% level or better.

The above results indicate that technical change is not Hicks neutral in the Dairy Products industry but is rather biased toward material inputs (materials-using). As Table 3.4.2 suggests, the hypotheses that technical progress is biased with respect to energy and capital could not be sustained and these variables were not included in the final estimation. The simple time trend variable was similarly dropped. According to the coefficient of labour, the industry operates under decreasing returns-to-scale conditions: returns-to-scale (unity plus the labour coefficient) is approximately 0.925. Since technical progress is biased, its magnitude varies over the study period and is given by equation (2.2.27). However, because technical progress entering the production process through material inputs was only slightly in excess of those entering through other factors of production, the graph of overall technical change appears as an almost linear curve declining over time. Technical progress averaged 0.077% per year over the study period.

Using the growth accounting framework of equation (2.3.2) and the above econometric results we can now analyse the changes in labour productivity growth this industry experienced during the study period. Labour productivity grew at an average annual rate of

3.403% per year between 1962 and 1982. As Table 3.4.1 indicates, 5-year average labour productivity growth increased between 1962 and 1976 but sharply declined in the following five years. This pattern also applies to the contributions of material inputs and returns-to-scale (labour). Aggregate labour employment declined during this period, causing some improvement in labour productivity growth but the most important source was the rising growth in the materials-labour ratio. The contributions of capital-labour ratio and energy-labour ratio, however, only increased over the first ten years of the study and declined between 1972 and 1982.

During the last six years, 1977 to 1982, labour productivity growth declined to almost half its average of the previous five years. As the analysis of Table 3.4.1 suggests, this fall of almost 2 percentage points originated mostly from the drastic fall in the growth rate of the materials-labour ratio. Other sources were the declining utilization of capacity and a slowdown in the rate at which labour employment contracted during this period relative to the previous ten years.

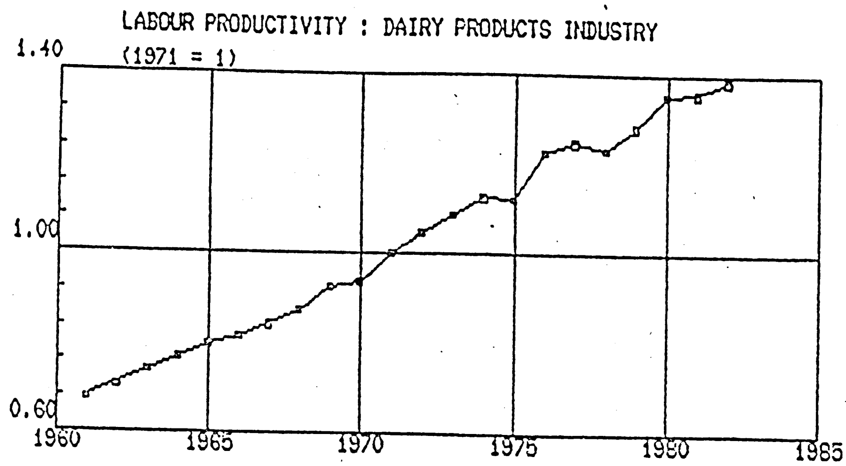
TABLE 3.4.1

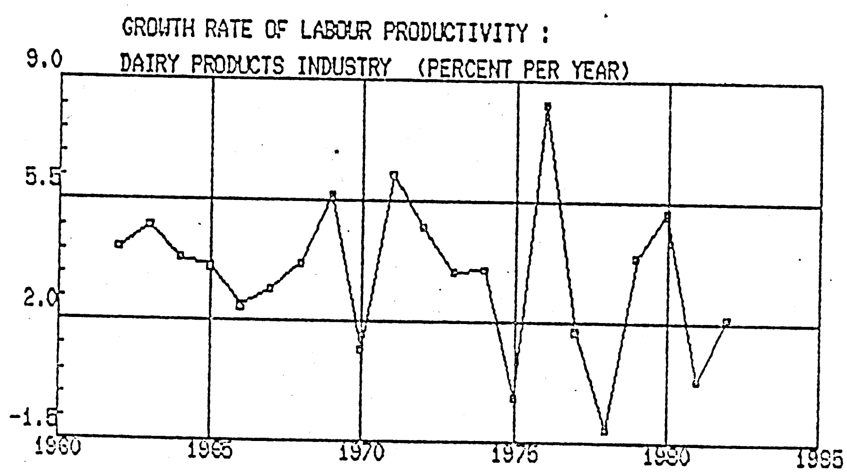
DAIRY PRODUCTS INDUSTRY

SOURCES OF LABOUR PRODUCTIVITY GROWTH: 1961-1982

(PERCENT PER YEAR)

	1962-66	1967-71	1972-76	1977-82	1962-1982
LABOUR PRODUCTIVITY GROWTH	3.787	3.998	4.028	2.067	3.403
TECHNICAL PROGRESS (T.F.P. GROWTH)	0.256	0.145	0.032	-0.090	0.077
CAPITAL	0.432	0.646	0.431	0.260	0.433
ENERGY	0.036	0.038	0.002	-0.010	0.015
MATERIAL INPUTS	2.740	3.387	3.555	1.834	2.829
UTILIZATION OF CAPACITY	0.183	-0.196	0.113	-0.041	0.011
RETURNS-TO-SCALE	0.006	0.200	0.214	0.051	0.115
RESIDUAL GROWTH	0.131	-0.221	-0.321	0.064	-0.079


LABOUR PRODUCTIVITY : DAIRY PRODUCTS INDUSTRY
(1971 = 1)
1.40
1.00
0.60
1960
1965
1970
1975
1980
1985


GROWTH RATE OF LABOUR PRODUCTIVITY :
DAIRY PRODUCTS INDUSTRY (PERCENT PER YEAR)
9.0
5.5
2.0
-1.5
1960
1965
1970
1975
1980
1985

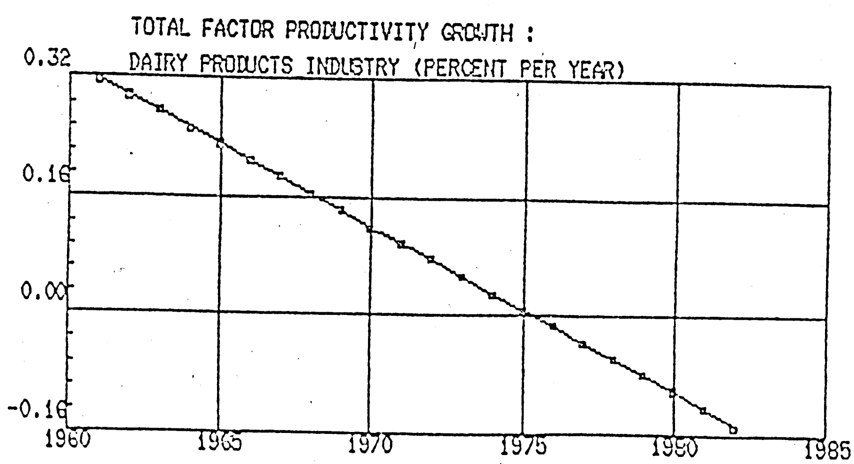

TOTAL FACTOR PRODUCTIVITY GROWTH :
DAIRY PRODUCTS INDUSTRY (PERCENT PER YEAR)
0.32
0.16
0.00
-0.16
1960
1965
1970
1975
1980
1985

TABLE 3.4.2

DAIRY PRODUCTS INDUSTRY (SIC 1040)

Alternative Regression Results

$$\ln q = \ln A + a_1 * \ln k + a_2 * \ln e + a_3 * \ln m + a_4 * t + a_5 * t^2 + a_6 * c + a_7 * \ln L + a_8 * t * \ln K + a_9 * t * \ln E + a_{10} * t * \ln M$$

a1=0.075724 a2=0.013668 a3=0.802762

Estimation Method	lnA	a4	a5	a6	a7	a8	a9	a10	R^2	D.W.	Rho	Cond.No.
OLS	-0.0336 (0.18)	0.0344 (1.31)	--	0.0006 (1.83	-0.0127 (0.37	-0.0068 (1.71)	-0.0027 (1.09)	0.0026 (0.41)	0.963	1.68	--	2080
OLS First Diff	-	-0.0098 (0.330	-0.0001 (0.88	0.0014 (3.07)	-0.0747 (2.12)	0.0001 (0.01)	-0.0007 (0.34)	0.0036 (.70)	0.760	1.53	--	142
OLS First Diff	--	-0.0095 (0.42)	-0.0001 (1.77)	0.0014 (4.65)	-0.0750 (2.54)	--	-0.0007 (0.37)	0.0037 (0.78)	0.760	1.54	--	101
OLS First Diff	--	-0.0126 (0.62)	-0.0001 (1.83)	0.0014 (4.77)	-0.0764 (2.68)	--	--	0.0035 (0.77)	0.758	1.48	--	87
OLS First Diff	--	--	-0.0001 (2.19)	0.0015 (5.12)	-0.0749 (2.69)	--	--	0.0007 (2.54)	0.752	1.51	--	4
OLS	-0.2407 (1.54)	0.0023 (3.79)	--	0.0008 (2.69)	0.0293 (0.90)	--	--	--	0.904	0.89	--	456
GLS	0.0576 (0.42)	0.0032 (3.79)	-0.0001 (3.04)	0.0014 (4.85)	-0.0473 (1.62)	--	--	--	0.871	1.52	0.714	244
OLS	--	0.0031 (2.43)	-0.0001 (2.07)	0.0015 (5.14)	-0.0749 (2.67)	--	--	--	0.749	1.51	--	4

3.5 Flour and Breakfast Cereal Products Industry

Table 3.5.1 summarizes most of the empirical results obtained for this industry. They are based on econometric estimation of equation (2.2.26) using aggregate data on inputs and other variables discussed in Appendices 1 and 2. Equation (2.2.22), based on Hicks neutrality of technical progress was also estimated but, as Table 3.5.2 shows, this assumption could not be maintained. The estimating equation, which accounts also for biased technical progress, is

d(lnq)=0.08571*d(lnk)+0.00814*d(lne)+0.807395*d(lnm)

-0.023576*d(t)-0.000119*d(t^2)+0.001955*d(c)
(2.76)   (2.73)   (21.77)

-0.08222*d(lnL)+0.005708*d(t*(lnK))
(5.24)   (3.00)

R^2 = 0.974039   D.W. = 1.62918   S.E.R. = 0.002171
Condition Number: 43

This equation is the first-difference of equation (2.2.26) and obtains estimated coefficients for the time trend, time squared, the effect of capacity utilization on labour productivity, q, the aggregate labour input (which in this formulation measures returns-to-scale) and for the interaction of time and capital stock. The Durbin-Watson statistic indicates absence of autocorrelation at the 1% level and the Condition Number does not indicate the presence of serious multicollinearity in our estimation. All estimated coefficients are significant at the 98% level or better.

The above results show that technical change is not Hicks neutral in this industry but is rather biased in favour of capital (capital-using). As Table 3.5.2 suggests, the hypotheses that technical change is biased with respect to energy and material inputs could not be sustained and these variables were not included in the final estimation. According to the coefficient of labour, the industry operates under decreasing returns-to-scale conditions: returns-to-scale (unity plus the labour coefficient) is approximately 0.917. Since technical progress is biased, its magnitude, which varies over the study period, is given by equation (2.2.27).

Using the growth accounting framework of equation (2.3.2) and the above econometric results we can now analyse the decline in labour productivity growth which occured over the study period. Labour productivity grew at an average annual rate of 2.332% per year between 1962 and 1966. As Table 3.5.1 indicates, the 5-year average growth rate continued to decline over the following ten years and then dropped sharply during the next six years (1977-82). Our analysis suggests that the sources of this decline were not uniform throughout the period. The slight decline (approximately half of one percentage point) which occurred over the first ten years seems to have originated from declining utilization of capacity and declining technical progress. The fall in labour productivity growth of the subsequent five years, however, occurred as a result of a substantial fall in the contribution of capital (declining capital-labour ratio) and of returns-to-scale (growing employment of labour).

During the last six years of the study period, 1977-82, labour productivity growth declined to little more than one third of its value during the previous five years. This was the result of a fall in the contributions of all sources of labour productivity growth, with the exception of capital. The most substantial decline, however, was in the contribution of material inputs: it fell to almost one sixth its value during the previous five years. In short, slower growth in the use of material inputs and larger growth in employment of labour (which reduced labour productivity growth directly as well) led to the drastic decline we observe.

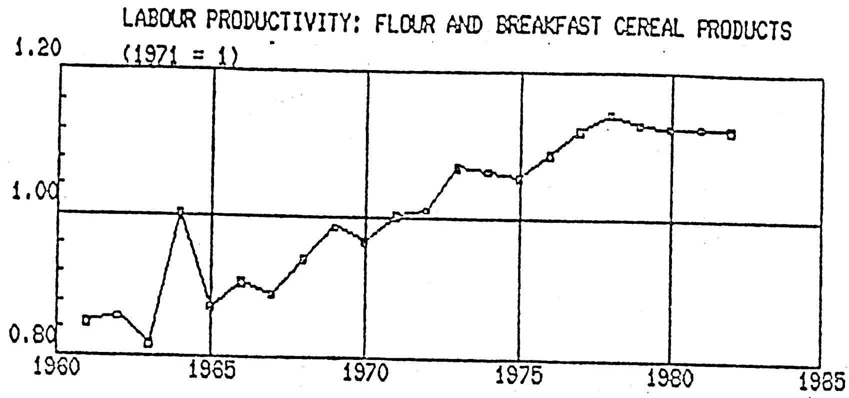
TABLE 3.5.1

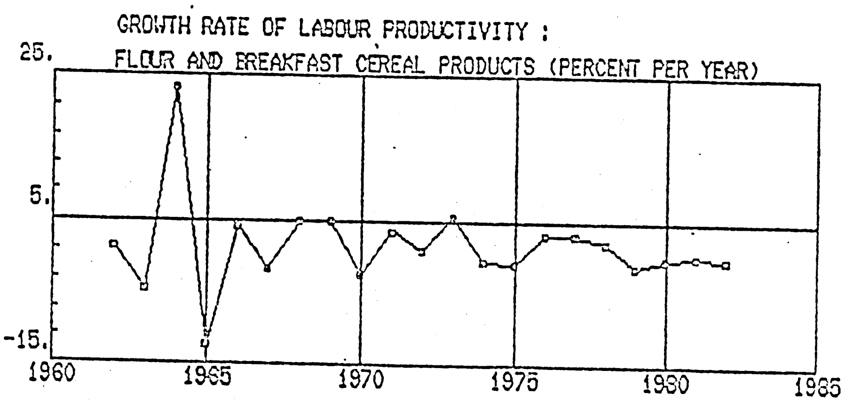
FLOUR & BREAKFAST CEREAL PRODUCTS INDUSTRY

SOURCES OF LABOUR PRODUCTIVITY GROWTH: 1961-1982

(PERCENT PER YEAR)

	1962-66	1967-71	1972-76	1977-82	1962-1982
LABOUR PRODUCTIVITY GROWTH	2.332	1.852	1.634	0.589	1.553
TECHNICAL PROGRESS (T.F.P. GROWTH)	0.140	0.083	-0.075	-0.180	-0.016
CAPITAL	0.409	0.427	-0.283	0.255	0.204
ENERGY	0.010	0.036	0.017	0.005	0.016
MATERIAL INPUTS	1.456	1.567	1.802	0.305	1.236
UTILIZATION OF CAPACITY	-0.146	-0.233	0.314	0.215	0.045
RETURNS-TO-SCALE	0.052	0.217	-0.020	-0.073	0.038
RESIDUAL GROWTH	0.408	-0.247	-0.119	0.061	0.027


LABOUR PRODUCTIVITY: FLOUR AND BREAKFAST CEREAL PRODUCTS
(1971 = 1)
1.20
1.00
0.80
1960
1965
1970
1975
1980
1985


GROWTH RATE OF LABOUR PRODUCTIVITY :
FLOUR AND BREAKFAST CEREAL PRODUCTS (PERCENT PER YEAR)
25.
5.
-15.
1960
1965
1970
1975
1980
1985

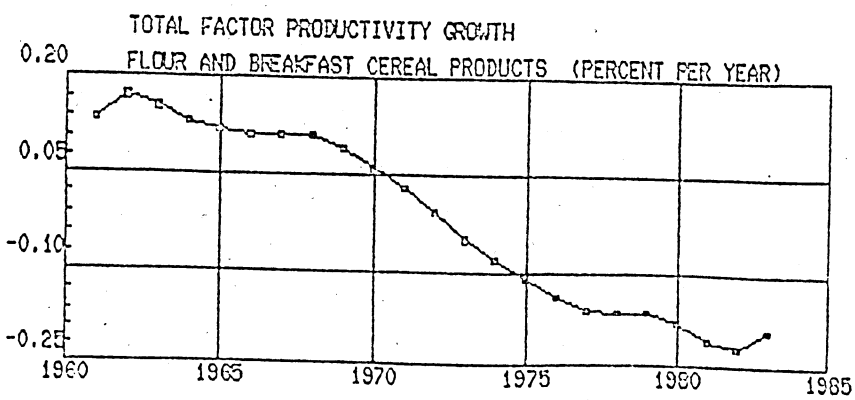

TOTAL FACTOR PRODUCTIVITY GROWTH
FLOUR AND BREAKFAST CEREAL PRODUCTS (PERCENT PER YEAR)
0.20
0.05
-0.10
-0.25
1960
1965
1970
1975
1980
1985

TABLE 3.5.2

FLOUR & BREAKFAST CEREAL PRODUCTS INDUSTRY (SIC 1050)

Alternative Regression Results

$\ln q = \ln A + a_1 * \ln k + a_2 * \ln e + a_3 * \ln m + a_4 * t + a_5 * t^2 + a_6 * c + a_7 * \ln L + a_8 * t * \ln K + a_9 * t * \ln E + a_{10} * t * \ln M$

a1=0.08571 a2=0.00814 a3=0.807395

Estimation Method	lnA	a4	a5	a6	a7	a8	a9	a10	R^2	D.W.	Rho	Cond.No.
OLS	0.1395 (1.05)	-0.0033 (0.29)	--	0.0019 (11.01)	-0.0674 (2.35)	0.0051 (3.07)	-0.0023 (1.08)	-0.0018 (0.59)	0.971	1.12	--	1200
OLS First Diff	--	-0.0248 (1.64)	-0.0001 (2.47)	0.0019 (17.71)	-0.0841 (4.39)	0.0054 (2.42)	0.0005 (0.34)	0.0001 (0.00)	0.974	1.61	--	83
OLS First Diff	--	-0.0247 (2.65)	-0.0001 (2.67)	0.0019 (20.59)	-0.0841 (4.97)	0.0054 (2.60)	0.0005 (0.37)	-	0.974	1.61	--	50
OLS First Diff	-	-0.0235 (2.76)	-0.0001 (2.73)	0.0019 (21.77)	-0.0822 (5.24)	0.0057 (3.00)	--	--	0.974	1.62	--	43
GLS	0.1944 (2.18)	0.0016 (1.79)	-0.0006 (1.81)	0.0018 (16.60)	-0.0790 (3.99)	--	--	--	0.957	1.68	0.773	130
GLS	0.2789 (3.46)	--	-0.0000 (0.54)	0.0018 (14.72)	-0.0957 (5.15)	--	--	--	0.946	1.70	0.645	140
GLS	0.2497 (2.79)	0.0006 (0.21)	--	0.0018 (15.35)	-0.0896 (4.43)	--	--	--	0.949	1.78	0.752	120
OLS First Diff	--	0.0018 (1.53)	-0.0007 (1.48)	0.0019 (17.77)	-0.0830 (4.36)	--	--	--	0.959	1.33	--	3

3.6 Feed Industry

Table 3.6.1 summarizes most of the empirical results obtained for this industry. They are based on econometric estimation of equation (2.2.22) using aggregate data on inputs and other variables discussed in Appendices 1 and 2. Equation (2.2.26), which relaxes the assumption of Hicks neutrality of technical progress, was also estimated on this data. The chosen estimating equation, maintaining Hicks neutrality, is

$$d(\ln q)=0.087025*d(\ln k)+0.010796*d(\ln e)+0.834008*d(\ln m)$$

$$\underset{(4.30)}{+0.011527*d(t)}\underset{(3.62)}{-0.000392*d(t^2)}\underset{(11.65)}{+0.001754*d(c)}$$

$$\underset{(2.26)}{-0.055778*d(\ln L)}$$

R^2=0.893981 D.W.=1.89343 S.E.R.=0.003498 Rho: 0.479189
Condition Number: 3.53759

This equation is the first-difference of equation (2.2.22) and obtains estimated coefficients for the time trend, the square of the time trend, the effect of capacity utilization on labour productivity, q, and for aggregate labour input which, in this formulation, measures return-to-scale. The Durbin-Watson statistic indicates absence of autocorrelation at the 5% level and the Condition Number assures us of absence of serious multicollinearity in our estimation.

Due to autocorrelation in our earlier estimation of this equation, the Cochrane-Orcutt procedure was used in the final estimation along with the Prais-Winsten procedure to avoid losing the first set of observations. All estimated coefficients were significant at the 96% level or better.

Our results are based on Hicks neutrality of technical progress. However, this rate was not constant over the study period as indicated by the coefficient of time trend squared. From the two time coefficients we know that technical progress is a declining function of time: at the beginning of the study period it occurred at the rate of 1.15% per year and declined by about 0.08% in each subsequent year so that by 1982 it approached negative half of one percent. Its average over the 1962-1982 period was 0.29% per year as Table 3.6.1 indicates. According to the coefficient of labour, the industry operates under decreasing returns-to-scale conditions: returns-to-scale (unity plus the labour coefficient) is approximately 0.944.

Using the growth accounting framework of equation (2.3.2) and the above econometric results, we can now analyse the changes in labour productivity growth this industry experienced over the study period. As Table 3.6.1 shows, labour productivity growth was remarkably high over the 1962-1966 sub-period. This rate of almost 7% per year declined over the next two sub-periods to 2.217% for 1972-76.

During the last sub-period (1977-82), however, it made a substantial recovery and rose to 3.921% per year. In analysing the sources of this productivity growth decline and later recovery, we first note that the growth of materials-labour ratio accounts for a substantial portion of growth in labour productivity -- almost 85% over the study period. As the growth rate of the materials-labour ratio declined over the first three sub-periods so also did labour productivity growth. The recovery of labour productivity growth during 1977-82 is also substantially attributable to rising growth in the materials-labour ratio: almost 85% of the recovery came from increased use of material inputs. It is noteworthy that the Feed Industry is highly materials-intensive: they account for more than 83% of the value of the industry's total output. Other factors which contributed both to the decline in labour productivity growth and to its recovery are utilization of capacity and the energy-labour ratio. These sources of growth are considerably smaller in magnitude but, together with the materials-labour ratio, share the overall pattern of productivity growth change.

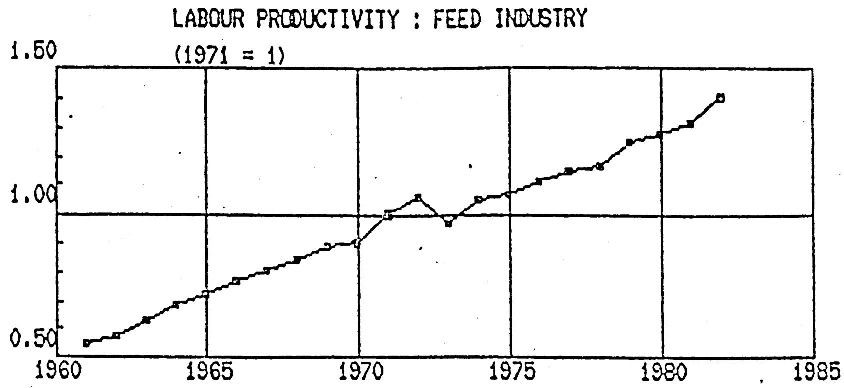
TABLE 3.6.1

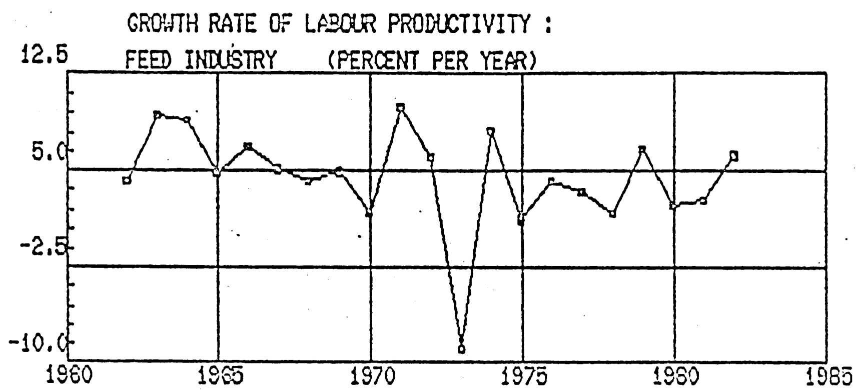
FEED INDUSTRY

SOURCES OF LABOUR PRODUCTIVITY GROWTH: 1961-1982

(PERCENT PER YEAR)

	1962-66	1967-71	1972-76	1977-82	1962-1982
LABOUR PRODUCTIVITY GROWTH	6.915	5.279	2.217	3.921	3.551
TECHNICAL PROGRESS (T.F.P. GROWTH)	0.917	0.525	0.133	-0.297	0.290
CAPITAL	0.191	0.619	0.533	0.288	0.402
ENERGY	0.061	0.025	0.009	0.035	0.033
MATERIAL INPUTS	5.366	4.436	2.430	3.318	3.861
UTILIZATION OF CAPACITY	0.000	-0.040	-0.507	0.438	-0.005
RETURNS-TO-SCALE	-0.056	0.018	0.040	-0.039	-0.010
RESIDUAL GROWTH	0.434	-0.307	-0.422	0.178	-0.019


LABOUR PRODUCTIVITY : FEED INDUSTRY
(1971 = 1)
1.50
1.00
0.50
1960
1965
1970
1975
1980
1985


GROWTH RATE OF LABOUR PRODUCTIVITY :
FEED INDUSTRY (PERCENT PER YEAR)
12.5
5.0
-2.5
-10.0
1960
1965
1970
1975
1980
1985

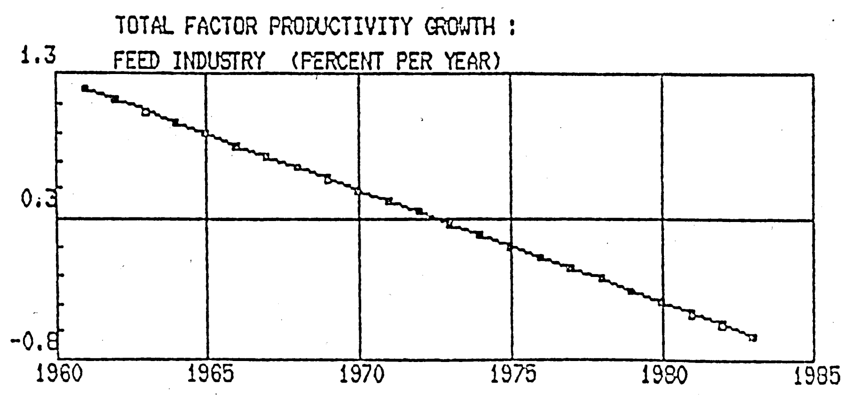

TOTAL FACTOR PRODUCTIVITY GROWTH :
FEED INDUSTRY (PERCENT PER YEAR)
1.3
0.3
-0.8
1960
1965
1970
1975
1980
1985

TABLE 3.6.2

FEED INDUSTRY (SIC 1060)

Alternative Regression Results

$\ln q = \ln A + a_1 * \ln k + a_2 * \ln e + a_3 * \ln m + a_4 * t + a_5 * t^2 + a_6 * c + a_7 * \ln L + a_8 * t * \ln K + a_9 * t * \ln E + a_{10} * t * \ln M$

a1=0.087025 a2=0.010796 a3=0.83408

Estimation Method	lnA	a4	a5	a6	a7	a8	a9	a10	R^2	D.W.	Rho	Cond.No.
OLS	-0.2100 (1.67)	0.0453 (9.29)	--	0.0017 (6.40)	-0.0074 (0.28)	-0.0135 (4.52)	-0.0005 (0.38)	0.0057 (1.4)	0.983	1.24	--	1100
OLS First Diff	--	0.0622 (2.71)	0.0001 (0.67)	0.0016 (8.39)	-0.0338 (1.46)	-0.0148 (2.87)	-0.0007 (0.55)	0.0033 (1.13)	0.930	1.83	--	110
OLS First Diff	--	0.0537 (3.21)	0.0007 (0.42)	0.0016 (8.81)	-0.0344 (1.53)	-0.0129 (3.41)	--	0.0026 (1.02)	0.929	1.76	--	71
OLS First Diff	--	0.0471 (7.13)	--	0.0016 (9.06)	-0.0359 (1.66)	-0.0116 (5.31)	--	0.0030 (1.21)	0.928	1.73	--	42
OLS First Diff	--	0.0506 (8.39)	--	0.0018 (12.06)	-0.0325 (1.49)	-0.0093 (7.59)	--	--	0.921	1.51	--	18
OLS	-0.3668 (2.81)	0.0109 (15.12)	-0.0004 (13.44)	0.0022 (9.47)	0.0168 (0.53)	--	--	--	0.964	1.31	-	430
GLS	-0.0945 (0.74)	0.0113 (7.98)	-0.0004 (6.53)	0.0018 (9.25)	-0.0344 (1.21)	--	--	--	0.909	1.17	0.878	72
GLS	--	0.0115 (8.11)	-0.0004 (6.64)	0.0018 (9.51)	-0.0653 (12.16)	--	--	--	0.905	1.06	0.886	10
OLS First Diff	--	0.0115 (6.70)	-0.0004 (5.74)	0.0017 (9.42)	-0.0362 (1.30)	--	--	--	0.874	1.15	--	3
GLS First Diff	--	0.0115 (4.30)	-0.0003 (3.62)	0.0017 (11.65)	-0.0557 (2.26)	--	--	--	0.893	1.89	0.479	3

3.7 Slaughtering and Meat Processors

The empirical results for this industry have been summarized in Table 3.7.1. They are based on econometric estimation of equation (2.2.22) using aggregate data discussed in Appendices 1 and 2. As Table 3.7.2 shows, this specification proved superior to equation (2.2.26) which assumes non-neutral technical change. Our estimating equation is

$$\underset{}{lnq}=\underset{(61.46)}{-0.201049}+0.0451*lnk+0.006011*lne+0.855353*lnm$$

$$\underset{(21.19)}{+0.007133*t}\underset{(7.56)}{-0.000116*t^2}\underset{(55.01)}{+0.151852*c}\underset{(19.18)}{-0.092913*lnL}$$

R^2=0.999092 D.W.=2.01112 S.E.R.=0.000785

Rho1 = 1.42578 Rho2: - 0.7003671
Condition Number: 18.261

All variables (except the time trend) were rescaled so that 1971=1 for regressions. This equation obtains estimated coefficients for the time trend (t and t^2), the effect of capacity utilization on labour productivity, q, and for aggregate labour input which, in this formulation, measures returns-to-scale. Second order autocorrelation of the residuals was corrected using the Cochrane-Orcutt procedure together with the Prais-Winsten procedure. The autocorrelation coefficients satisfy stationarity conditions. All estimated coefficients are highly significant. Other regression statistics are quite satisfactory, showing no significant multicollinearity or autocorrelation.

Our final results indicate that technical progress is best described as Hicks neutral with a mildly declining trend over time. According to the coefficient of labour, the industry operates under descreasing returns-to-scale conditions: returns-to-scale (unity plus the labour coefficient) is approximately 0.907.

Table 3.7.1 summarizes the sources of labour productivity growth for the study period as well as four subperiods. Labour productivity grew at an average annual rate of about 3.4 percent and displayed only small variations except during the 1977-82 subperiod when it averaged about 2.5 percent per year. This decline appears to have originated mostly from a decline in the growth of materials to labour ratio, which accounted for about 85 percent of labour productivity growth over the study period. The second most important source of labour productivity was technical progress, which averaged about 0.46 percent per year and declined by 0.02 percent each year. With decreasing returns-to-scale in production, growing labour employment in this industry made a negative contribution toward labour productivity growth but its magnitude was rather negligible. The contributions of capital-labour and energy-labour ratios were similarly small.

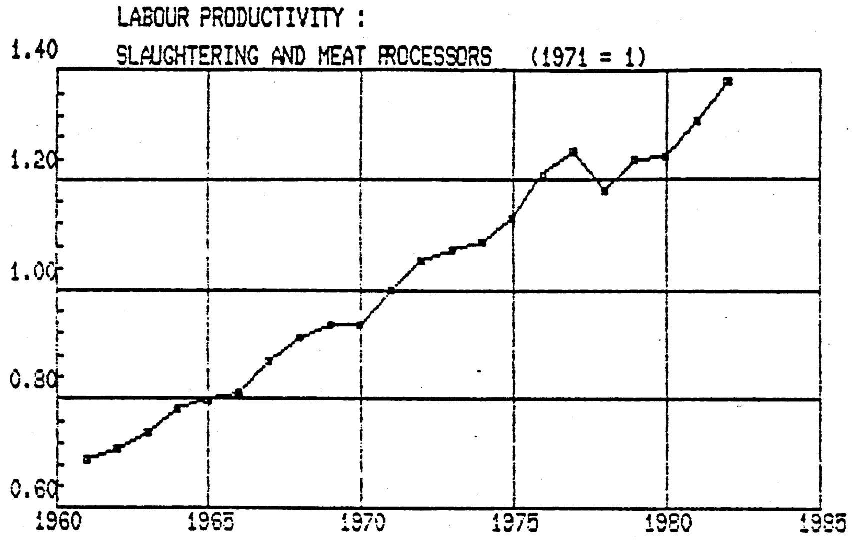
TABLE 3.7.1

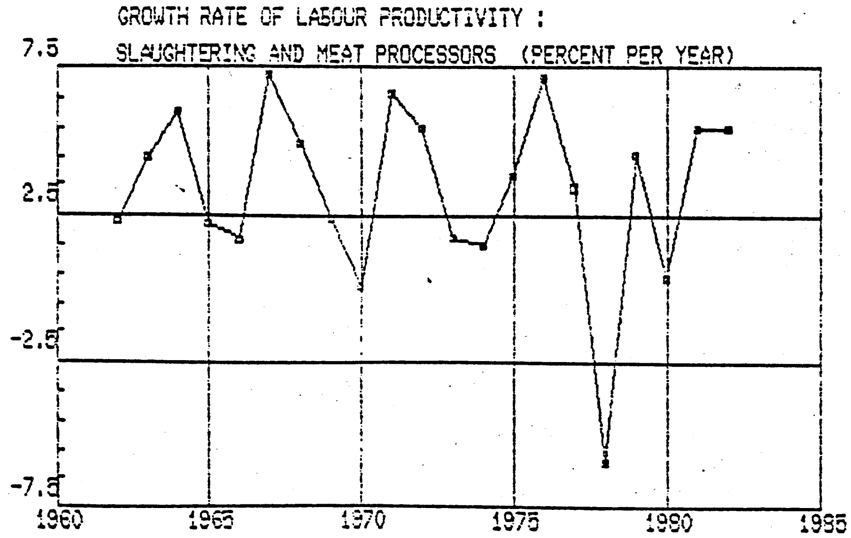
SLAUGHTERING AND MEAT PROCESSORS

SOURCES OF LABOUR PRODUCTIVITY GROWTH: 1961-1982

(PERCENT PER YEAR)

	1962-66	1967-71	1972-76	1977-82	1962-1982
LABOUR PRODUCTIVITY GROWTH	3.328	4.277	3.940	2.246	3.391
TECHNICAL PROGRESS (T.F.P. GROWTH)	0.644	0.528	0.412	0.284	0.458
CAPITAL	0.034	0.130	0.098	0.109	0.094
ENERGY	0.032	0.012	0.018	0.001	0.015
MATERIAL INPUTS	2.744	3.572	3.251	2.341	2.947
UTILIZATION OF CAPACITY	-0.193	0.115	0.201	-0.478	-0.123
RETURNS-TO-SCALE	-0.078	-0.073	-0.078	0.005	-0.053
RESIDUAL GROWTH	0.146	-0.006	0.038	-0.016	0.038


LABOUR PRODUCTIVITY :
SLAUGHTERING AND MEAT PROCESSORS (1971 = 1)
1.40
1.20
1.00
0.80
0.60
1960
1965
1970
1975
1980
1985


GROWTH RATE OF LABOUR PRODUCTIVITY :
SLAUGHTERING AND MEAT PROCESSORS (PERCENT PER YEAR)
7.5
2.5
-2.5
-7.5
1960
1965
1970
1975
1980
1985

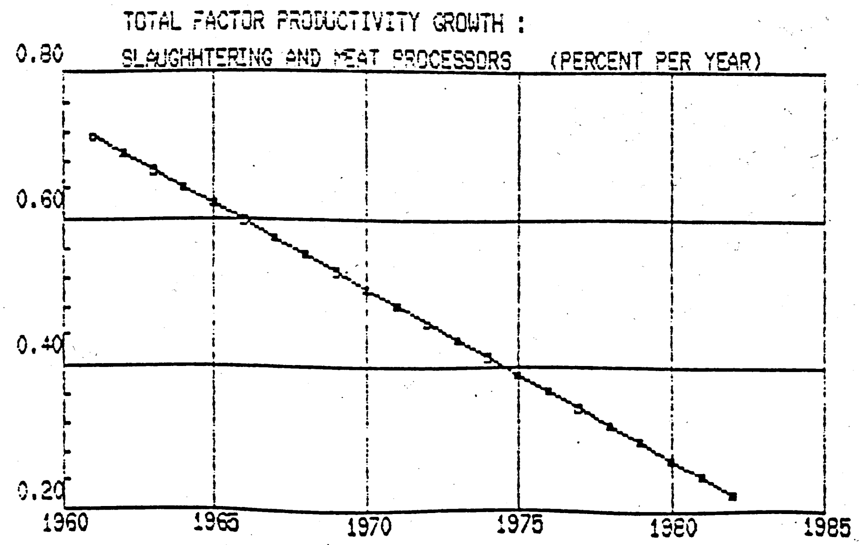

TOTAL FACTOR PRODUCTIVITY GROWTH :
SLAUGHHTERING AND MEAT PROCESSORS (PERCENT PER YEAR)
0.80
0.60
0.40
0.20
1960
1965
1970
1975
1980
1985

TABLE 3.7.2 SLAUGHTERING AND MEAT PROCESORS (SIC 1011)

Alternative Regression Results

$$\ln q = \ln A + a_1 * \ln k + a_2 * \ln e + a_3 * \ln m + a_4 * t + a_5 * t^2 + a_6 * c + a_7 * \ln L + a_8 * t * \ln K + a_8 * t * \ln E + a_{10} * t * \ln M$$

a1=0.0451 a2=0.006011 a3=0.855353

Estimation Method	lnA	a4	a5	a6	a7	a8	a9	a10	R^2	D.W.	Rho1	Rho2	Cond. No.
OLS	-0.2010 (29.68)	0.0054 (12.41)	0.0006 (1.60)	0.1515 (21.91)	-0.07069 (9.33)	-0.0058 (5.41)	-0.0005 (1.17)	-0.0007 (0.69)	0.999	1.341	-	-	186
GLS	-0.2014 (64.69)	0.0061 (20.52)	-2.5E-06 (0.10)	0.1510 (51.99)	-0.0867 (15.61)	-0.0045 (4.61)	-0.0002 (0.59)	-	0.999	1.54	0.7474	-	36
GLS	-0.2013 (69.47)	0.0061 (55.57)	-	0.1509 (55.69)	-0.0867 (17.60)	-0.0047 (15.81)	-	-	0.999	1.55	0.7732	-	14
GLS	-0.2038 (16.99)	0.0048 (13.03)	-	0.1542 (20.31)	-0.0933 (6.74)	-	-	-	0.997	0.0383	0.9803	-	2
GLS	-0.2039 (40.21)	0.0073 (16.57)	-0.0001 (6.42)	0.1529 (33.94)	-0.0962 (11.54)	-	-	-	0.998	0.874	0.8828	-	10
GLS AR2	-0.2010 (61.46)	0.0071 (21.19)	-0.0001 (7.56)	0.1518 (55.01)	-0.0929 (19.18)	-	-	-	0.999	2.011	1.4257	-0.7036	18

3.8 Poultry Processors

The empirical results for this industry have been summarized in Table 3.8.1. They are based on econometric estimation of equation (2.2.26) using aggregate data discussed in Appendices 1 and 2. The parameters of equation (2.2.22), which restricts technical change to be Hicks neutral, were also estimated but the model performed better with the former specification. Our estimating equation is

$$\underset{(1.71)}{\ln q=0.009451}+0.054388*\ln k+0.008837*\ln e+0.829021*\ln m$$

$$\underset{(2.08)}{-0.000107*t^2}\underset{(5.74)}{-0.098063*\ln L}\underset{(4.51)}{+0.008127*t*\ln M}$$

R^2=0.928972   D.W. = 2.17926   S.E.R. = 0.005727

Rho1: 0.81763 Rho2: -0.52474
Condition Number: 13.056

All variables of the regression (except the time trend) were rescaled so that 1971=1. This equation obtains estimated coefficients for the square of the time trend, the aggregate labour input (which measures returns-to-scale), and the interaction of time and material inputs index. The results indicate that technical progress in this industry is not Hicks neutral but biased toward material inputs (materials-using).

Second order autocorrelation of the residuals was corrected using the Cochrane-Orcutt procedure together with the Prais-Winten procedure. The significance level of the coefficient of time squared is approximately 95%. Other coefficients are significant at the 98% level or better. Other regression statistics are quite satisfactory, showing no significant multicollinearity or autocorrelation. Since the coefficient of labour is less than zero, returns-to-scale is decreasing in this industry: The value of this parameter (unity plus the labour coefficient) is approximately 0.90. Since technical change is biased its magnitude for each year is given by equation (2.2.27).

Table 3.8.1 summarizes the sources of labour productivity growth for the study period and four subperiods. Labour productivity grew at an average annual rate of about 2.7 percent but this rate varied considerably between the four subperiods. From an average annual rate of about 4.5 percent between 1962 and 1966 it declined to about 2.6 percent over the next five years, and fell to less than one third of a percent per year between 1972 and 1976. During the last subperiod, 1977-1982, it recovered substantially and averaged about 3.2 percent per year. Our analysis suggests that both the decline and the recovery of labour productivity growth originated mainly from changes in the materials-labour and capital-labour ratio. The growth rates of both of these contributing factors declined sharply over the first three subperiods (1962-1976) resulting in a decline in labour productivity growth. The 1977-1982 recovery was almost entirely caused by a large increase in the growth rate of the materials-labour ratio. Over the study period, this variable accounted for about 97 percent of the growth in labour productivity.

Technical progress was negative during the entire study period and averaged -0.24 percent per year. However, as other regression results in Table 3.8.2 also confirm, technical progress increased substantially during this period from a low of about -0.43 percent in the first subperiod to a high of about -0.13 percent per year between 1977 and 1982. Since technical progress is materials-using, its improvement was entirely due to the increasing share of material inputs in the value of the industry's gross output. As Table 3.8.1 shows, the growth in the energy-labour ratio made only a small contribution to labour productivity growth. With decreasing returns-to-scale in production, growing labour employment made a negative contribution to labour productivity growth. This contribution varied from a low of -0.54 percent during the first subperiod to a high of -0.11 percent for the last period.

TABLE 3.8.1

POULTRY PROCESSORS

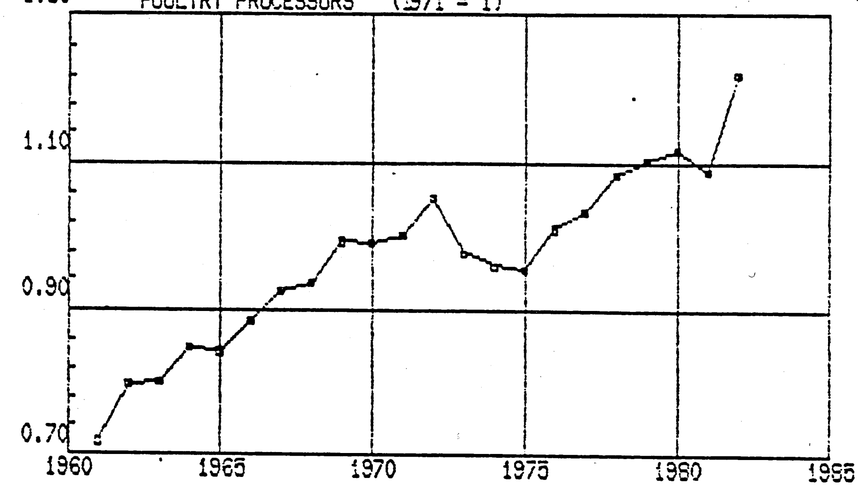
SOURCES OF LABOUR PRODUCTIVITY GROWTH: 1961-1982

(PERCENT PER YEAR)

	1962-66	1967-71	1972-76	1977-82	1962-1982
LABOUR PRODUCTIVITY GROWTH	4.471	2.599	0.284	3.256	2.682
TECHNICAL PROGRESS (T.F.P. GROWTH)	-0.428	-0.232	-0.192	-0.129	-0.240
CAPITAL	1.813	0.605	0.289	0.151	0.688
ENERGY	0.034	0.029	0.004	0.013	0.020
MATERIAL INPUTS	4.097	2.240	0.488	3.421	2.603
RETURNS-TO-SCALE	-0.507	-0.227	-0.305	-0.110	-0.279
RESIDUAL GROWTH	-0.536	0.184	0.000	-0.090	-0.110

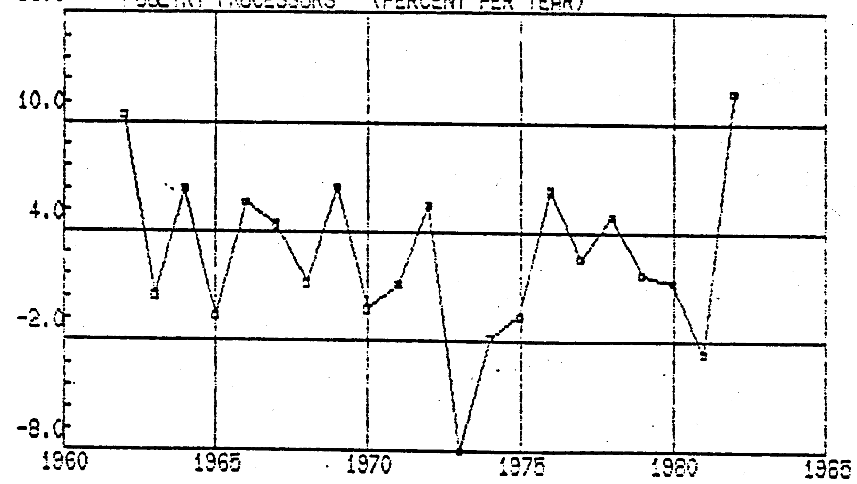
LABOUR PRODUCTIVITY :

POULTRY PROCESSORS (1971 = 1)



GROWTH RATE OF LABOUR PRODUCITIVY :

POULTRY PROCESSORS (PERCENT PER YEAR)



TOTAL FACTOR PRODUCTIVITY GROWTH :

POULTRY PROCESSORS (PERCENT PER YEAR)

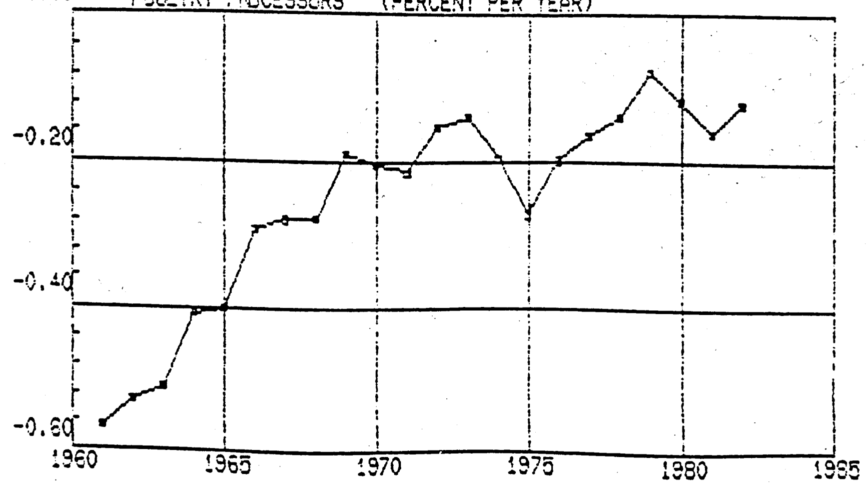


TABLE 3.8.2 POULTRY PROCESSORS (SIC 1012)

Alternative Regression Results

$\ln q = \ln A + a_1 * \ln k + a_2 * \ln e + a_3 * \ln m + a_4 * t + a_5 * t^2 + a_6 * c + a_7 * \ln L + a_8 * t * \ln E + a_{10} * t * \ln M$

a1=0.054388 a2=0.008837 a3=0.829021

Estimation Method	lnA	a4	a5	a6	a7	a8	a9	a10	R^2	D.W.	RhO1	RhO2	Cond. No.
OLS	-0.1512	0.0087	-0.0006	0.1373	-0.2272	0.0082	-0.0029	0.0092	0.968	1.558	-	-	131
	(5.06)	(3.17)	(4.36)	(5.08)	(6.11)	(4.68)	(0.97)	(2.89)					
GLS	-0.1467	0.0064	-0.0004	0.1420	-0.2043	0.0072	-0.0013	0.0067	0.970	1.861	0.3557	-	101
	(4.89)	(2.17)	(2.98)	(5.05)	(5.46)	(3.72)	(0.43)	(2.06)					
OLS	-	0.0015	-0.0001	0.1450	-0.1664	0.0045	0.0007	0.0035	0.860	1.981	-	-	15
FIRST DIFF		(0.39)	(0.89)	(5.38)	(4.47)	(1.79)	(0.29)	(1.13)					
GLS	-0.1458	0.0054	-0.0004	0.1450	-0.1945	0.0065	-	0.0054	0.970	1.853	0.4334	-	78
	(5.04)	(2.04)	(2.97)	(5.49)	(5.69)	(4.33)		(2.46)					
GLS	-0.1201	0.0037	-0.0003	0.1266	-0.1629	0.0056	-	0.0050	0.972	1.954	0.6112	-0.3703	97
AR2	(4.31)	(1.49)	(2.50)	(4.91)	(5.00)	(3.80)		(2.30)					
GLS	-0.0023	0.0045	-0.0004	-	-0.1506	0.0029	-	0.0116	0.912	1.601	0.4743	-	68
	(0.11)	(1.01)	(1.76)		(2.71)	(1.25)		(3.71)					
GLS	0.0058	0.0018	-0.0002	-	-0.1154	0.0015	-	0.0091	0.930	2.186	0.7457	-0.4902	85
AR2	(0.3)	(0.48)	(1.13)		(2.46)	(0.74)		(3.12)					
GLS	0.0163	-	-0.0001	-	-0.1017	0.0015	-	0.0093	0.909	1.500	0.5487	-	15
	(1.85)		(2.22)		(4.71)	(0.75)		(4.32)					
GLS	0.0124	-	-0.0001	-	-0.0956	0.0008	-	0.0079	0.929	2.191	0.7951	-0.5214	23
AR2	(1.55)		(1.70)		(5.42)	(0.49)		(3.17					
GLS	0.0094	-	-0.0001	-	-0.0980	-	-	0.0081	0.928	2.179	0.8176	-0.5247	13
AR2	(1.71)		(2.08)		(5.74)			(4.51)					
GLS	-0.1185	-0.0054	0.0002	0.1521	-0.1018	-	-	-	0.952	1.005	0.8792	-	12
	(4.00)	(2.40)	(3.25)	(6.43)	(3.64)								
GLS	-0.1025	-0.0040	0.0002	0.1262	-0.0925	-	-	-	0.968	1.803	1.2742	-0.6771	28
AR2	(5.01)	(2.61)	(3.91)	(7.32)	(4.85)								

3.9 Biscuit Manufacturers

The empirical results for this industry have been summarized in Table 3.9.1 They are based on econometric estimation of equation (2.2.26) using aggregate data discussed in Appendices 1 and 2. The selected estimating equation, which accounts for biased technical progress, is

$$\ln q=-0.05406+0.124868*\ln k+0.010357*\ln e+0.624764*\ln m$$
$$(10.36)$$

$$+0.005346*t+0.033357*t*\ln K+0.01075*t*\ln E$$
$$(7.34) \qquad (3.22) \qquad (2.91)$$

$$-0.012638*t*\ln M$$
$$(8.67)$$

R^2=0.765975   D.W. = 2.36421   S.E.R. = 0.013489

Rho1: 0.205869 Rho2: -0.423495
Condition Number: 12.7303

All variables of the regression (except the time trend) were rescaled so that 1971=1. This equation obtains estimated coefficients for the time trend, t, and for the interaction of time with capital, energy and material inputs. Technical progress in this industry is not Hicks neutral: The last three coefficients indicate that the bias is capital-using, energy-using and materials-saving. All coefficients are significant at the 99.5% level or better. However, in earlier specifications the coefficient of labour, which measures returns-to-scale, was found to be statistically insignificant and the variable was dropped from subsequent regressions. This implies that the industry operates under approximately constant returns-to-scale. The capacity utilization variable was also dropped from the regression as it was collinear with other independent variables. Second order autocorrelation of the residuals was corrected using The Cochrane-Orcutt procedure together with the Prais-Winsten procedure. Although Rho1 is only significant at the 67% level, the Cochrane-Orcutt procedure was found necessary because Rho2 is significant at the 94% level. Other regression statistics are quite satisfactory, showing no significant multicollinearity or autocorrelation in the final regression. Since technical progress is biased, its magnitude for each year is given by equation (2.2.27).

Table 3.9.1 summarizes the sources of labour productivity growth for the study period and four subperiods. Labour productivity grew at an average annual rate of about 2.4 percent over the study period. This rate increased substantially over the first three subperiods: labour productivity between 1972 and 1976 grew almost 2.4 times faster than it did between 1962 and 1966. Over the next six years, however, it dropped drastically, contracting at about -0.72 percent per year. Our analysis suggests that the substantial improvements of the first 15 years were due to growing materials-labour ratio (particularly for the 1972-76 period), growing capital-labour ratio (mostly over the first 10 years) and significantly increasing energy-labour ratio. Unlike most industries in the food and beverage sector, energy-labour ratio made a sizeable contribution to labour productivity growth, amounting to more than one half of one percent for the 1972-76 subperiod.

A sharp turnaround in labour productivity growth as well as technical progress occurred between the third and fourth subperiod. Our analysis finds that this was due to a sharp decline in labour employment from 1974 onwards combined with quickly increasing output until 1976. This led to a large labour productivity gain for the 1974-1976 period. After 1976, however, industry output declined sharply though at a slower rate than labour employment, producing a negative growth rate for labour productivity. Falling output was accompanied by falling purchases of material inputs, capital stock and energy input. These declining trends produced a smaller growth rate for the materials-labour ratio and negative growth rates for the capital-labour and energy-labour ratios which together reduced labour productivity growth to its (negative) level between 1977 and 1982. Technical progress, which depended on the levels of capital, energy and materials inputs used, also declined over this period: it averaged almost 0.15 percent per year, though it had substantially increased between 1962 and 1973.

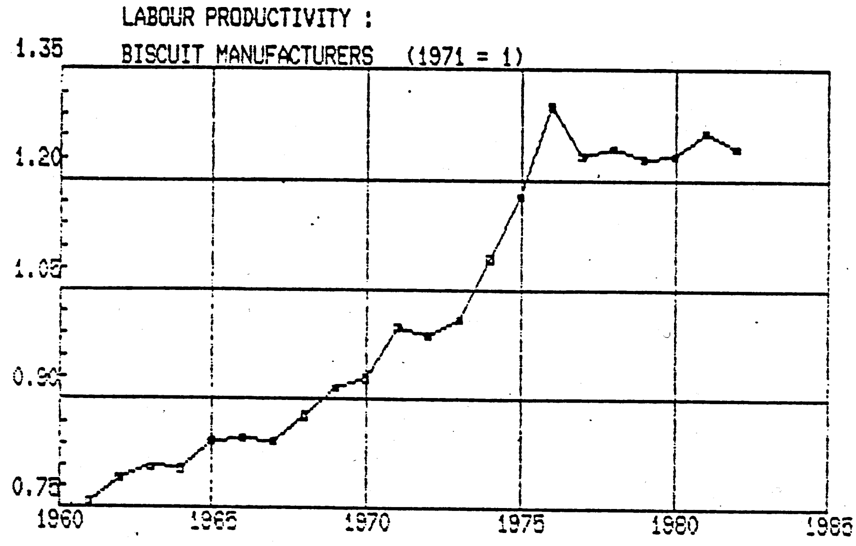
TABLE 3.9.1

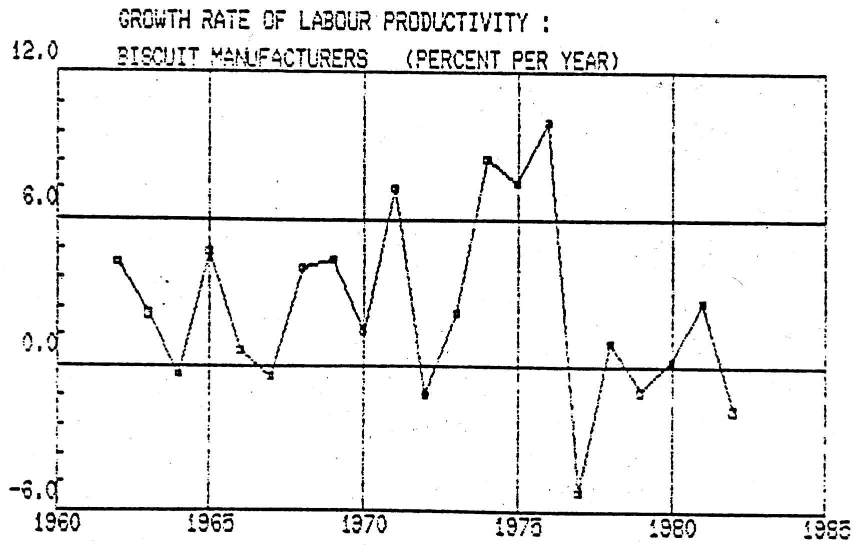
BISCUIT MANUFACTURERS

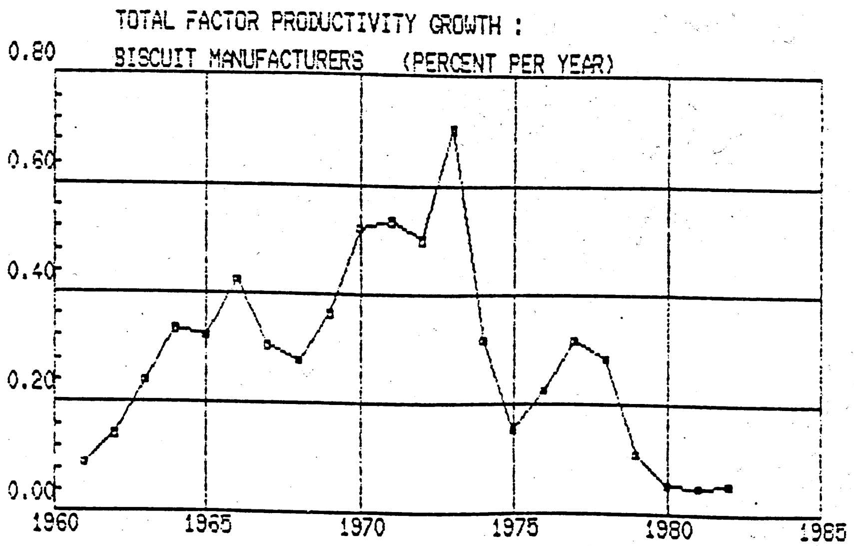
SOURCES OF LABOUR PRODUCTIVITY GROWTH: 1961-1982

(PERCENT PER YEAR)

	1962-66	1967-71	1972-76	1977-82	1962-1982
LABOUR PRODUCTIVITY GROWTH	2.245	3.317	5.395	-0.716	2.404
TECHNICAL PROGRESS (T.F.P. GROWTH)	0.293	0.402	0.381	0.146	0.298
CAPITAL	0.531	0.702	0.210	-0.387	0.233
ENERGY	0.120	0.127	0.555	-0.617	0.015
MATERIAL INPUTS	1.406	1.941	3.883	0.595	1.891
RESIDUAL GROWTH	-0.106	0.144	0.366	-0.452	-0.033


LABOUR PRODUCTIVITY :
BISCUIT MANUFACTURERS (1971 = 1)
1.35
1.20
1.05
0.90
0.75
1960
1965
1970
1975
1980
1985


GROWTH RATE OF LABOUR PRODUCTIVITY :
BISCUIT MANUFACTURERS (PERCENT PER YEAR)
12.0
6.0
0.0
-6.0
1960
1965
1970
1975
1980
1985


TOTAL FACTOR PRODUCTIVITY GROWTH :
BISCUIT MANUFACTURERS (PERCENT PER YEAR)
0.80
0.60
0.40
0.20
0.00
1960
1965
1970
1975
1980
1985

Alternative Regression Results

$$\ln q = \ln A + a_1 * \ln k + a_2 * \ln e + a_3 * \ln m + a_4 * t + a_5 * t^2 + a_6 * c + a_7 * \ln L + a_8 * t * \ln E + a_{10} * t * \ln M$$

a1=0.124868 a2=0.010357 a3=0.624764

Estimation Method	lnA	a4	a5	a6	a7	a8	a9	a10	R^2	D.W.	Rh01	Rh02	Cond. No.
OLS	-0.1651	0.0046	-4.8E-06	0.1168	0.0515	0.0211	0.0075	-0.0097	0.780	2.196	-	-	113
	(1.66)	(1.74)	(0.02)	(1.09)	(0.52)	(1.39)	(1.61)	(2.87)					
GLS	-0.1825	0.0044	1.3E-05	0.1370	0.0404	0.0282	0.0064	-0.0104	0.785	2.153	-0.1932	-	145
	(1.74)	(1.87)	(0.08)	(1.21)	(0.43)	(1.91)	(1.45)	(3.42)					
GLS	-0.1844	0.0046	-	0.1387	0.0357	0.0281	0.0063	-0.0102	0.785	2.147	-0.1891	-	129
	(1.88)	(5.04)		(1.30)	(0.49)	(1.97)	(1.55)	(5.07)					
OLS	-0.2023	0.0045	-	0.1593	-	0.0271	0.0080	-0.0102	0.773	2.287	-	-	77
	(2.73)	(4.40)		(2.01)		(2.27)	(1.90)	(4.83)					
GLS	-0.0535	0.0049	-	-	-	0.0253	0.0112	-0.0113	0.715	2.128	-	-	10
	(6.99)	(4.50)				(1.96)	(2.65)	(5.14)					
GLS	-0.0540	0.0053	-	-	-	0.0333	0.0107	-0.0126	0.765	2.364	-0.2085	-0.4234	12
	(10.36)	(7.34)				(3.22)	(2.91)	(8.67)					

3.10 Bakeries

The empirical results for this industry have been summarized in Table 3.10.1. They are based on econometric estimation of equation (2.2.26) using aggregate data described in Appendices 1 and 2. The selected estimating equation, which accounts for biased technical progress, is

$$\underset{(5.22)}{\ln q=-0.030168}+0.118289*\ln k+0.022004*\ln e+0.576753*\ln m$$

$$\underset{(6.12)}{+0.003233*t}\underset{(9.10)}{-0.257266*\ln L}\underset{(4.08)}{+0.00506*t*\ln E}\underset{(11.27)}{+0.020589*t*\ln M}$$

R^2=0.979705 D.W. = 2.01332 S.E.R. = 0.006683

Rho1: -0.330246 Rho2: -0.337384
Condition Number: 20.8901

All variables of the regression (except the time trend) were rescaled so that 1971=1. This equation obtains estimated coefficients for the time trend, t, aggregate labour input (which measures returns-to-scale), and for the interaction of time with energy input and material inputs. The signs of the last two coefficients indicate that technical progress in this industry is not Hicks neutral but rather biased toward energy and material inputs (energy-using and materials-using). All estimated coefficients are significant at the highest possible level. The returns-to-scale, given by unity plus the coefficient of labour, is approximately 0.74 indicating strongly decreasing returns. The capacity utilization variable and the square of the time trend were both dropped from the regression as they were highly collinear with other independent variables. The coefficient of interaction of time with capital input, however, was not statistically significant so this variable was also dropped from the regression. Second order autocorrelation of the residuals was corrected using the Cochrane-Orcutt procedure together with the Prais-Winsten procedure. All regression statistics are quite satisfactory, showing no significant multicollinearity or autocorrelation in the final regression. The magnitude of technical progress, which varies over time, is computed using equation (2.2.27).

Table 3.10.1 summarizes the sources of labour productivity growth for the study period and four subperiods. Labour productivity grew at an average annual rate of about 1.8 percent between 1962 and 1982. Almost one percent of this growth rate is accounted for by the growth rate of materials-labour ratio. With decreasing returns-to-scale in the industry, falling labour employment over most of the study period accounted for about 24 percent of the observed labour productivity growth. The growth in capital-labour ratio contributed about 0.2 percent per year, or about 12 percent of average labour productivity. Our results show that labour productivity considerably improved over the second subperiod, declined over the third subperiod and fell severely to a negative level between 1977 and 1982. The most important explanatory factor for these changes seems to be the growth rate of materials-labour ratio, which rose over the first ten years of the study period but declined thereafter and became negative between 1977 and 1982. Returns-to-scale also contributed to declining labour productivity. Although aggregate employment declined over the study period--contributing positively to labour productivity--it contracted at a progressively slower rate thus contributing less each year. Technical progress which rose sharply between 1961 and 1968 and generally declined thereafter accounted significantly for both rising and falling labour productivity. The energy-labour ratio declined over most of the study period which helped reduce labour productivity. The magnitude of this effect was, on average, quite small.

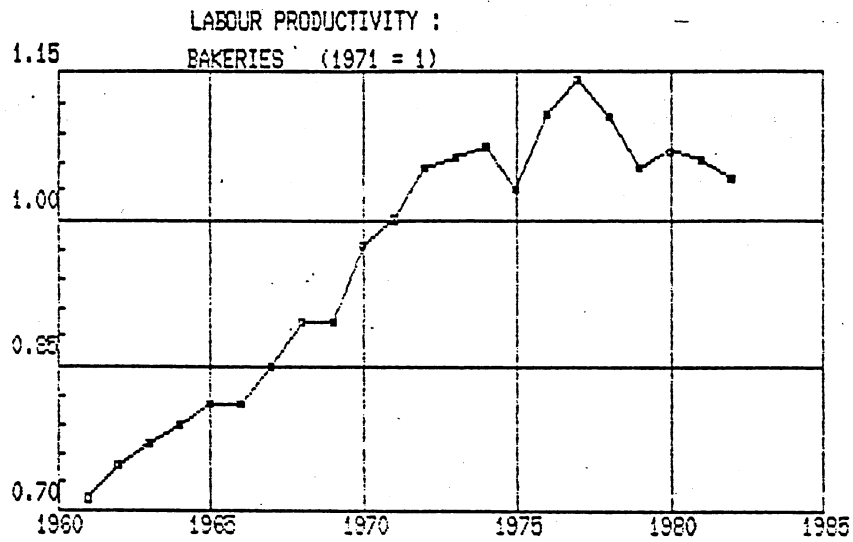
TABLE 3.10.1

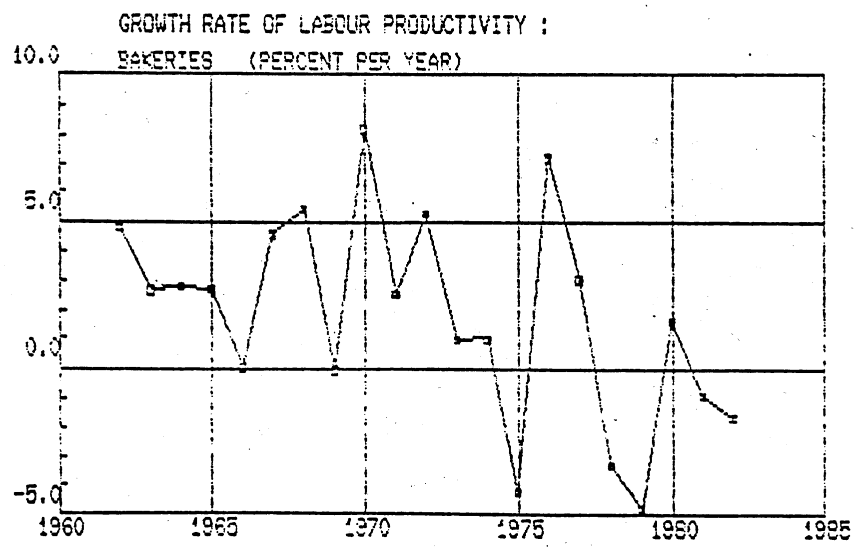
BAKERIES

SOURCES OF LABOUR PRODUCTIVITY GROWTH: 1961-1982

(PERCENT PER YEAR)

	1962-66	1967-71	1972-76	1977-82	1962-1982
LABOUR PRODUCTIVITY GROWTH	2.593	4.130	2.045	-0.989	1.805
TECHNICAL PROGRESS (T.F.P. GROWTH)	0.176	0.414	0.236	0.051	0.211
CAPITAL	0.249	0.442	0.218	0.032	0.225
ENERGY	0.058	-0.186	-0.263	0.206	-0.034
MATERIAL INPUTS	2.375	2.453	1.153	-1.503	0.995
RETURNS-TO-SCALE	-0.132	0.962	0.675	0.241	0.427
RESIDUAL GROWTH	-0.133	0.046	0.027	-0.016	-0.019


LABOUR PRODUCTIVITY :
BAKERIES (1971 = 1)
1.15
1.00
0.85
0.70
1960
1965
1970
1975
1980
1985


GROWTH RATE OF LABOUR PRODUCTIVITY :
BAKERIES (PERCENT PER YEAR)
10.0
5.0
0.0
-5.0
1960
1965
1970
1975
1980
1985

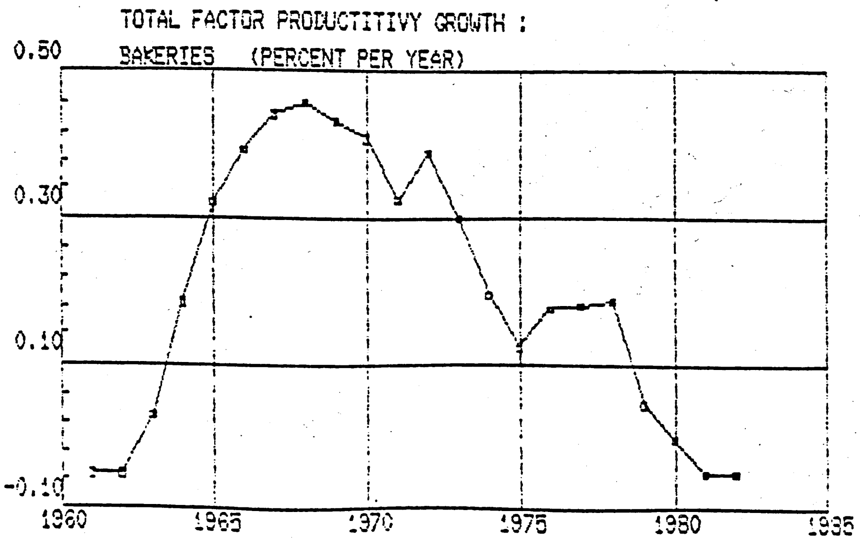

TOTAL FACTOR PRODUCTITIVY GROWTH :
BAKERIES (PERCENT PER YEAR)
0.50
0.30
0.10
-0.10
1960
1965
1970
1975
1980
1985

TABLE 3.10.2 BAKERIES (SIC 1072)

Alternative Regression Results

$lnq = lnA + a_1 * lnk + a_2 * lne + a_3 * lnm + a_4 * t + a_5 * t^2 + a_6 * c + a_7 * lnL + a_8 * t * lnE + a_{10} * t * lnM$

a1=0.118289 a2=0.022004 a3=0.576753

Estimation Method	lnA	a4	a5	a6	a7	a8	a9	a10	R^2	D.W.	Rh01	Rh02	Cond. No.
GLS	-0.3183 (6.87)	0.0067 (8.00)	-0.0002 (3.90)	0.2849 (6.13)	-0.2151 (12.30)	0.0063 (0.91)	0.0020 (1.62)	0.0050 (1.40)	0.995	2.518	-0.4203	-	304
GLS	-0.2917 (8.03)	0.0066 (8.02)	-0.0002 (4.03)	0.2575 (7.20)	-0.2169 (12.63)	-	0.0027 (2.61)	0.0073 (2.91)	0.994	2.54	-0.4363	-	221
GLS AR2	-0.2619 (12.95)	0.0062 (14.40)	0.0001 (6.64)	0.2283 (11.29)	-0.2237 (29.04)	-	0.0034 (5.80)	0.0086 (6.99)	0.997	2.246	-0.8312	-0.7625	324
GLS AR2	-0.2258 (5.38)	0.0035 (11.52)	-	0.1988 (4.69)	-0.2381 (14.25)	-	0.0061 (8.04)	0.0159 (11.07)	0.991	1.819	-0.5942	-0.4506	255
OLS	-0.0316 (3.45)	0.0033 (3.99)	-	-	-0.2499 (5.64)	-	0.0047 (2.76)	0.0209 (8.57)	0.974	2.509	-	-	18
GLS	-0.0301 (4.21)	0.0032 (4.93)	-	-	-0.2562 (7.35)	-	0.0049 (3.43)	0.0206 (9.99)	0.976	2.130	-0.2975	-	19
GLS AR2	-0.0301 (5.22)	0.0032 (6.12)	-	-	-0.2572 (9.10)	-	0.0050 (4.08)	0.0205 (11.27)	0.979	2.013	-0.3302	-0.3373	20

3.11 Confectionery Manufacturers

The empirical results for this industry have been summarized in Table 3.11.1. They are based on econometric estimation of equation (2.2.26) using aggregate data described in Appendices 1 and 2. Equation (2.2.22) which restricts technical progress to be Hicks neutral was also estimated but the former equation, assuming biased technical progress, was found to perform much better. The selected estimating equation is

$$\ln q = -0.056393 + 0.158581*\ln k + 0.009572*\ln e + 0.635917*\ln m$$
$$(4.58)t$$

$$+0.004794*t - 0.173684*\ln L - 0.013516*t*\ln K + 0.030374*t*\ln M$$
$$(3.59) \quad (4.63) \quad (5.56) \quad (11.48)$$

$R^2 = 0.96244$ D.W. 1.95905   S.E.R. = 0.007906

Rho1: 1.33557 Rho2: -0.624735
Condition Number: 6.12383

All variables of the regression (except the time trend) were rescaled so that 1971=1. This equation obtains estimated coefficients for the time trend, t, aggregate labour input (which measures returns-to- scale), and for the interaction of time with capital and material inputs. The signs of the last two coefficients indicate that technical progress in this industry is not Hicks neutral but has a capital-saving and materials-using bias. All estimated coefficients are significant at the 99% level or better. Second order autocorrelation of the residuals was corrected using the Cochrane-Orcutt procedure together with the Prais-Winsten procedure. The coefficients of autocorrelation satisfy the conditions required for stationarity. All regression statistics are quite satisfactory, showing no significant multicollinearity or autocorrelation in the final regression. According to the coefficient of labour returns-to-scale (given by unity plus this coefficient) is approximately 0.83. The capacity utilization variable was excluded from the regression as it was found collinear with other independent variables. However, time squared and the interaction of time with energy input were dropped because of their low significance levels. As Table 3.11.2 shows estimated technical progress results with the model under Hicks neutrality closely approximate those found with the above regression. Since the selected regression incorporates biased technical change, technical progress is computed using equation (2.2.27).

Table 3.11.1 summarizes the sources of labour productivity growth in this industry for the study period and four subperiods. Labour productivity grew at an average annual rate of about 2.5 percent between 1962 and 1982. Almost three quarters of this growth rate is accounted for by the growth rate of material inputs to labour ratio and nearly 12 percent by technical progress. The growth rate of capital-labour ratio made a somewhat smaller contribution to labour productivity growth and those of energy-labour ratio and returns-to-scale were considerably smaller. With decreasing returns-to-scale in the industry contracting labour employment made a positive contribution to labour productivity growth.

As Table 3.11.1 shows five year average labour productivity growth declined gradually from 4.46 to about 0.66 percent per year between the first and fourth subperiod. This trend originated principally from falling growth rates of materials-labour and capital-labour ratios. The particularly poor performance of the 1977-82 subperiod, however, was mostly due to the contribution of capital which fell to a negative magnitude. Our model explains this by the falling coefficient of capital implied by capital-saving technical change. The falling contributions of energy-labour ratio and returns-to-scale (generally falling employment over the last three subperiods) explain to a smaller extent the slowdown in labour productivity growth. The sizeable fall in the returns-to-scale contribution was mostly the result of a large increase in labour employment in 1980.

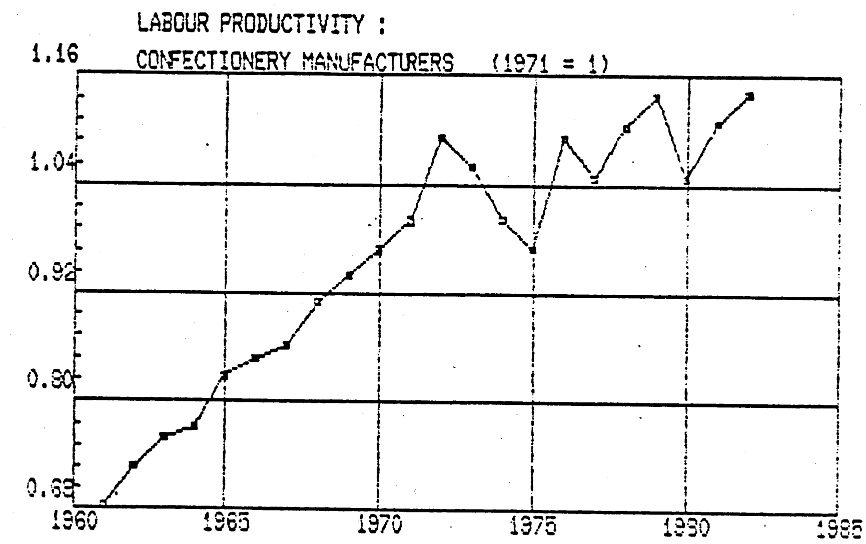
TABLE 3.11.1

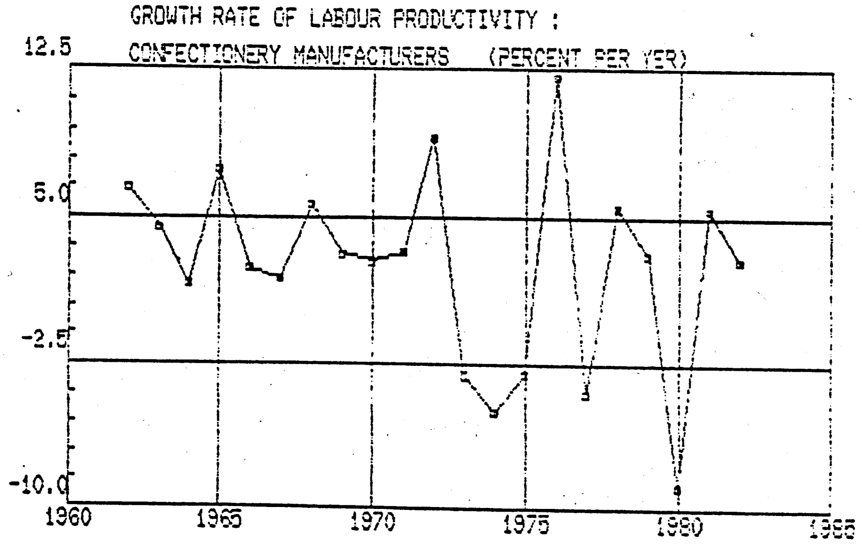
CONFECTIONERY MANUFACTURERS

SOURCES OF LABOUR PRODUCTIVITY GROWTH: 1961-1982

(PERCENT PER YEAR)

	1962-66	1967-71	1972-76	1977-82	1962-1982
LABOUR PRODUCTIVITY GROWTH	4.460	3.308	2.004	0.659	2.515
TECHNICAL PROGRESS (T.F.P. GROWTH)	0.128	0.494	0.443	0.154	0.298
CAPITAL	0.627	0.435	0.290	-0.497	0.180
ENERGY	0.018	0.050	0.027	0.010	0.025
MATERIAL INPUTS	3.196	2.312	1.283	0.844	1.858
RETURNS-TO-SCALE	-0.236	0.345	0.259	0.024	0.094
RESIDUAL GROWTH	0.727	-0.328	-0.297	0.125	0.060


LABOUR PRODUCTIVITY :
CONFECTIONERY MANUFACTURERS (1971 = 1)
1.16
1.04
0.92
0.80
0.68
1960
1965
1970
1975
1980
1985


GROWTH RATE OF LABOUR PRODUCTIVITY :
CONFECTIONERY MANUFACTURERS (PERCENT PER YER)
12.5
5.0
-2.5
-10.0
1960
1965
1970
1975
1980
1985

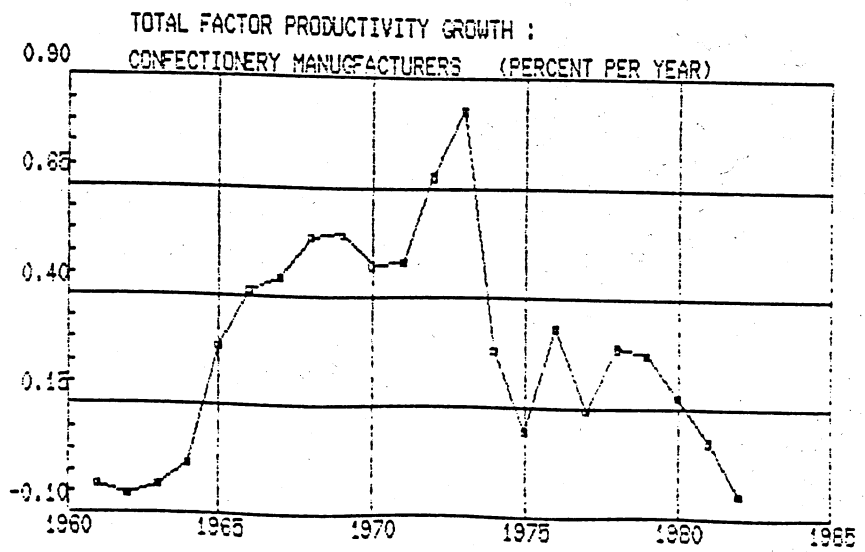

TOTAL FACTOR PRODUCTIVITY GROWTH :
CONFECTIONERY MANUGFACTURERS (PERCENT PER YEAR)
0.90
0.65
0.40
0.15
-0.10
1960
1965
1970
1975
1980
1985

TABLE 3.11.2 CONFECTIONERY MANUFACTURERS (SIC 1081)

Alternative Regression Results

$\ln q = \ln A + a_1 * \ln k + a_2 * \ln e + a_3 * \ln m + a_4 * t + a_5 * t^2 + a_6 * c + a_7 * \ln L + a_8 * t * \ln E + a_{10} * t * \ln M$

a1=0.158581 a2=0.009572 a3=0.635917

Estimation Method	lnA	a4	a5	a6	a7	a8	a9	a10	R^2	D.W.	Rho1	Rho2	Cond. No.
GLS	-0.4531 (5.29)	0.0101 (5.32)	-0.0004 (2.89)	0.4093 (4.23)	0.0012 (0.01)	-0.0017 (0.48)	0.0100 (1.70)	0.0078 (1.38)	0.953	2.121	-0.2999	-	179
GLS	-0.0730 (4.79)	0.0094 (2.28)	-0.0002 (0.89)	-	-0.1425 (1.96)	-0.0104 (2.03)	0.0031 (0.60)	0.0302 (6.42)	0.947	1.247	0.7809	-	20
GLS	-0.0704 (4.01)	0.0059 (3.50)	-	-	-0.1180 (1.98)	-0.0143 (5.11)	0.0042 (0.86)	0.0287 (6.98)	0.949	1.123	0.8473	-	4
GLS AR2	-0.0629 (4.97)	0.0079 (2.23)	-0.0002 (0.89)	-	-0.1834 (3.16)	-0.0107 (2.62)	-	0.0309 (10.44)	0.962	1.990	1.2512	-0.05885	25
GLS AR2	-0.0563 (4.58)	0.0047 (3.59)	-	-	-0.1736 (4.63)	-0.0135 (5.56)	-	0.0303 (11.48)	0.962	1.959	1.3355	-0.6247	6
GLS	-0.5454 (8.29)	0.0092 (5.50)	-0.0004 (5.84)	0.5092 (6.69)	-0.0255 (0.48)	-	-	-	0.931	1.811	0.0049	-	87
OLS	-0.1070 (8.79)	0.0163 (6.80)	-0.0006 (5.21)	-	0.0871 (0.93)	-	-	-	0.750	1.485	-	-	16
GLS	-0.1032 (7.31)	0.0158 (5.54)	-0.0006 (4.34)	-	0.0710 (0.71)	-	-	-	0.763	1.799	0.2312	-	15

3.12 Cane and Beet Sugar Processors

The empirical results for this industry have been summarized in Table 3.12.1. They are based on econometric estimation of equation (2.2.26) using aggregate data described in Appendices 1 and 2. There results were found superior to those obtained from estimation of equation (2.2.22) which restricts technical progress to be Hicks neutral. The selected estimating equation is

$$\underset{}{\ln q}=-0.278424+\underset{(12.75)}{0.12654}*\ln k+0.019542*\ln e+0.763137*\ln m$$

$$+\underset{(4.55)}{0.004949}*t+\underset{(12.20)}{0.243773}*c-\underset{(3.33)}{0.229733}*\ln L$$

$$-\underset{(6.31)}{0.008647}*t*\ln K-\underset{(1.33)}{0.005241}*t*\ln E+\underset{(2.77)}{0.00938}*t*\ln M$$

R^2=0.981818 D.W. = 2.22103 S.E.R. = 0.007507

Rho1: 0.885721 Rho2: -0.571339
Condition Number: 24.5013

All variables of the regression (except the time trend) were rescaled so that 1971=1. This equation obtains estimated coefficients for the time trend, t, the index of capacity utilization, aggregate labour input (which measures returns-to-scale) and for the interaction of time with capital, energy and material inputs. The last three estimated coefficients indicate that technical progress in this industry is capital-saving, energy-saving and materials-using. The coefficient of energy-time interaction is significant at about the 80% level. All other coefficients are significant at the 98% level or better. Second order autocorrelation of the residuals was corrected using the Cochrane-Orcutt procedure together with the Prais-Winsten procedure. All regression statistics are quite satisfactory, showing no significant multicollinearity or autocorrelation in the selected regression.

According to the coefficient of labour, returns-to-scale (given by unity plus this coefficient) is approximately 0.77. As Table 3.12.2 shows, the square of the time trend was dropped from most regressions because its coefficient was not statistically significant. Since technical progress is biased, its magnitude is computed from the time trend and the coefficients of the interaction of time with capital, energy and material inputs using equation (2.2.27).

Table 3.12.1 summarizes the sources of labour productivity growth in this industry for the study period and four subperiods. Labour productivity grew at an average annual rate of about 3.4 percent between 1962 and 1982. About 78 percent of this growth is accounted for by the growth rate of materials - labour ratio. The next largest source of labour productivity growth was technical progress which showed considerable variation over the study period: generally rising up to 1973 and generally declining between 1974 and 1982. The contribution of returns-to-scale was fairly significant: with decreasing returns-to-scale falling labour employment accounted for about one third of one percent of labour productivity growth.

Although labour productivity varied considerably from year to year it maintained a fairly stable five-year average over the four subperiods. Its decline in the third subperiod (1972-1976) to 1.736% per year followed from a sharp decline in the growth of materials - labour ratio (to almost half of its contribution in previous subperiods) as well as lower growth of material inputs use. With rising material inputs coefficient (materials-using technical change), a decline in the growth rate of material inputs used--as occurred over this subperiod--would lead to lower labour productivity growth independently of the effect of the growth rate of materials-labour ratio.

A second significant factor contributing to labour productivity slowdown over this subperiod was energy. The contribution of this factor fell significantly below its 1967-71 average because the coefficient of energy was decling (energy-saving technical change) and the industry showed quickly increasing energy use in 1975 and 1976.

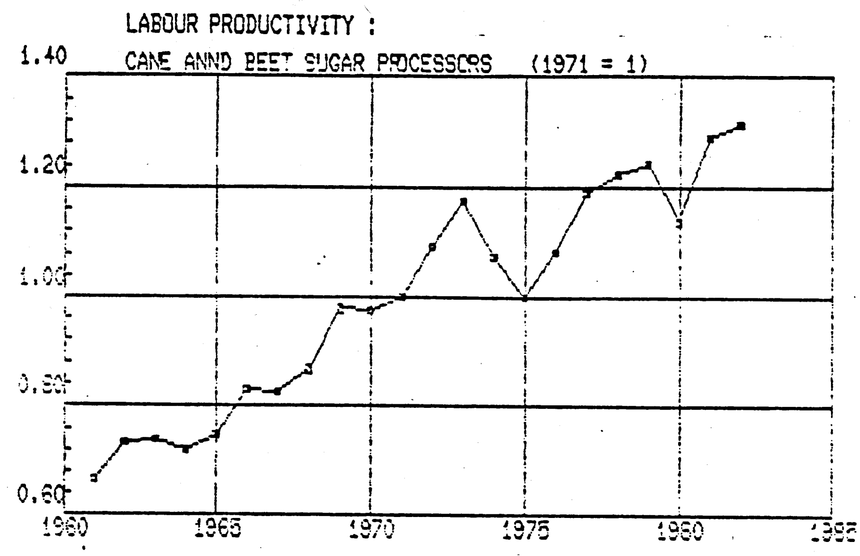
TABLE 3.12.1

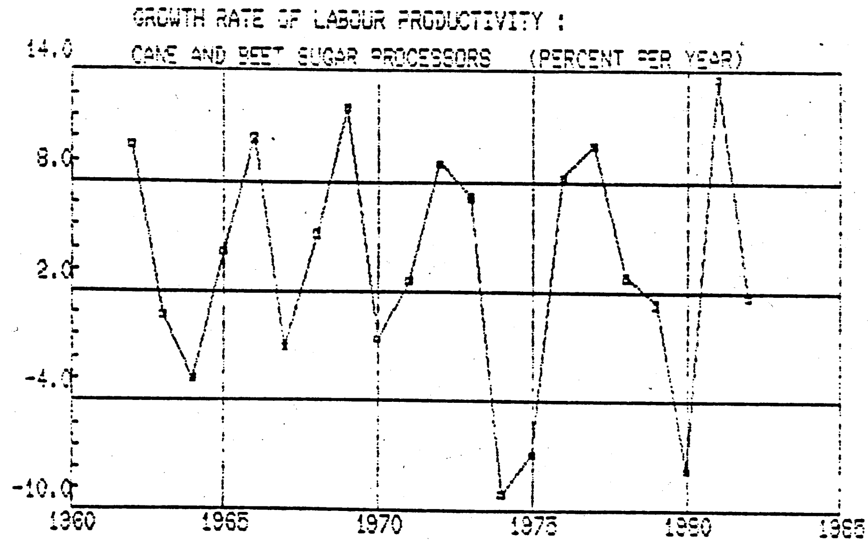
CANE AND BEET SUGAR PROCESSORS

SOURCES OF LABOUR PRODUCTIVITY GROWTH: 1961-1982

(PERCENT PER YEAR)

	1962-66	1967-71	1972-76	1977-82	1962-1982
LABOUR PRODUCTIVITY GROWTH	4.504	3.666	1.736	3.664	3.406
TECHNICAL PROGRESS (T.F.P. GROWTH)	0.240	0.428	0.478	0.364	0.377
CAPITAL	0.303	0.083	0.156	0.142	0.170
ENERGY	0.030	0.059	-0.095	0.240	0.067
MATERIAL INPUTS	3.594	3.172	1.412	2.575	2.683
UTILIZATION OF CAPACITY	0.115	-0.237	-0.381	-0.384	-0.229
RETURNS-TO-SCALE	0.181	0.277	0.218	0.617	0.337
RESIDUAL GROWTH	0.041	-0.116	-0.052	0.110	0.001


LABOUR PRODUCTIVITY :
CANE ANND BEET SUGAR PROCESSORS (1971 = 1)
1.40
1.20
1.00
0.80
0.60
1960
1965
1970
1975
1980
1985


GROWTH RATE OF LABOUR PRODUCTIVITY :
CANE AND BEET SUGAR PROCESSORS (PERCENT PER YEAR)
14.0
8.0
2.0
-4.0
-10.0
1960
1965
1970
1975
1980
1985

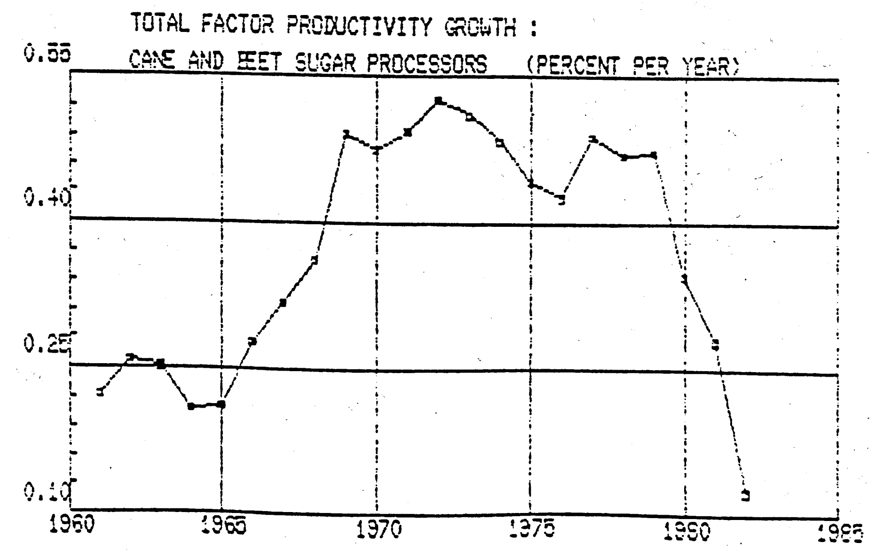

TOTAL FACTOR PRODUCTIVITY GROWTH :
CANE AND BEET SUGAR PROCESSORS (PERCENT PER YEAR)
0.55
0.40
0.25
0.10
1960
1965
1970
1975
1980
1985

TABLE 3.12.2 CANE AND BEET SUGAR PROCESSORS (SIC 1082)

Alternative Regression Results

$$\ln q = \ln A + a_1{*}\ln k + a_2{*}\ln e + a_3{*}\ln m + a_4{*}t + a_5{*}t^2 + a_6{*}c + a_7{*}\ln L + a_8{*}t{*}\ln E + a_{10}{*}t{*}\ln M$$

a1=0.126541 a2=0.019542 a3=0.763137

Estimation Method	lnA	a4	a5	a6	a7	a8	a9	a10	R^2	D.W.	Rho1	Rho2	Cond. No.
GLS	-0.3015 (9.08)	0.0042 (1.86)	5.3E-05 (0.44)	0.2690 (8.76)	-0.2133 (2.10)	-0.0094 (4.66)	-0.0054 (1.02)	0.0106 (2.02)	0.973	1.642	0.4095	-	30
GLS	-0.3011 (9.60)	0.0050 (3.51)	-	0.2670 (9.56)	-0.2230 (2.34)	-0.0089 (5.75)	-0.0051 (1.02)	0.0106 (2.15)	0.973	1.631	0.4882	-	22
GLS	-0.2930 (9.55)	0.0041 (3.59)	-	0.2662 (9.46)	-0.2856 (3.94)	-0.0084 (5.78)	-	0.0068 (2.15)	0.971	1.643	0.4608	-	23
GLS AR2	-0.2784 (12.75)	0.0049 (4.55)	-	0.2437 (12.20)	-0.2297 (3.33)	-0.0086 (6.31)	-0.0052 (1.33)	0.0098 (2.77)	0.981	2.221	0.8857	-0.5713	24
GLS	-0.3468 (10.02)	0.0109 (2.75)	-0.0003 (1.98)	0.2986 (9.78)	-0.1926 (2.16)	-	-	-	0.940	1.320	0.8156	-	11
GLS AR2	-0.3246 (12.51)	0.0113 (3.32)	-0.0003 (2.37)	0.2691 (11.50)	-0.2261 (3.28)	-	-	-	0.955	2.157	1.2221	-0.6018	17

3.13 Vegetable Oil Mills

The empirical results for this industry have been summarized in Table 3.13.1. They are based on econometric estimation of equation (2.2.22) using aggregate data described in Appendices 1 and 2. This equation, based on the assumption of Hicks neutral technical change, yielded more reliable coefficient estimates than equation (2.2.26) which incorporates biased technical progress. The estimating equation is

$$\ln q = -0.048421 + 0.064169 * \ln k + 0.01254 * \ln e + \underset{(12.20)}{0.886914} * \ln m$$

$$+ \underset{(11.92)}{0.0091} * t - \underset{(8.39)}{0.000466} * t^2 + \underset{(3.33)}{0.050369} * \ln L$$

$R^2 = 0.907237$ D.W. = 1.68702 S.E.R. = 0.005592
Condition Number: 21.9872

All variables of the regression (except the time trend) were rescaled so that 1971=1. Using Ordinary Least Squares procedures, this equation obtains estimated coefficients for the time trend and time squared as well as aggregate labour input which, in this formulation, measures returns-to-scale. All estimated coefficients are significant at the 99% level or better. Other regression statistics are quite satisfactory, showing no significant multicollinearity or autocorrelation in the selected regression. According to the coefficient of labour, returns-to-scale (given by unity plus this coefficient) is approximately 1.05. As Table 3.13.2 shows, the capacity utilization variable was excluded from this regression as it was highly collinear with other independent variables. Technical progress over the study period has the intercept 0.91 (percent per year) and slope -0.000932 percent per year (see equation (2.2.2.7)).

Table 3.13.1 summarizes the sources of labour productivity growth in this industry for the study period and four subperiods. During the study period labour productivity grew at an average annual rate of about 3.18 percent. The growth of materials-labour ratio contributed about 2.9 percent to this labour productivity gain. With increasing returns-to-scale growing labour employment was the next largest source of labour productivity growth in this industry. Growing capital-labour ratio also positively contributed to labour productivity gains.

Our analysis shows that the decline in labour productivity experienced during the third and fourth subperiod resulted from falling growth rates of materials-labour and energy-labour ratios. The latter ratio actually declined (on average) between 1977 and 1982.

Though materials-labour ratio was most important in explaining falling labour productivity gains in the second half of the study period, technical progress made a gradual but significant contribution. Technical progress occurred at about one percent per year in 1961 but by 1982 it was slightly less than negative one percent: a fall of approximately two percent over the study period.

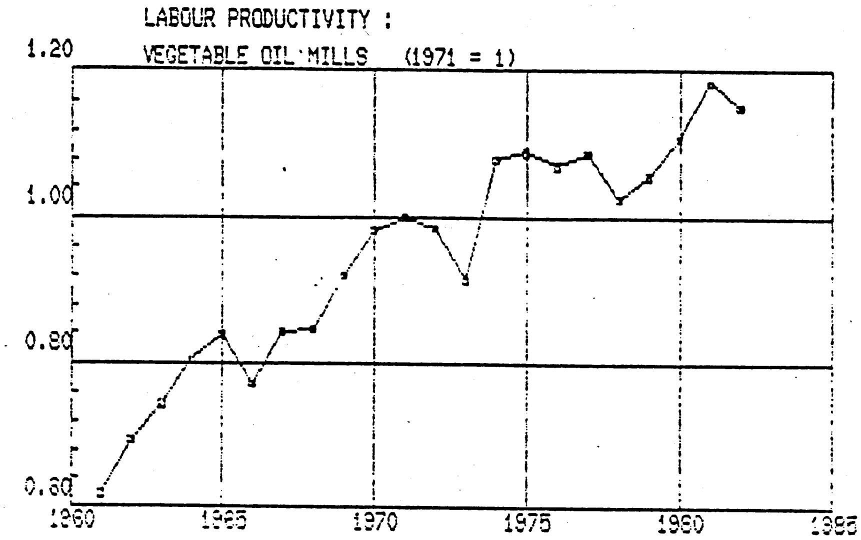
TABLE 3.13.1

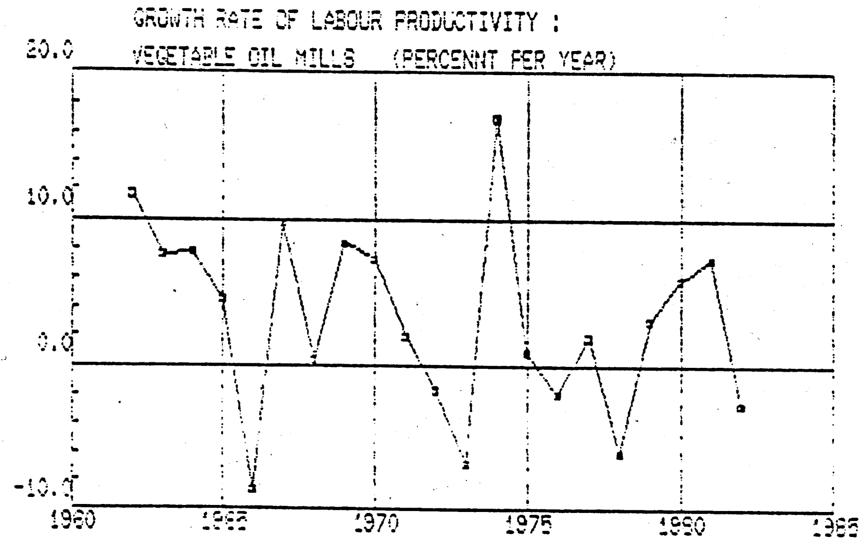
VEGETABLE OIL MILLS

SOURCES OF LABOUR PRODUCTIVITY GROWTH: 1961-1982

(PERCENT PER YEAR)

	1962-66	1967-71	1972-76	1977-82	1962-1982
LABOUR PRODUCTIVITY GROWTH	4.596	5.528	1.431	1.497	3.179
TECHNICAL PROGRESS (T.F.P. GROWTH)	0.630	0.164	-0.302	-0.814	-0.115
CAPITAL	-0.239	0.007	0.471	0.467	0.190
ENERGY	0.032	0.035	0.027	-0.040	0.011
MATERIAL INPUTS	4.231	4.809	1.509	1.223	2.861
RETURNS-TO-SCALE	0.098	0.095	0.201	0.490	0.234
RESIDUAL GROWTH	-0.157	0.417	-0.475	0.171	-0.002


LABOUR PRODUCTIVITY :
VEGETABLE OIL MILLS (1971 = 1)
1.20
1.00
0.80
0.60
1960
1965
1970
1975
1980
1985


GROWTH RATE OF LABOUR PRODUCTIVITY :
VEGETABLE OIL MILLS (PERCENNT PER YEAR)
20.0
10.0
0.0
-10.0
1960
1965
1970
1975
1980
1985

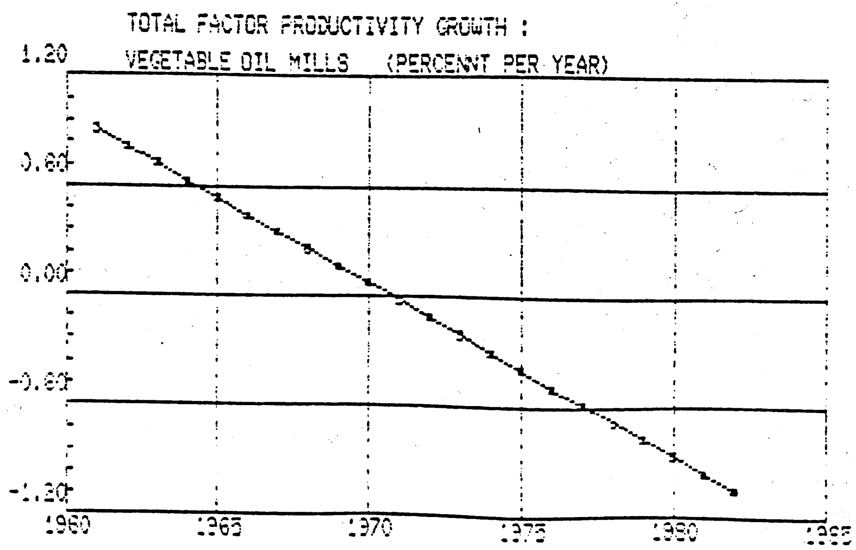

TOTAL FACTOR PRODUCTIVITY GROWTH :
VEGETABLE OIL MILLS (PERCENNT PER YEAR)
1.20
0.60
0.00
-0.60
-1.20
1960
1965
1970
1975
1980
1985

TABLE 3.13.2 VEGETABLE OIL MILLS (SIC 1083)

Alternative Regression Results

$$\ln q = \ln A + a_1 * \ln k + a_2 * \ln e + a_3 * \ln m + a_4 * t + a_5 * t^2 + a_6 * c + a_7 * \ln L + a_8 * t * \ln E + a_{10} * t * \ln M$$

a1=0.064169 a2=0.01254 a3=0.886914

Estimation Method	lnA	a4	a5	a6	a7	a8	a9	a10	R^2	D.W.	RhO1	RhO2	Cond. No.
GLS	-0.0352 (1.28)	0.0112 (6.33)	-0.0005 (4.04)	-0.0256 (0.93)	-0.0073 (0.34)	-0.0015 (3.65)	-0.0055 (1.87)	0.0082 (4.71)	0.981	1.850	-0.3078	-	220
GLS	-0.0606 (13.92)	0.0112 (6.27)	-0.0005 (3.91)	-	-0.0124 (0.60)	-0.0015 (3.49)	-0.0036 (1.73)	0.0068 (6.47)	0.980	1.857	-0.2524	-	183
OLS	-0.0583 (29.17)	0.0102 (9.48)	-0.0004 (4.84)	-	-	-0.0014 (3.19)	-0.0047 (3.03)	0.0063 (9.25)	0.978	2.232	-	-	89
GLS	-0.0582 (33.56)	0.0103 (10.79)	-0.0004 (5.56)	-	-	-0.0014 (3.46)	-0.0046 (3.43)	0.0063 (10.24)	0.979	1.866	-0.2078	-	95
OLS	-0.0470 (13.34)	0.0044 (10.93)	-	-	0.0483 (2.54)	-0.0018 (2.99)	-0.0111 (7.13)	0.0047 (3.92)	0.962	1.748	-	-	33
OLS	-0.1247 (5.82)	0.0095 (15.78)	-0.0004 (8.53)	0.0715 (3.60)	0.0187 (1.27)	-	-	-	0.947	2.119	-	-	62
OLS	-0.0484 (12.20)	0.0091 (11.92)	-0.0004 (8.39)	-	0.0503 (3.33)	-	-	-	0.9072	1.68	-	-	21

3.14 Miscellaneous Food Processors, NES

The empirical results for this industry have been summarized in Table 3.13.1. They are based on econometric estimation of equation (2.2.22) using aggregate data described in Appendices 1 and 2. This equation, based on the assumption of Hicks neutral technical change yielded better estimation results than equation (2.2.26) which incorporates biased technical change. The selected estimating equation is

$$\underset{}{\ln q}=-\underset{(6.99)}{0.292438}+0.169747*\ln k+0.011303*\ln e+0.697576*\ln m$$

$$+\underset{(3.48)}{0.000111}*t^2+\underset{(6.82)}{0.28918}*c-\underset{(4.57)}{0.115822}*\ln L$$

R^2= 0.751752 D.W. = 2.16942 S.E.R. = 0.007332

Rho1: 0.557969 Rho2: -0.622977
Condition Number: 65.8907

All variables of the regression (except the time trend) were rescaled so that 1971=1. This equation obtains estimated coefficients for the square of the time trend, the effect of capacity utilization on labour productivity, and for aggregate labour input (which measures returns-to-scale). The coefficient of first order autocorrelation is significant at the 98% level; all other coefficients are significant at the 99% level or better. Second order autocorrelation was corrected using the

Cochrane-Orcutt procedure together with the Prais-Winsten procedure. All regression statistics are quite satisfactory, though the Condition Number indicates fairly high collinearity among independent variables. As Table 3.14.2 shows, the simple time trend variable was not statistically significant in earlier estimation results and was dropped. The F statistic for this coefficient was 0.32. According to the coefficient of time squared technical change increased over the study period. The slope of this curve is 0.0222 (percent per year) with zero for its intercept. This yields a technical progress rate of about half of one percent in 1982. The coefficient of labour indicates that returns-to-scale (given by unity plus this coefficient) is approximately 0.88.

Table 3.14.1 summarizes the sources of labour productivity growth in this industry for the study period and four subperiods. Labour productivity gains averaged about 1.8 percent per year between 1962 and 1982 with about 1.25 percent accounted for by the growth rate of materials-labour ratio. With decreasing returns-to-scale in the industry growing labour employment made a negative contribution to labour productivity growth during all four subperiods. Technical progress and the growing capital-labour ratio both made significant contributions to labour productivity gains.

Labour productivity declined severely over the 1967-71 period, compared to fair growth rates in the previous and subsequent subperiods. Our analysis finds that this was almost entirely the result of a large increase in labour employment in 1970: industry employment grew by 14.7 percent whereas gross output rose by only 5.2 percent leading to labour productivity growth of negative 9.5 percent. In terms of sources of growth, this occurred through a fall in the materials-labour ratio, lower growth in the capital-labour ratio and a negative contribution from returns-to-scale. A second, though slight, fall in labour productivity growth occurred in the fourth subperiod. This was similarly the result of a large increase in labour employment and less than one percent growth in gross output. Falling capital-labour and materials-labour ratios were the principal sources of declining growth, as capital stock and purchased materials lagged behind employment growth.

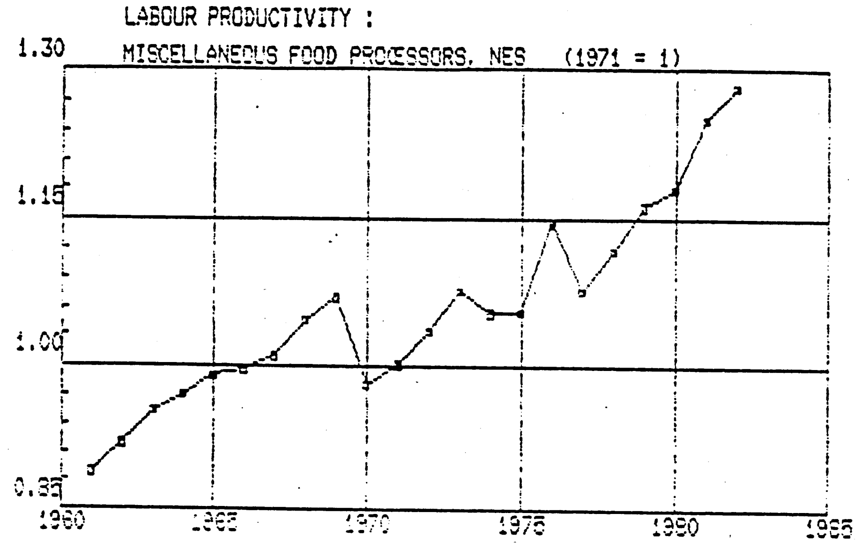
TABLE 3.14.1

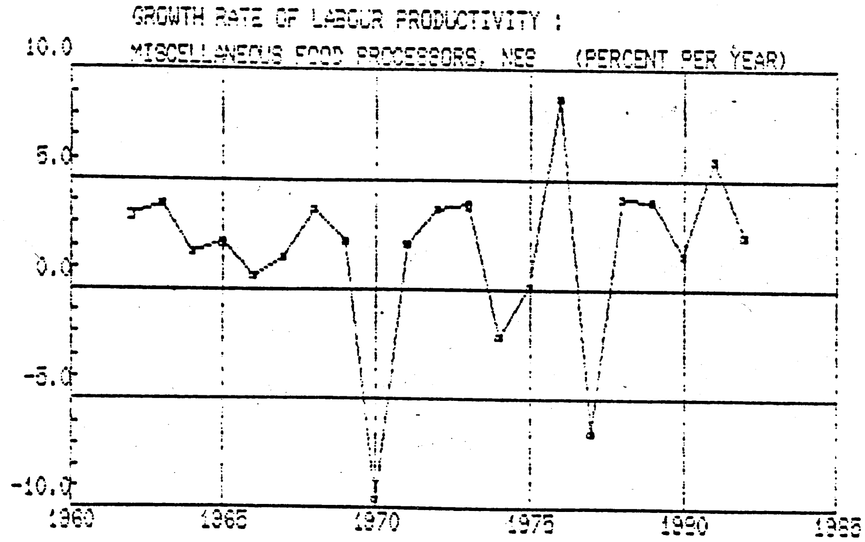
MISCELLANEOUS FOOD PROCESSORS, NES

SOURCES OF LABOUR PRODUCTIVITY GROWTH: 1961-1982

(PERCENT PER YEAR)

	1962-66	1967-71	1972-76	1977-82	1962-1982
LABOUR PRODUCTIVITY GROWTH	2.335	-0.011	2.849	1.941	1.786
TECHNICAL PROGRESS (T.F.P. GROWTH)	0.067	0.178	0.289	0.411	0.244
CAPITAL	0.763	0.110	0.810	-0.006	0.399
ENERGY	0.038	0.024	0.032	0.005	0.024
MATERIAL INPUTS	1.439	-0.129	2.076	1.549	1.249
UTILIZATION OF CAPACITY	0.180	0.415	-0.354	0.031	0.066
RETURNS-TO-SCALE	-0.251	-0.599	-0.137	-0.212	-0.296
RESIDUAL GROWTH	0.279	0.404	-0.222	0.195	0.166


LABOUR PRODUCTIVITY :
MISCELLANEOUS FOOD PROCESSORS, NES (1971 = 1)
1.30
1.15
1.00
0.85
1960
1965
1970
1975
1980
1985


GROWTH RATE OF LABOUR PRODUCTIVITY :
MISCELLANEOUS FOOD PROCESSORS, NES (PERCENT PER YEAR)
10.0
5.0
0.0
-5.0
-10.0
1960
1965
1970
1975
1980
1985

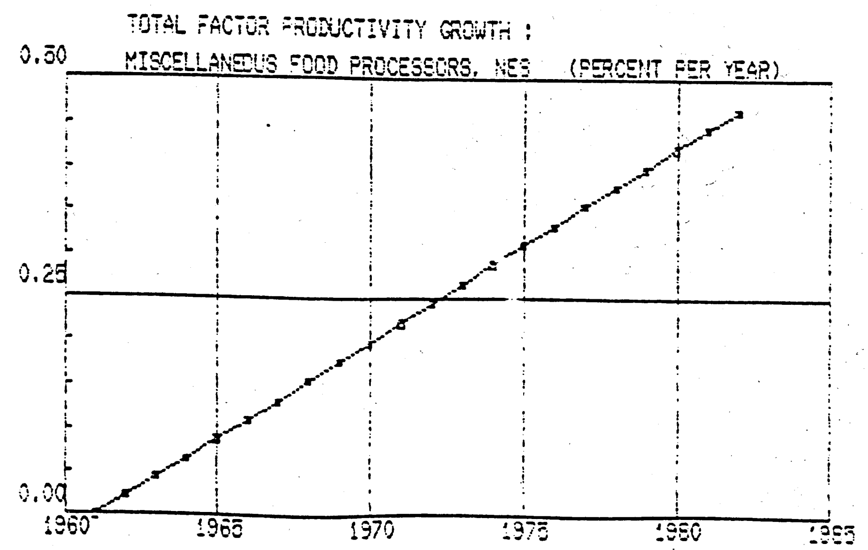

TOTAL FACTOR PRODUCTIVITY GROWTH :
MISCELLANEOUS FOOD PROCESSORS, NES (PERCENT PER YEAR)
0.50
0.25
0.00
1960
1965
1970
1975
1980
1985

TABLE 3.14.2 MISCELLANEOUS FOOD PROCESSORS, NES (SIC 1089)

Alternative Regression Results

$$\ln q = \ln A + a_1 * \ln k + a_2 * \ln e + a_3 * \ln m + a_4 * t + a_5 * t^2 + a_6 * c + a_7 * \ln L + a_8 * t * \ln E + a_{10} * t * \ln M$$

a1=0.169747 a2=0.011303 a3=0.697576

Estimation Method	lnA	a4	a5	a6	a7	a8	a9	a10	R^2	D.W.	Rho1	Rho2	Cond. No.
GLS	-0.1228 (2.33)	0.0037 (1.01)	2.2E-07 (0.00)	0.0881 (1.67)	-0.0904 (1.94)	-0.0101 (3.94)	-0.0014 (0.50)	0.0098 (1.98)	0.898	1.977	0.0169	-	190
OLS	-0.1272 (2.85)	0.0039 (3.46)	-	0.0911 (2.35)	-0.0960 (2.39)	-0.0110 (5.90)	-	0.0094 (6.17)	0.896	1.825	-	-	117
GLS	-0.1325 (2.98)	0.0039 (3.48)	-	0.0960 (2.47)	-0.0993 (2.49)	-0.0109 (5.73)	-	0.0094 (5.98)	0.897	1.928	0.0980	-	106
OLS	-0.0237 (1.84)	0.0024 (2.07)	-	-	-0.0234 (0.71)	-0.0124 (5.01)	-0.0025 (0.87)	0.0124 (8.48)	0.867	2.254	-	-	38
OLS	-0.3068 (5.36)	0.0043 (1.81)	5.7E-05 (1.05)	0.2589 (5.38)	-0.2145 (3.52)	-	-	-	0.668	1.377	-	-	80
GLS	-0.2830 (4.88)	0.0034 (1.36)	6.7E-05 (0.99)	0.2432 (4.77)	-0.1857 (3.10)	-	-	-	0.700	1.791	0.3363	-	58
GLS AR2	-0.3064 (6.49)	0.0019 (0.89)	7.7E-05 (153)	0.2853 (6.71)	-0.1568 (3.02)	-	-	-	0.754	2.186	0.4589	-0.5779	84
GLS AR2	-0.2924 (6.99)	-	0.0001 (3.48)	0.2891 (6.82)	-0.1158 (4.57)	-	-	-	0.751	2.169	0.5579	-0.6229	65

3.15 Soft Drink Manufacturers

The empirical results for this industry have been summarized in Table 3.15.1. They are based on econometric estimation of equation (2.2.26) using aggregate data described in Appendices 1 and 2. This equation incorporates biased technical progress (found to be only materials-using) and yielded substantially better estimated results than equation (2.2.22) based on Hicks neutrality. The selected estimating equation is

$$\underset{(4.18)}{\ln q=-0.043371}+0.162799*\ln k+0.016221*\ln e+0.607463*\ln m$$

$$\underset{(3.89)}{+0.008609*t}\ \underset{(3.10)}{-0.000404*t^2}\ \underset{(3.64)}{-0.0265545*\ln L}\ \underset{(4.53)}{+0.014406*t*\ln M}$$

R^2=0.953485 D.W.=1.75514 S.E.R.=0.010935

Rhol: 0.286187
Condition Number: 23.712

All variables of the regression (except the time trend) were rescaled so that 1971=1. This equation obtains estimated coefficients for the time trend, time squared, aggregate labour input and the interaction of time with material inputs. The sign of the last coefficient indicates that technical progress in this industry is not Hicks neutral but rather biased toward material inputs (materials-using). The coefficient of autocorrelation is significant at the 80% level; other coefficients are significant at the 99% level or better. Autocorrelation among the residuals was corrected using the Cochrane-Orcutt procedure together with the Prais-Winsten procedure. All regression statistics are quite satisfactory, showing no significant multicollinearity or autocorrelation in the selected regression. According to the coefficient of labour returns-to-scale (given by unity plus this coefficient) is approximately 0.73. As Table 3.15.2 indicates, time-capital and time-energy interaction variables were dropped from the final regression as their coefficients were not statistically significant. The capacity utilization index was ommitted as it was found highly collinear with other independent variables. Since technical progress is biased, its magnitude for each year is given by equation (2.2.27).

Table 3.15.1 summarizes the sources of labour productivity growth for this industry for the study period and four subperiods. Productivity gains averaged about 5 percent per year between 1962 and 1982 with about 4.5 percent coming from growing materials-labour ratio. During the second subperiod labour productivity gains showed a significant improvement, averaging about 8.3 percent per year. Our analysis suggests that this was a result of low (and often negative) growth in the employment of labour and greater employment of intermediate inputs. This substitution was accompanied by high growth rates in the industry's gross output over the subperiod. With decreasing returns-to-scale in the industry, falling labour employment positively contributed to labour productivity gains during this and the following subperiods. The decline in labour productivity growth during the next subperiod (1972-76) was mostly due to the reversal of the trend of materials-labour ratio. Falling energy-labour ratio made a negative contribution.

Technical progress was negative over most of the study period. However, since it varied with the level of intermediate inputs used, technical progress rose during (approximately) the first half of the study period and then generally declined. It reached positive levels between 1970 and 1973.

TABLE 3.15.1

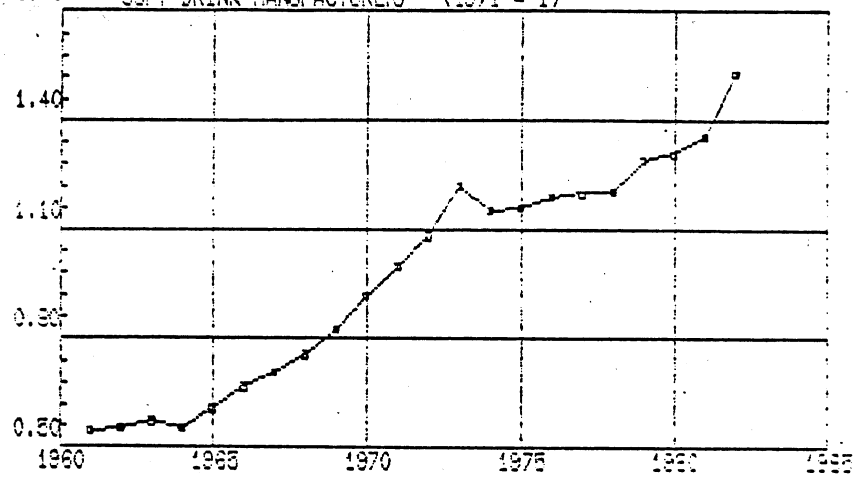
SOFT DRINK MANUFACTURERS

SOURCES OF LABOUR PRODUCTIVITY GROWTH: 1961-1982

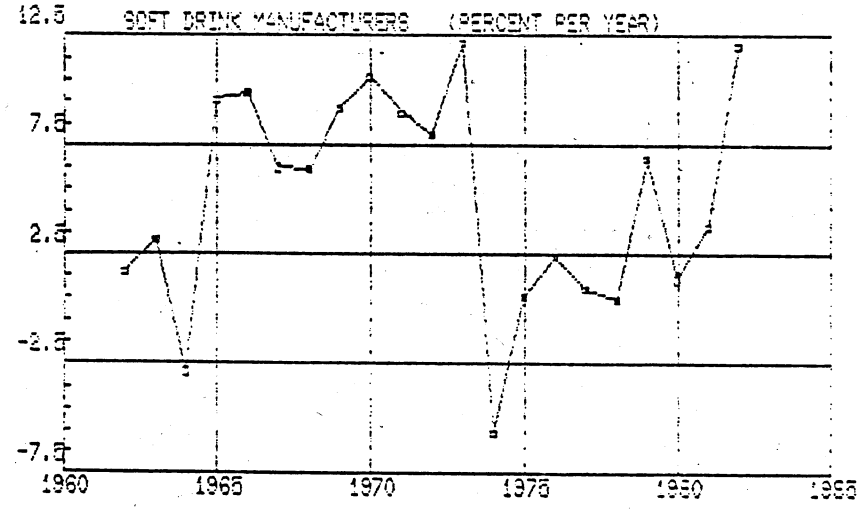
(PERCENT PER YEAR)

	1962-66	1967-71	1972-76	1977-82	1962-1982
LABOUR PRODUCTIVITY GROWTH	4.300	8.326	3.540	4.257	5.065
TECHNICAL PROGRESS (T.F.P. GROWTH)	-0.436	-0.072	-0.053	-0.336	-0.230
CAPITAL	0.959	0.634	0.619	0.784	0.751
ENERGY	0.031	0.025	-0.031	0.030	0.015
MATERIAL INPUTS	4.243	7.983	2.953	3.093	4.498
RETURNS-TO-SCALE	-0.472	0.072	0.121	0.652	0.120
RESIDUAL GROWTH	-0.024	-0.317	-0.069	0.034	-0.088

LABOUR PRODUCTIVITY :
SOFT DRINK MANUFACTURERS (1971 = 1)



GROWTH RATE OF LABOUR PRODUCTIVITY :
SOFT DRINK MANUFACTURERS (PERCENT PER YEAR)



TOTAL FACTOR PRODUCTIVITY GROWTH :
SOFT DRINK MANUFACTURERS (PERCENT PER YEAR)

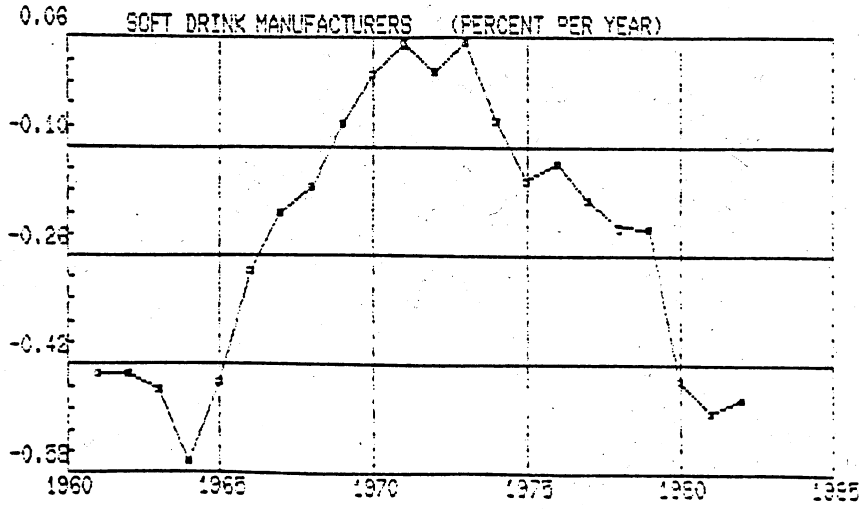


TABLE 3.15.2 SOFT DRINK MANUFACTURERS (SIC 1091)

Alternative Regression Results

$lnq = lnA + a_1*lnk + a_2*lne + a_3*lnm + a_4*t + a_5*t^2 + a_6*c + a_7*lnL + a_8*t*lnE + a_{10}*t*lnM$

a1=0.162799 a2=0.016221 a3=0.607463

Estimation Method	lnA	a4	a5	a6	a7	a8	a9	a10	R^2	D.W.	Rh01	Rh02	Cond. No.
GLS	-0.2721	0.0085	-0.0005	0.2566	-0.3251	0.0060	-0.0023	0.0144	0.981	1.776	0.3546	-	81
	(5.15)	(2.86)	(1.98)	(4.42)	(4.84)	(0.68)	(0.80)	(5.09)					
GLS	-0.2583	0.0090	-0.0005	0.2370	-0.3418	0.0052	-1.1E-05	0.0140	0.984	2.214	0.3904	-0.4865	140
AR2	(4.99)	(3.07)	(1.90)	(3.11)	(5.41)	(0.54)	(0.00)	(5.95)					
GLS	-0.2583	0.0090	-0.0005	0.2371	-0.3419	0.0052	-	0.0140	0.984	2.213	0.3895	-0.4874	129
AR2	(5.44)	(3.27)	(2.01)	(4.48)	(5.70)	(0.56)		(6.55)					
GLS	-0.2516	0.0075	-0.0003	0.2303	-0.3188	-	-	0.0146	0.983	2.178	0.3601	-0.4787	108
AR2	(5.65)	(6.70)	(6.28)	(4.60)	(7.81)			(7.97)					
GLS	-0.0472	0.0075	-0.0002	-	-0.2518	-0.0072	-	0.0145	0.963	2.414	0.3399	-0.4497	107
AR2	(5.21)	(1.83)	(0.61)		(2.96)	(0.55)		(4.58)					
OLS	-0.0455	0.0088	-0.0004	-	-0.2700	-	-	0.0138	0.949	1.433	-	-	24
	(5.00)	(5.02)	(3.95)		(4.26)			(4.84)					
GLS	-0.0433	0.0086	-0.0004	-	-0.2655	-	-	0.0144	0.953	1.755	0.2861	-	23
	(3.18)	(3.89)	(3.10)		(3.64)			(4.53)					
GLS	-0.0560	0.0049	-	-	-0.2316	-	-	-	0.902	1.723	0.4789	-	3
	(5.34)	(5.51)			(2.76)								

3.16 Distillers

The empirical results for this industry have been summarized in Table 3.16.1. They are based on a modified specification of equation (2.2.26) which allows non-linear trends for the output elasticities of factor inputs (non-linear biases in technical change). The estimated equation gives a quadratic form to the exponents of capital, energy and material inputs. This is accomplished by adding to equation (2.2.26) variables of interation of time squared with each of the above factor inputs. This new specification was found necessary for the data on this industry because, as Table 3.16.2 shows, estimated output elasticities of capital, energy and intermediate materials were negative even at the mean of the time trend. These elasticities are given by a_1+a_8*t, a_2+a_9*t and $a_3+a_{10}*t$, where the time trend t=0,1,...21. With the new specification these elasticities are given by $a_1+a_8*t+a_{11}*t^2$, $a_2+a_9*t+a_{12}*t^2$ and $a_3+a_{10}*t+a_{13}*t^2$ for capital, energy and material inputs respectively. Since the coefficient of interaction of time and energy was found statistically insignificant (with F statistic 0.089) suggesting zero energy bias, this variable and its interaction with time squared were ommitted from subsequent estimations. The selected estimating equation is

$$\ln q = -0.11119 + 0.347535 * \ln k + 0.01847 * \ln e + 0.495993 * \ln m$$
$$(13.71)$$

$$+0.013983 * t - 0.000404 * t^2 - 0.072298 * t * \ln K + 0.004681 * t^2 * \ln K$$
$$(6.87) \quad (3.60) \quad (8.90) \quad (5.44)$$

$$+0.04993^2 * t * \ln M - 0.001425 * t^2 * \ln M$$
$$(5.53) \quad (2.53)$$

R^2=0.987794 D.W.=2.19767 S.E.R.=0.009455
Condition Number: 50.276

All variables of the regression (except the time trend) were rescaled so that 1971=1. Using Ordinary Least Squares procedures this equation obtains estimated coefficients for the time trend, time squared, and the interactions of time and time squared with both capital and material inputs. Except for the last estimated coefficient, significant at the 97% level, all others are significant at the 99% level or better. Other regression statistics are quite satisfactory, showing no significant multicollinearity or autocorrelation problems. The coefficient of labour, found insignificant in earlier estimations, was constrained to remain at zero in this equation (reflecting approximately constant returns-to-scale). The capacity utilization variable was highly collinear with other independent variables in earlier regressions and was dropped from the estimating equation.

The new specification changes our computation of the technical progress rate otherwise given by equation (2.2.27). This rate, given by the partial derivative of the logarithm of output-labour ratio (q) with respect to time, now becomes

$$a_4+2a_5*t+a_8*\ln K+2a_{11}*t*\ln K+a_9*\ln E+2a_{12}*t*\ln E$$
$$+a_{10}*\ln M+2a_{13}*t*\ln M$$

in terms of the coefficients of Table 3.16.2.

Our estimated results indicate that technical progress in this industry was capital-saving between 1961 and 1976 but became (mildly) capital-using from 1977 onward; it was also materials-using but this bias declined over the study period. One implication of these findings is that, with capital and materials-using technical change after 1976, a reduction in the price of capital (its user cost) or of intermediate inputs would increase technical progress. In this case labour productivity gains would improve through increasing capital-labour and materials-labour ratios as well as through greater technical progress.

Table 3.16.1 summarizes the sources of labour productivity growth for this industry for the study period and four subperiods. Labour productivity gains, which showed considerable variation over the study period, averaged about 4.3 percent per year. Our analysis indicates that the decline in the second subperiod relative to the first occurred primarily because of falling technical progress. The lower growth rate of energy-labour ratio was a second contributing factor. The slight decline of the third subperiod relative to the second was mostly due to lower growth of the capital labour ratio and a sharp decline in energy use relative to labour employment. In the fourth subperiod labour productivity actually contracted at an average annual rate of 0.18 percent. This is accounted for by the industry's use of intermediate inputs relative to labour which made a large negative contribution to labour productivity growth. Technical progress which, on average, was close to zero over this subperiod was a second and significant factor.

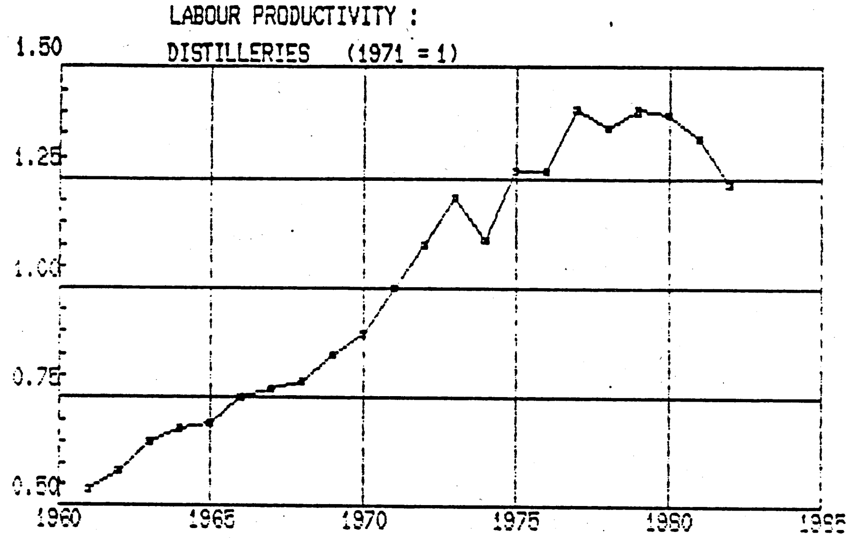
TABLE 3.16.1

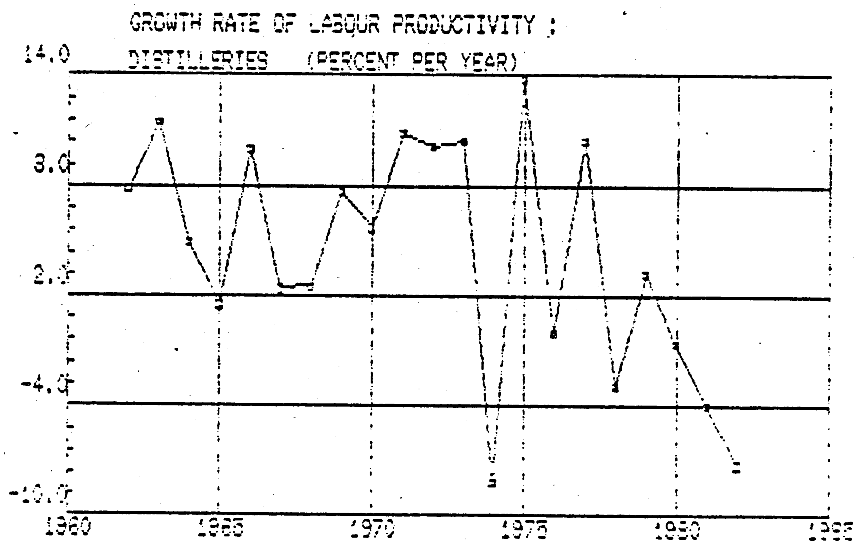
DISTILLERIES

SOURCES OF LABOUR PRODUCTIVITY GROWTH: 1961-1982

(PERCENT PER YEAR)

	1962-66	1967-71	1972-76	1977-82	1962-1982
LABOUR PRODUCTIVITY GROWTH	7.146	5.851	5.232	-0.181	4.289
TECHNICAL PROGRESS (T.F.P. GROWTH)	2.255	0.593	0.814	0.007	0.874
CAPITAL	-0.185	0.710	0.202	0.358	0.275
ENERGY	0.144	0.079	-0.067	0.030	0.046
MATERIAL INPUTS	4.408	4.495	4.422	-0.794	2.946
RESIDUAL GROWTH	0.523	-0.026	-0.139	0.219	0.148


LABOUR PRODUCTIVITY :
DISTILLERIES (1971 = 1)
1.50
1.25
1.00
0.75
0.50
1960
1965
1970
1975
1980
1985


GROWTH RATE OF LABOUR PRODUCTIVITY :
DISTILLERIES (PERCENT PER YEAR)
14.0
8.0
2.0
-4.0
-10.0
1960
1965
1970
1975
1980
1985

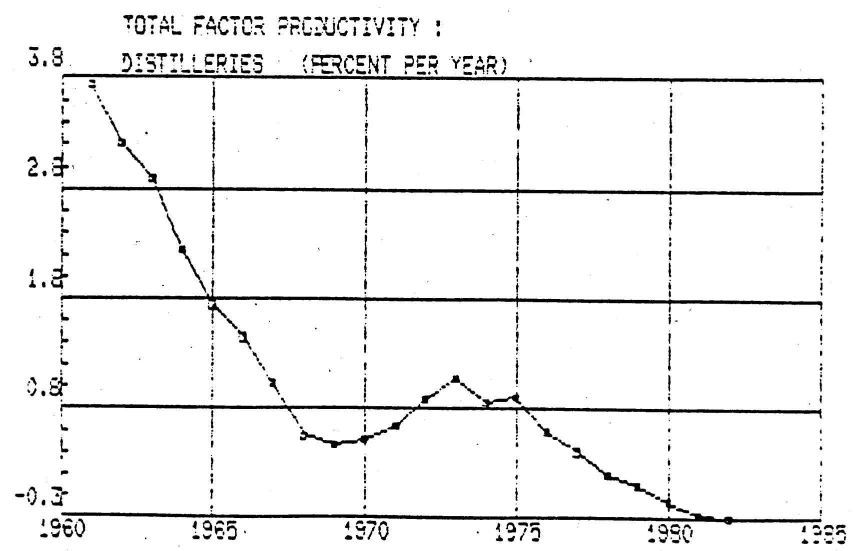

TOTAL FACTOR PRODUCTIVITY :
DISTILLERIES (PERCENT PER YEAR)
3.8
2.8
1.8
0.8
-0.3
1960
1965
1970
1975
1980
1985

TABLE 3.16.2 DISTILLERIES (SIC 1092)

Alternative Regression Results

$lnq=lnA+a_1*lnk+a_2*lne+a_3*lnm+a_4*t+a_5*t^2+a_6*c+a_7*lnL+a_8*t*lnK+a_9*t*lnE+a_{10}*t*lnM+a_{11}*t^2*lnK+a_{12}*t^2*lnE+a_{13}*t^2*lnM$

a1=0.347535 a2=0.01847 a3=0.495993

Estimation Method	lnA	a4	a5	a6	a7	a8	a9	a10	a11	a12	a13	R^2	D.W.	RhO	Cond. No.
GLS	-0.5802	0.0182	-0.0005	0.4929	-0.1634	-0.0182	-0.0059	0.0147	-	-	-	0.979	1.605	0.5482	114
	(2.72)	(3.67)	(2.65)	(2.14)	(1.62)	(1.92)	(1.48)	(1.76)							
GLS	-0.1265	0.0199	-0.0007	-	-0.1081	-0.0340	-0.0012	0.0300	-	-	-	0.973	1.775	0.3684	35
	(4.69)	(3.83)	(3.61)		(1.04)	(6.58)	(0.31)	(7.53)							
GLS	-0.1309	0.0208	-0.0007	-	-0.1280	-0.0339	-	0.0296	-	-	-	0.973	1.772	0.3564	29
	(5.90)	(4.85)	(4.05)		(1.62)	(6.82)		(8.23)							
OLS	-0.1263	0.0164	-0.0004	-	0.0786	-0.0706	-	0.0547	0.0041	-	-0.0017	0.989	2.224	-	51
	(9.54)	(6.25)	(3.95)		(1.42)	(8.89)		(5.84)	(4.53)		(2.96)				
OLS	-0.1111	0.0139	-0.0004	-	-	-0.0722	-	0.0499	0.0046	-	-0.0014	0.987	2.197	-	50
	(13.71)	(6.87)	(3.60)			(8.90)		(5.53)	(5.44)		(2.53)				
OLS	-0.0964	0.0071	-	-	-	-0.0868	-	0.0755	0.0050	-	-0.0031	0.977	1.396	-	21
	(10.40)	(7.26)				(9.30)		(10.20)	(4.42)		(7.48)				
GLS	-0.0971	0.0069	-	-	-	-0.0882	-	0.0762	0.0050	-	-0.0030	0.978	1.624	0.2540	20
	(9.36)	(6.69)				(8.25)		(8.97)	(3.87)		(6.21)				
OLS	-0.0924	0.0068	-	-	0.0261	-0.0863	-	0.0721	0.0051	-	-0.0028	0.977	1.410	-	34
	(6.51)	(4.94)			(0.38)	(8.94)		(6.21)	(3.18)		(4.02)				
GLS	-0.0930	0.0066	-	-	0.0269	-0.0877	-	0.0727	0.0052	-	-0.0028	0.978	1.646	0.2425	29
	(6.20)	(4.89)			(0.37)	(7.98)		(5.75)	(3.70)		(3.75)				
OLS	-0.9013	0.0250	-0.0007	0.8126	-0.3740	-	-	-	-	-	-	0.958	1.230	-	83
	(8.45)	(5.75)	(3.85)	(7.23)	(4.67)										
GLS	-0.8475	0.0247	-0.0006	0.7572	-0.3488	-	-	-	-	-	-	0.964	1.571	0.4102	50
	(8.44)	(5.16)	(3.36)	(7.43)	(3.74)										
GLS	-0.1240	0.0263	-0.0007	-	-0.1141	-	-	-	-	-	-	0.849	1.824	0.4203	24
	(2.47)	(2.73)	(1.85)		(0.64)										

3.17 Breweries

The empirical results for this industry have been summarized in Table 3.17.1. They are based on econometric estimation of equation (2.2.22) using aggregate data described in Appendices 1 and 2. The estimating equation, which finds Hicks neutral technical progess is

$$\ln q = -0.160755 + \underset{(20.97)}{0.330967} * \ln k + 0.013989 * \ln e + 0.453326 * \ln m$$

$$+ \underset{(13.23)}{0.020258} * t - \underset{(4.61)}{0.000411} * t^2 - \underset{(2.03)}{0.143957} * \ln L$$

$R^2 = 0.970131$ D.W.=1.8744 S.E.R.=0.011822
Condition Number: 18.4177

All variables of the regression (except the time trend) were rescaled so that 1971=1. Using Ordinary Least Squares estimation, this equation obtains coefficients for the time trend, square of the time trend and aggregate labour input (which, in this formulation, measures returns-to-scale). The coefficient of labour is significant at the 94% level and others are significant at the highest possible level. All regression statistics are quite satisfactory, showing no significant multicollinearity or autocorrelation. As Table 3.17.2 shows, the hypothesis of biased technical progress can easily be rejected, supporting the specification presented above. The capacity utilization variable was excluded from the estimating equation as it was highly collinear with other independent variables. According to the coefficients of time and time squared, technical progress has the intercept 2.02 and slope -0.08 (both in percent per year). The coefficient of labour indicates returns-to-scale of about 0.86 (given by unity plus this coefficient).

Table 3.17.1 summarizes the sources of labour productivity growth in this industry for the study period and four subperiods. Labour productivity gains averaged about 2.7 percent per year over the study period most of which originated from growth of materials-labour ratio and technical progress. The proportion of labour productivity growth coming from technical progress was on average 42 percent, the largest among food and beverage industries.

Labour productivity growth showed a slight increase during the second subperiod compared to the first. Most of this change was due to residual factors not encompassed by our model of the industry's production function. The large decline in the third subperiod, however, is accounted for by a substantial drop in the growth rate of materials-labour ratio, an increase in labour employment (due to decreasing returns-to-scale in the industry) and falling capital-labour and energy-labour ratios. Lower technical progress compared to previous subperiods was also a contributing factor. During the last six years of the study period labour productivity growth showed some improvement, averaging about 1.6 percent per year. This was substantially due to higher growth rates of the materials-labour ratio, though lower labour employment growth (through returns-to-scale) helped this process.

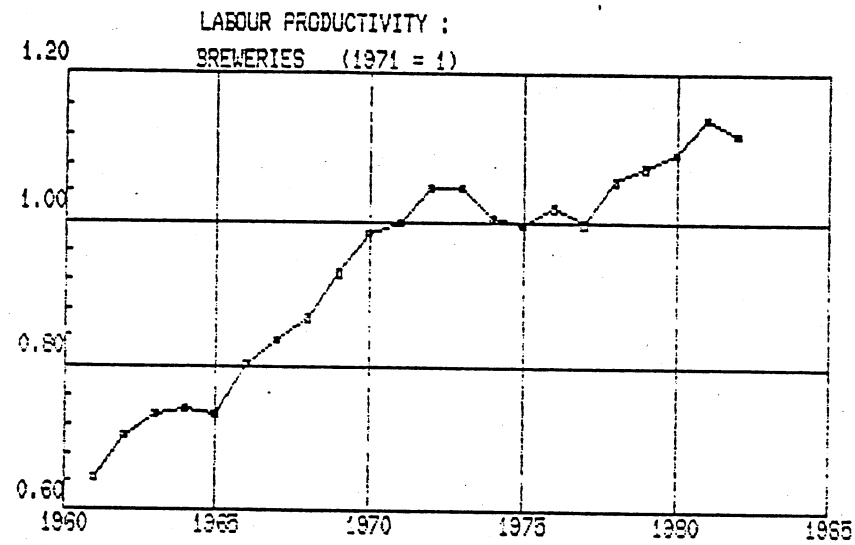
TABLE 3.17.1

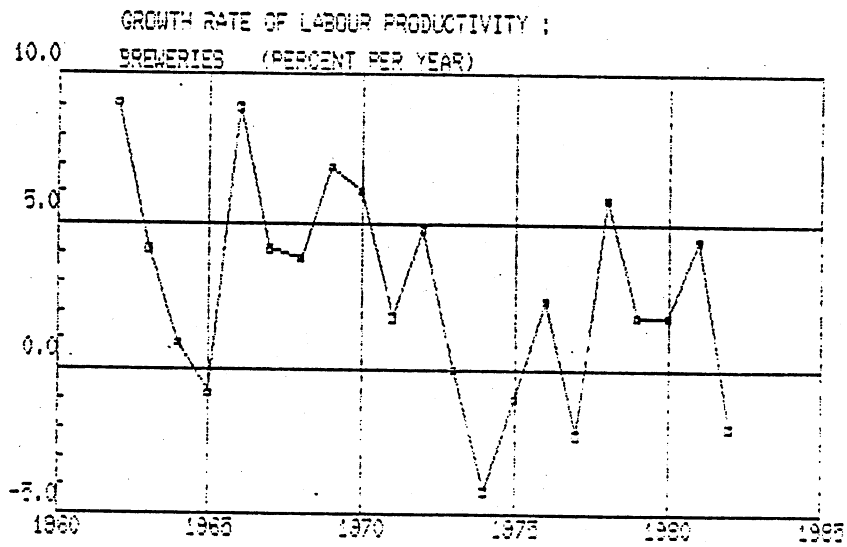
BREWERIES

SOURCES OF LABOUR PRODUCTIVITY GROWTH: 1961-1982

(PERCENT PER YEAR)

	1962-66	1967-71	1972-76	1977-82	1962-1982
LABOUR PRODUCTIVITY GROWTH	4.442	4.511	0.377	1.585	2.674
TECHNICAL PROGRESS (T.F.P. GROWTH)	1.779	1.368	0.957	0.505	1.122
CAPITAL	0.172	1.378	-0.317	-0.154	0.249
ENERGY	0.038	0.069	0.012	-0.039	0.017
MATERIAL INPUTS	2.183	2.054	0.108	1.503	1.464
RETURNS-TO-SCALE	0.002	-0.043	-0.561	-0.231	-0.209
RESIDUAL GROWTH	0.269	-0.315	0.178	0.001	0.032


LABOUR PRODUCTIVITY :
BREWERIES (1971 = 1)
1.20
1.00
0.80
0.60
1960
1965
1970
1975
1980
1985


GROWTH RATE OF LABOUR PRODUCTIVITY :
BREWERIES (PERCENT PER YEAR)
10.0
5.0
0.0
-5.0
1960
1965
1970
1975
1980
1985

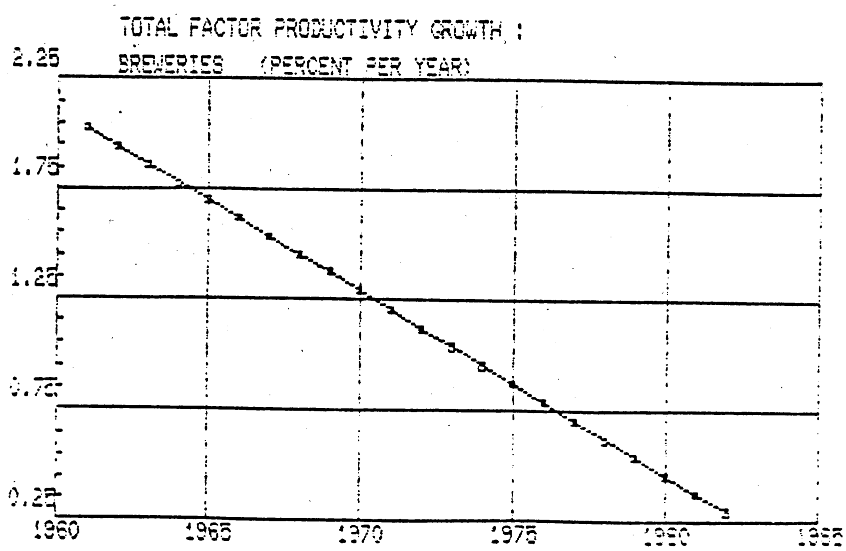

TOTAL FACTOR PRODUCTIVITY GROWTH :
BREWERIES (PERCENT PER YEAR)
2.25
1.75
1.25
0.75
0.25
1960
1965
1970
1975
1980
1985

TABLE 3.17.2 BREWERIES (SIC 1093)

Alternative Regression Results

$\ln q = \ln A + a_1 * \ln k + a_2 * \ln e + a_3 * \ln m + a_4 * t + a_5 * t^2 + a_6 * c + a_7 * \ln L + a_8 * t * \ln E + a_{10} * t * \ln M$

a1=0.330967 a2=0.013989 a3=0.453326

Estimation Method	lnA	a4	a5	a6	a7	a8	a9	a10	R^2	D.W.	RhO1	Cond. No.
GLS	-0.5370 (7.31)	0.0205 (6.28)	-0.0004 (1.30)	0.4010 (5.13)	-0.3776 (3.83)	0.0082 (0.81)	0.0076 (1.45)	-0.0018 (0.26)	0.989	1.673	0.3729	103
OLS	-0.1607 (20.23)	0.0205 (9.52)	-0.0004 (2.29)	-	-0.2444 (1.83)	0.0001 (0.01)	0.0048 (0.63)	-	0.971	1.823	-	42
GLS	-0.1609 (16.69)	0.0201 (7.40)	-0.0003 (1.21)	-	-0.2648 (1.47)	-0.0031 (0.15)	0.0068 (0.53)	-	0.971	1.901	0.1276	60
OLS	-0.1607 (20.88)	0.0205 (13.08)	-0.0004 (4.52)	-	-0.2443 (1.88)	-	0.0049 (0.92)	-	0.971	1.819	-	20
OLS	-0.1607 (20.97)	0.0202 (13.23)	-0.0004 (4.61)	-	-0.1439 (2.03)	-	-	-	0.965	1.874	-	18

3.18 Wineries

The empirical results for this industry have been summarized in Table 3.18.1. They are based on econometric estimation of equation (2.2.22) using aggregate data described in Appendices 1 and 2. This estimating equation, based on the assumption of Hicks neutral technical change, is

$$\ln q = -0.234741 + \underset{(8.11)}{0.205022} * \ln k + 0.009466 * \ln e + 0.632394 * \ln m$$

$$+ \underset{(2.68)}{0.017218} * t - \underset{(1.38)}{0.000408} * t^2$$

$R^2 = 0.823732$ D.W. = 2.04421   S.E.R. = 0.03175

Rho1: 0.782117 Rho2: -0.378838
Condition Number: 15.592

All variables of the regression (except the time trend) were rescaled so that 1971=1. This equation obtains estimated coefficients for the time trend and the square of the time trend. Their significance levels are 98% and 82% respectively. Second order autocorrelation was corrected using the Cochrane-Orcutt procedure together with the Prais-Winsten procedure. All regression statistics are quite satisfactory, showing no significant multicollinearity or autocorrelation in the selected regression. The coefficients of autocorrelation satisfy the conditions required for stationarity. The aggregate labour employment variable was ommitted from the estimating equation as its coefficient was statistically insignificant in previous regressions. The F statistic for this coefficient is 0.03. Our estimated results thus indicate constant returns-to-scale in this industry.

As Table 3.18.2 shows equation (2.2.26), which incorporates biases in technical progress, was also estimated with varying specifications. The estimation results, however, were not satisfactory. In regressions free of multicollinearity and autocorrelation problems, we found capital-saving bias which even at the mean of the time trend made the output elasticity of capital negative. Two possible explanations of the difficulty are unreliability of data on capital stock and non-linearities in the time trend of this elasticity. The latter possibility was pursued but the problem could not be successfully resolved. Therefore, although the hypothesis of biased technical change cannot be rejected, the results of Table 3.18.1 are based on a Cobb-Douglas specification for this industry's productions function.

The sources of labour productivity growth for the study period and four subperiods have been summarized in Table 3.18.1. Labour productivity gains averaged about 4 percent per year between 1962 and 1982 with about 2.2 percent originating from growing materials-labour ratio and more than 0.8 percent from technical progress. Growing capital-labour ratio contributed 0.6 percent to labour productivity growth. Over the study period only 0.314 percent of labour productivity changes were left unexplained by our analysis.

The industry experienced large and highly variable labour productivity gains. Five year average rates varied from a high of 8.7 percent to low of about -2.9 percent between the second and third subperiod. For the second subperiod, most of the increased growth originated from the materials-labour ratio which grew at more than twice its rate in the first subperiod but almost 3 percent of the gains remain unexplained. The large negative growth of the third subperiod (1972-76) similarly resulted from sharply falling materials-labour ratio. However, an even more substantial part (-3.741%) was due to residual, unexplained factors. Labour productivity recovered over the last subperiod, growing at about 5.3 percent per year. Once again, the largest contributing factor was growing materials-labour ratio.

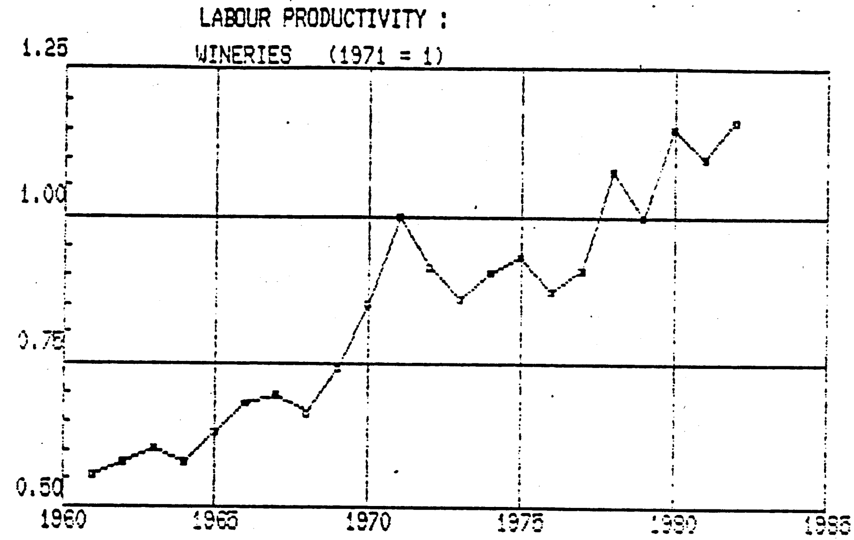
TABLE 3.18.1

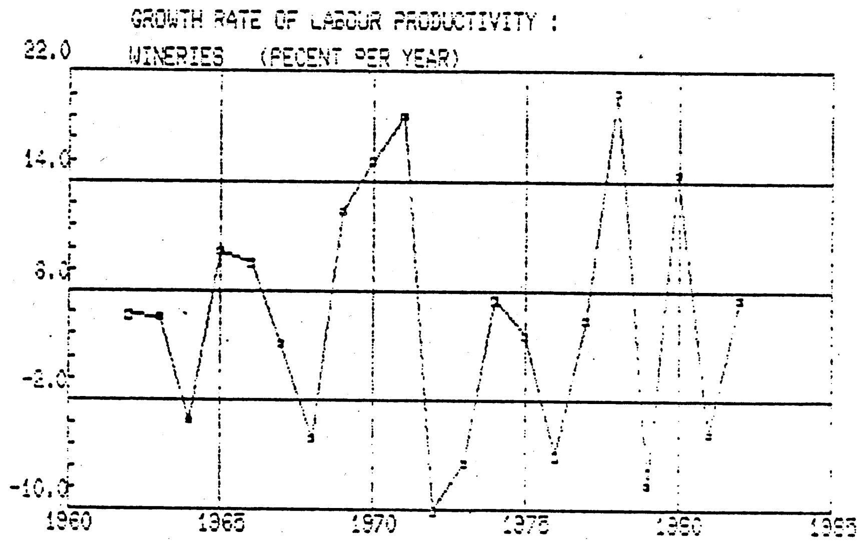
WINERIES

SOURCES OF LABOUR PRODUCTIVITY GROWTH: 1961-1982

(PERCENT PER YEAR)

	1962-66	1967-71	1972-76	1977-82	1962-1982
LABOUR PRODUCTIVITY GROWTH	4.358	8.731	-2.896	5.341	3.953
TECHNICAL PROGRESS (T.F.P. GROWTH)	1.477	1.069	0.661	0.212	0.824
CAPITAL	0.696	0.008	1.831	0.021	0.609
ENERGY	0.024	0.009	0.008	0.014	0.014
MATERIAL INPUTS	2.047	4.717	-1.655	3.412	2.191
RESIDUAL GROWTH	0.114	2.929	-3.741	1.682	0.314


LABOUR PRODUCTIVITY :
WINERIES (1971 = 1)
1.25
1.00
0.75
0.50
1960
1965
1970
1975
1980
1985


GROWTH RATE OF LABOUR PRODUCTIVITY :
WINERIES (PECENT PER YEAR)
22.0
14.0
6.0
-2.0
-10.0
1960
1965
1970

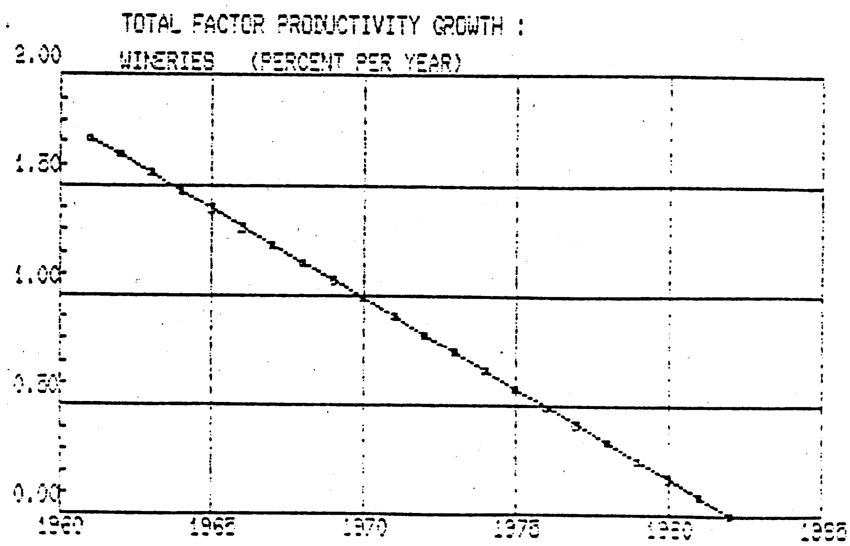

TOTAL FACTOR PRODUCTIVITY GROWTH :
WINERIES (PERCENT PER YEAR)
2.00
1.50
1.00
0.50
0.00

TABLE 3.18.2 WINERIES (SIC 1094)

Alternative Regression Results

$\ln q = \ln A + a_1 * \ln k + a_2 * \ln e + a_3 * \ln m + a_4 * t + a_5 * t^2 + a_6 * c + a_7 * \ln L + a_8 * t * \ln E + a_{10} * t * \ln M$

a1=0.205022 a2=0.009466 a3=0.632394

Estimation Method	lnA	a4	a5	a6	a7	a8	a9	a10	R^2	D.W.	Rho1	Rho2	Cond. No.
GLS	-0.1349	0.0434	-0.0012	-0.1961	-0.1723	-0.0206	0.0004	0.0323	0.985	1.826	0.2142	-	90
	(2.16)	(7.05)	(4.40)	(3.41)	(2.49)	(7.87)	(0.14)	(9.73)					
OLS	-0.1251	0.0451	-0.0013	-0.2117	-0.1835	-0.0205	-	0.0339	0.985	1.751	-	-	110
	(2.05)	(7.36)	(4.70)	(3.91)	(2.74)	(9.17)		(10.48)					
OLS	-	0.0405	-0.0010	-0.1387	-0.1667	-0.0211	-	0.0288	0.918	1.955	-	-	8
FIRST DIFF		(5.37)	(2.85)	(2.28)	(2.65)	(5.25)		(9.23)					
OLS	-0.3318	0.0456	-0.0014	-	-0.2065	-0.0168	-	0.0308	0.970	1.348	-	-	100
	(7.97)	(5.41)	(3.60)		(2.25)	(6.02)		(7.13)					
OLS	-0.1900	0.0154	-	-	0.1149	-0.0229	-0.0031	0.0177	0.946	1.192	-	-	26
	(6.97)	(5.06)			(1.97)	(7.29)	(0.52)	(5.80)					
OLS	-0.1966	0.0161	-	-	0.0975	-0.0236	-	0.0168	0.945	1.086	-	-	20
	(8.31)	(6.01)			(2.08)	(8.72)		(6.77)					
GLS	-0.2512	0.0223	-	-	-0.0415	-0.0289	-	0.0208	0.966	1.441	0.8417	-	6
	(7.72)	(6.86)			(0.73)	(8.08)		(8.21)					
OLS	-0.2399	0.0204	-	-	-	-0.0247	-	0.0169	0.931	0.660	-	-	12
	(19.46)	(11.15)				(8.49)		(6.24)					
GLS	-0.2365	0.0212	-	-	-	-0.0286	-	0.0202	0.965	1.510	0.7799	-	6
	(11.46)	(8.14)				(8.37)		(8.23)					
OLS	-0.1791	0.0095	-0.0002	-	0.1017	-	-	-	0.707	0.916	-	-	31
	(2.53)	(0.92)	(0.73)		(0.76)								
GLS	-0.2190	0.0141	-0.0002	-	0.0234	-	-	-	0.795	1.593	0.5664	-	20
	(2.78)	(1.17)	(0.72)		(0.16)								
GLS	-0.2511	0.0194	-0.0004	-	-0.0317	-	-	-	0.824	2.05	0.7992	-0.3889	29
AR2	(2.94)	(1.52)	(1.15)		(0.20)								
GLS	-0.2347	0.0172	-0.0004	-	-	-	-	-	0.823	2.04	0.7821	-0.3788	15
AR2	(8.11)	(2.68)	(1.38)										

APPENDIX 1

DATA AGGREGATION

In most productivity analysis we are interested to know the effects, for instance, of total energy input on output or productivity rather than those of individual energy components. To do this, we need to aggregate the quantities (or prices) of various productive inputs into categories such as capital, labour, energy and intermediate materials. This aggregation can be performed in a number of different ways. The theoretical considerations related to our choice of index number formulae are discussed in Section 2. Here we will attempt only to detail some technical aspects of the procedures used and, for simplicity, demonstrate this using two input components: labour of type 1, X^1 and type 2, X^2. The factor prices (wage rates in this example) are denoted by W^1 and W^2. The subscripts indicate the time period (0 for the base period and 1 for the first period) to which the data belong.

To aggregate the input components, we have employed Irving Fisher's (1922) ideal index number (see Allen, 1975). Fisher's quantity and price indices are defined, respectively, as

$$Q_F(W_0, W_1; X_0, X_1) = (Q_P * Q_L)^{\frac{1}{2}} \qquad \text{(A1.1)}$$

$$P_P(W_0, W_1; X_0, X_1) = (P_P * P_L)^{\frac{1}{2}} \qquad \text{(A1.2)}$$

where the asterisks denote the product of Q_p, Q_L and P_p, P_L taken for any time period, W_0, W_1, X_0 and X_1 are vectors with two elements (for our two types of labour and wage rate) and the subscripts F, P, and L refer to Fisher, Paasche and Laspeyres indices respectively. The indices are for Paasche

$$Q_P(W_0, W_1; X_0, X_1) = \frac{W_1 \cdot X_1}{W_1 \cdot X_0} = \frac{W_1^1 * X_1^1 + W_1^2 * X_1^2}{W_1^1 * X_0^1 + W_1^2 * X_0^2}, \tag{A1.3}$$

$$P_P(W_0, W_1; X_0, X_1) = \frac{W_1 \cdot X_1}{W_0 \cdot X_1} = \frac{W_1^1 * X_1^1 + W_1^2 * X_1^2}{W_0^1 * X_1^1 + W_0^2 * X_1^2}, \tag{A1.4}$$

and for Laspeyres

$$Q_L(W_0, W_1; X_0, X_1) = \frac{W_0 \cdot X_1}{W_0 \cdot X_0} = \frac{W_0^1 * X_1^1 + W_0^2 * X_1^2}{W_0^1 * X_0^1 + W_0^2 * X_0^2}, \tag{A1.5}$$

$$P_L(W_0, W_1; X_0, X_1) = \frac{W_1 \cdot X_0}{W_0 \cdot X_0} = \frac{W_1^1 * X_0^1 + W_1^2 * X_0^2}{W_0^1 * X_0^1 + W_0^2 * X_0^2}, \tag{A1.6}$$

where the inner product of two vectors is indicated by a dot between them. With some algebraic rearrangement we can write (A1.3) as

$$Q_P = \left(\frac{W_1^1 \ast X_0^1 + W_1^2 \ast X_0^2}{W_1^1 \ast X_1^1 + W_1^2 \quad X_1^2} \right)^{-1}$$

$$\left(\frac{X_1^1}{X_1^1} \ast \frac{W_1^1 \ast X_0^1}{W_1^1 \ast X_1^1 + W_1^2 \ast X_1^2} + \frac{X_1^2}{X_1^2} \ast \frac{W_1^2 \ast X_0^2}{W_1^1 \ast X_1^1 + W_1^2 \ast X_1^2} \right)^{-1}$$

$$\left(\frac{X_0^1}{X_1^1} \ast S_1^1 + \frac{X_0^2}{X_1^2} \ast S_1^2 \right)^{-1} \qquad \text{(A1.7)}$$

where S_1^1 and S_1^2 are shares of expenditure on type 1 and type 2 labour in the total wage bill for the current period. The Paasche price index is similarly rearranged to get

$$P_P = \left(\frac{W_0^1}{W_1^1} \ast S_1^1 + \frac{W_0^2}{W_1^2} \ast S_1^2 \right)^{-1} \qquad \text{(A1.8)}$$

The Laspeyres quantity and price indices can also be simplified for computational purposes. The quantity index becomes

$$Q_L = \frac{X_0^1}{X_0^1} \ast \frac{W_0^1 \ast X_1^1}{W_0^1 \ast X_0^1 + W_0^2 \ast X_0^2} + \frac{X_0^2}{X_0^2} \ast \frac{W_0^2 \ast X_1^2}{W_0^1 \ast X_0^1 + W_0^2 \ast X_0^2} \qquad \text{(A1.9)}$$

$$= \frac{X_1^1}{X_0^1} \ast S_0^1 + \frac{X_1^2}{X_0^2} \ast S_0^2$$

and the Laspeyres price, derived analogously, is

$$P_L = \frac{W_1^1}{W_0^1} \ast S_0^1 + \frac{W_1^2}{W_0^2} \ast S_0^2 \qquad \text{(A1.10)}$$

where S_0^1 and S_0^1 are base-period expenditure shares of labour components in the total wage bill. When our indices are fixed-base, we use the 1971 share values as base-year values for all years in the Laspeyres index but current year shares for the Paasche index. In quantity and price relatives, such as W_1/W_0 or X_0/X_1, the 1971 values of wage rates or quantities are used for base-year values in both Laspeyres and Paasche indices. All data except share values are normalized to 1971 and scaled at 100 prior to being used in indices. This is done by dividing values of all price (wage rate) and quantity components for all years by their 1971 values and multiplying them by 100.

When the indices are chain-linked, there is a base year for each year for which data is available. In constructing the Laspeyres index, therefore, the share values of the two input components (S_0^1, S_0^2) for all years are those of the preceding year, rather than 1971. The price (wage rate) and quantity relatives entering into Paasche and Laspeyres formulations are also taken relative to the last period, so that W_0^1 and X_0^1 indicate the wage rate and the quantity of labour of type 1 used in the preceding year. For the chain-linked index, the variables are normalized by dividing them by their 1961 values, the first year for which complete industry data is available. By so doing the value of all indices for 1961 will be 1, unless they are scaled to 100. The advantage of using 1961 as the normalization base is that the value of the index for that (first) year can be determined (and will be unity). Using any other year to normalize input component time series results in losing the value of the index for 1961, since for that year data on lagged (1960) values of input components are not available.

Using the chain-linked method, the derivation of indices for year 1 is the same as produced above, but for subsequent years they become

$$Q_p^n = Q_p^{(1)} * Q_p^{(2)} * \cdots * Q_p^{(n)} \tag{A1.11}$$

where the terms on the right-hand side refer to Paasche quantity indices constructed on the chain principle between the base and the first year, the first and the second year, etc. Their cumulative product is an index of quantity for the nth year relative to the base year.

The value of this and other indices is unity ($Q_p = 1$) for 1961 and that for subsequent years an index number <u>relative</u> to unity. The indices are then scaled to 100.

For some productive inputs such as energy, the desired quantity indices are derived indirectly through price indices using Fisher's weak factor reversal test (Allen, p. 46). Given a Fisher price index, the corresponding quantity index is the product of the latter and the ratio of current to base (or lagged, for the chain-linked price index) period expenditure on the input. This simply is

$$Q_F = P_F * \left(\frac{W_1^1 * X_1^1 + W_1^2 * X_1^2}{W_o^1 * X_0^1 + W_0^2 * X_0^2} \right) \qquad (A1.12)$$

where P_F is the Fisher price index derived above.

In terms of our mnemonics, the fixed-base labour quantity index has been constructed by the following set of equations using the command DO in TROLL:

PPWFB=((VPWFB/QPWFB/ 3.045877)*100, (A1.13)

PNPWFB=((VNPWFB/QNPWFB)/8.147664)*100, (A1.14)

SPWFB=VPWFB/(VPWFB+VNPWFB), (A1.15)

SNPWFB=1-SPWFB, (A1.16)

PLLAFB=PPWFB*0.579719+PNPWFB*0.420280, (A1.17)

PPLAFB=(1/(SPWFB/PPWFB+SNPWFB/PNPWFB)), (A1.18)

PFLAFB=(PLLAFB*PPLAFB)**0.5, (A1.19)

XFLAFB=((VPWFB+VNPWFB)/1471183*100)/PFLAFB*100. (A1.20)

Equations (A1.13) and (A1.14) obtain (average) unit prices for labour services offered by production workers and non-production workers respectively within the food and beverage sector. After obtaining these averages by dividing expenditures on labour types by their quantities, these prices are divided by their 1971 values to produce a normalized series and are then scaled to 100. Equations (A1.15) and (A1.16) calculate the shares of expenditure on each type of labour in total labour costs. Since shares by definition sum to one, the expenditure share of non-production workers is simply one minus that of production workers. Equation (A1.17) produces a Laspeyres price index series for labour by summing normalized current unit prices of each type of labour, weighted by the share of each type in total labour costs. Since the share values are maintained at their 1971 level throughout, they appear as parameters. Equation (A1.18) produces the Paasche price index series. The share values, as indicated, are for current year, and unit prices for labour are normalized (and scaled) current values. Equation (A1.19) obtains the geometric mean of the above price indices which is the Fisher index of the unit price of (aggregate) labour and equation (A1.20) converts the Fisher index of price to the corresponding quantity index.

The chain-linked Fisher index of labour input, using TROLL's DO command is constructed by

```
XPWFB=QPWFB/VALUE(QPWFB,1961),                                    (A1.21)
XNPWFB=QNPWFB/VALUE(QNPWFB,1961),                                 (A1.22)
QLLAFB=CUMPROD(XPWFB/XPWFB(-1)*SPWFB(-1)+
     XNPWFB/XNPWFB(-1)*SNPWFB(-1))*100,                           (A1.23)
QPLAFB=CUMPROD(1/(XPWFB(-1)/XPWFB*SPWFB+
     NPWFB(-1)/XNPWFB*SNPWFB))*100,                               (A1.24)
QFLAFB=(QLLAFB*QPLAFB)**0.5.                                      (A1.25)
```

Their differences with the equations for the fixed-base index are as follows. The first two equations normalize the series for quantities of production and non-production labour relative to their values in 1961. Equation (A1.23) obtains a chain-linked Laspeyres quantity index using current and one-period lagged values of labour quantities and expenditure shares. The annual (aggregate) quantity ratios are then converted to total ratios by taking the cumulative product of all elements between the base year and the current year. The index is then scaled to 100. Equation (A1.24) is a chain-linked Paasche index of aggregate labour quantity. It uses the same quantity series and lagged series as Laspeyres, but expenditure share values are those of the current period. Equation (A1.25) produces a chain-linked Fisher quantity index series using the results of equations (A1.23) and (A1.24).

APPENDIX 2

DATA SOURCES AND TRANSFORMATIONS

The data used in this study are for output, capital, labour, energy, material inputs and capacity utilization rates for the food and beverage sector and its 17 constituent industries at the 3- or 4-digit level of Standard Industrial Classification. This section is divided into 6 subsections, each dealing with the source(s) and structure of data for one of the above categories. Each subsection concludes with a discussion of the transformations done on data series and the TROLL facilities used to effect them.

A2.1 Output

The output data used in this study are constant dollar values of gross output. Two separate series on output of each industry were used: a constant 1961 dollar series spanning the 1961-1971 period and a constant 1971 dollar series for the 1971-1983 period with overlapping data for 1971. Both sets of data were obtained from the Industry Product Division of Statistics Canada. Though the above data are not published, comparable data at the 3-digit level of S.I.C are published by Statistics Canada in Systems of National Accounts, Gross Domestic Product by Industry, Catalogue No. 61-213. Since the series based on the 1960 and 1970 S.I.C. breakdowns do not agree on the values of output for 1971, the following procedure was used to link them and obtain one continuous series for output of each industry.

VGOFBK=OVERLAY(VGOFB7K,VGOFB6K*VALUE(VGOFB7K,1971)
    /VALUE(VGOFB6K,1971)). (A2.1.1)

Here, VGOFB7K is the output series spanning the 1970s and VGOFB6K is the corresponding data series for the 1960s. The desired, continuous series VGOFBK which runs from 1961 to 1983 is obtained by transforming VGOFB6K and attaching it to the 1970s series (VGOFB7K) such that both series have the same values for 1971. The transformation involves multiplying the 1970s series by a constant obtained by dividing the value of VGOFB7K in 1971 by the value of VGOFB6K in the same year. This operation changes the last (1971) element of VGOFB6K to that of the first (1971) element in VGOFB7K and the OVERLAY function simply integrates them into one (23-element) vector by giving it a new mnemonic.

Before being used for productivity measurement, all output series are normalized by their 1971 or 1961 values (depending on the fixed-base or chain-linked indices with which they are used). The series are then scaled to 100 to produce 1971 or 1961 based indices of gross output. Using TROLL's DO command, the indices are produced by

GOFB=VGOFBK/VALUE(VGOFBK,1971)*100, (A2.1.2)

and

GYFB=VGOFBK/VALUE(VGOFBK,1961)*100. (A2.1.3)

where GOFB and GYFB are indices of gross output for the food and beverage sector such that (GOFB, 1971) = 100 and (GYFB, 1961) = 100.

The above procedure is performed for the food and beverage sector as well as its 17 constituent (3-and 4-digit level) industries using TROLL's MACRO facility. The MACROs created for this operation are RAWI01, INDI01 and INDI02.

The first MACRO, RAWI01, contains separate raw data series on output (and material inputs) during the 1960s and the 1970s and OVERLAY equations (equation (A2.1.1)) to link the series. The MACRO then adds COMMENTS to the resulting (continuous) series to supplement their identification and writes them in TROLL data archive RAW85. The second MACRO, INDI01, produces the required gross output indices using an equation such as (A2.1.2) for each linked series constructed by RAWI01. This MACRO writes the resulting derived data in data archive DER85. The third MACRO, INDI02 contains only indexing equations (A2.1.3) which produce output indices with 1961 as the base year. This MACRO also writes the indices produced in DER85.

All above MACROs perform these operations also on material inputs data (see A2.5 below).

A2.2 Capital

Following the assumptions outlined in the section on methodology, we have employed our data series on the two types of capital stock as the best available proxy for capital services. The two series for each industry were then used to produce an index of aggregate capital services to be used in constructing productivity measures.

They consist of a constant (1971) dollar series on net mid-year stock of construction capital and a constant (1971) dollar series on net mid-year stock of machinery and equipment for each 3-digit level industry. In order to aggregate these capital components, we also obtained implicit price indices for construction capital as well as machinery and equipment. The price indices were for the aggregate food and beverage sector, whereas the two series on capital stock were for 3-digit level industries comprising the sector. All series were obtained from the Construction Division of Statistics Canada. However, since such data are normally published only at the 2-digit level, our series were taken from a special tabulation equivalent to Fixed Capital Flows and Stocks, Catalogue No. 13-211, Annual.

For the food and beverage sector, the two series were constructed by summing all 3-digit level series. Using our mnemonics, where the last two characters of each mnemonic denote the last two digits of industries' S.I.C. number, we have

NSCONFB=NSCON10+NSCON20+NSCON30+NSCON40+
NSCON50+NSCON60+NSCON70+NSCON80+NSCON90, (A2.2.1)

NSMEFB=NSME10+NSME20+NSME30+NSME40+NSME50+
NSME60+NSME70+NSME80+NSME90. (A2.2.2)

As explained in Appendix 1, individual factors of production must be aggregated to form categories of inputs to which we attach some significance, such as capital, labour or energy. In order to impose the least restrictive assumptions on industries' productive technology we perform this aggregation using a superlative index number which assumes a flexible functional form for the technology involving construction capital and machinery and equipment capital. For each industry we construct a capital stock series using the Fisher ideal index formulation as follows.

SCONFB+NSCONFB*PCONFB/(NSCONFB*PCONFB+NSMEFB*PMEFB), (A2.2.3)

SMEFB=NSMEFB*PMEFB/(NSCONFB*PCONFB+NSMEFB*PMEFB), (A2.2.4)

XLKFB=(NSCONFB/VALUE(NSCONFB,1971)*VALUE(SCONFB,1971)

+NSMEFB/VALUE(NSMEFB,1971)*VALUE(SMEFB,1971)*100, (A2.2.5)

XPKFB=(1/(VALUE(NSCONFB,1971)/NSCONFB*SCONFB+VALUE(NSMEFB,1971)/
NSMEFB*SMEFB)*100, (A2.2.6)

XFKFB=(XLKFB*XPKFB)**0.5 (A2.2.7)

Equations (A2.2.3) and (A2.2.4) use the sector price indices to produce current dollar shares for each type of capital. Equations (A2.2.5) and (A2.2.6) generate Laspeyres and Paasche indices of capital stock respectively and equation (A2.2.7) uses the last two variables to form the Fisher ideal index of net mid-year aggregate capital stock with 1971=100.

These operations were performed by a MACRO named INDCAP1 for all 3-digit level industries which subsequently wrote them in data archive DER85. The raw data series read by this MACRO were entered into data archive RAW85 by another MACRO named RAWCAP which contained the constant dollar series and the implicit price index.

A2.3 Labour

The labour data used in this study consist of 4 series for each (3- or 4-digit) industry plus the food and beverage sector. These are:

1. person-hours worked by production workers ('000),
2. total wages of production workers ($'000),
3. employment of salaried employees,
4. total salaries of salaried employees ($'000)

for 1961 to 1982, and wages and salaries data are in current dollars. The series were obtained from the Census of Manufacturers of Statistics Canada and most of them are published in <u>Manufacturing Industries of Canada: National and Provincial Areas</u>, Catalogue No. 31-203, Annual. Since the first data series (person-hours worked by production workers) is not published, the data were obtained from the public tape of the Census. The extraction was performed by Bruce Junkins of the Statistical Analysis Unit using SAS (in a cross-sectional format). To minimize handling of data, they were directly read into our data archive RAW85 (formerly PRODA) in TROLL and converted into the required time-series format. The data were subsequently checked against existing labour data in data archive PROD of our original (1981) data base.

To supplement identification of the series by their mnemonics with a more detailed description, a comment was added to each individual data file. This was done by editing and executing a MACRO named COMLAB which contains COMMENTs for all 3- and 4-digit level labour data series and the necessary commands to add them to the appropriate data files.

A2.4 Energy

A2.4.1 Data Sources

The data on fuel and electricity used by the food and beverage sector and its 17 constituent industries for 1960 (which is not covered by this study) and 1961 were obtained from annual industry publications of Statistics Canada. Table A2.4.1 summarizes the relevant information on these publications and the S.I.C. number of the industries covered.

TABLE A2.4.1

INDUSTRY PUBLICATION	CATALOGUE NO.	S.I.C.
Meat and Poultry Products Industries, Annual	32-232	1011,1012
Fish Products Industry, Annual	32-216	102
Fruit and Vegetable Processing Industries, Annual	32-218	103
Dairy Products Industry, Annual	32-209	104
Flour and Breakfast Cereal Products Industry, Annual	32-228	105
Feed Industry, Annual	32-214	106
Biscuit Manufacturers, Annual	32-202	1071
Bakeries, Annual	32-203	1072
Confectionery Manufacturers, Annual	32-213	1081
Cane and Beet Sugar Processors, Annual	32-222	1082
Vegetable Oil Mills, Annual	32-223	1083
Miscellaneous Food Processors, Annual	32-224	1089
Soft Drink Manufacturers, Annual	32-208	1091
Alcoholic Beverage Industries, Annual	32-231	1092,1093,1094

Since the 3- and 4-digit level data cover the entire food and beverage sector, data series for consumption of fuel and electricity at the sector level were constructed by summing over the 17 industry level series for 1960 and 1961.

The data for the 1962-1974 period were obtained from Statistics Canada publication Consumption of Purchased Fuel and Electricity by the Manufacturing, Mining and Electric Power Industries, Catalogue No. 57-506. In the 1975-1981 period, the publication used is Consumption of Purchased Fuel and Electricity by the Manufacturing, Mining, Logging and Electric Power Industries, Catalogue No. 57-208. For 1982, the final year of the study, the data were supplied by R.J. Staveley of the Industry Division (Manufacturing and Primary Industries Division) of Statistics Canada in computer printout form.

A2.4.2 Data Grouping

Between 1960 and 1982, data collection and reporting procedures underwent important changes. In 1960 for instance, quantity and cost data were reported for 15 fuel and electricity categories and cost data alone for establishments reporting only their total fuel and total electricity costs. For establishments not reporting any data, estimates were made and reported for each industry of total fuel and electricity costs. Between 1975 and 1982 on the other hand, cost and quantity data were reported for 13 categories and cost alone for one energy category. Furthermore, some earlier categories are not compatible with those reported in later years. In 1962, cost data reporting for establishments not reporting fuel type detail (but only total fuel costs and electricity costs) was discarded; only the estimate of total fuel and electricity costs for small establishments was maintained. With an apparent improvement in data colection procedures, reporting of these cost estimates (which did not specify the fuel type or electricity used) was discontinued in 1970. Throughout the 1960-1971 period, however, quantities and costs were reported for such fuel types as bituminous coal, sub-bituminous coal, anthracite coal and lignite coal as well as coke, wood, steam and "other manufactured gases". Starting in 1971, only a coal and coke category is reported and wood, steam and "other manufactured gases" appear to be included in the "other fuel" category. New categories introduced are kerosene-stove oil, diesel oil, light fuel oil and heavy fuel oil. These seem to have been grouped together in the 1960-1971 period and reported as "fuel oil including kerosene or coal oil".

Clearly, a changing data structure, such as that outlined above, necessitates grouping of data into more encompassing categories whenever two or more fuel types are reported collectively for any sub-period. In order to construct a consistent set of data series for fuel and electricity spanning the 1961-1982 period, we have grouped the data into the following:

1) Coal and Coke (QCC, VCC)
2) Natural Gas (QNG, VNG)
3) Gasoline (QGS, VGS)
4) Fuel Oils (QFO, VFO)
5) Liquified Petroleum Gases (QLPG, VLPG)
6) Electricity (QEL, VEL) and
7) Other Fuel (VOF)

The mnemonics for quantity and cost (value) of each group appear in parantheses. The first group, Coal and Coke, is a simple sum of quantity and cost data on the five types of coal and of coke reported prior to 1972, while for the 1972-1982 period it is simply the data reported as "Coal and Coke". The second and third group are the same as those reported between 1960 and 1982: these categories were not affected by changes in data collection methods. The fourth, Fuel Oils, is the sum of data on the four types of fuel oil reported after 1972. Both quantity (QFO) and cost (VFO) data thus constructed are simple sums. Though it was possible to aggregate the quantities of the four fuel types by converting them to quantities with a common BTU before summing, simple summation seemed more appropriate. Since data on consumption of fuel oils prior to 1972 were for number of Imperial gallons consumed of all four types, using BTU conversion to better aggregate them for the later period would be inconsistent with the structure of early data. Our Fuel Oils series (QFO, VFO) for the early (1960-1971) period is simply the data reported as "fuel oil including kerosene or coal oil". The fifth and sixth group, like the first and second, simply reproduce reported data, the structure of which did not change between 1960 and 1982. The seventh group, Other Fuel, is simply reported data of the same name for the 1972-1982 period. For the earlier period, our group includes expenditures on wood, "other manufactured gas" and steam as well as data reported under "other fuel". The "cost of fuel" and "cost of electricity" for establishments not reporting consumption by fuel type and the estimate of fuel and electricity costs for establishments not reporting any data are also added to this group. Because most of the data entered into this group are only for expenditures made by the industry, the group comprises only a cost series (VOF) for each industry.

Quantity data for 1960 to 1979 are published in Imperial units but starting in 1980 they are expressed in metric units. To make the two series compatible, those in metric units (3 years) were converted into Imperial using conversion ratios given in the Statistics Canada publication cited immediately above (Catalogue No. 57-208).

A2.4.3 Data Transformations

Once data series were grouped into the above seven, a manually performed operation, price indices were constructed for each group except Other Fuel. Individual energy-type price indices are constructed by dividing their cost or expenditure series by their quantity series (to obtain annual prices) and then divided by their values for 1971 and multiplied by 100. This yields a price index for each energy-type (e.g., gasoline, PGS) for each year with 1971=100. Using the same procedure, these indices are also constructed with 1961 as the base year (1961=1), to be used with chain-linked indices which are normalized to 1961 values. These indices are only constructed for the food and beverage sector as a whole and not repeated for its 17 constituent industries. Industry (3- or 4-digit) level energy-type price indices are taken to be the same as those computed for the sector level. It is not unusual for prices at which various energy-types (e.g. liquified petroleum gases) are attainable by firms to vary between industries. The difference, which can be substantial, is attributable to such factors as the volume purchased by industry establishments. The volume purchased depends, in turn, on the size of establishments, which is not uniform across industries, their productive technology or how intensively they use various types of energy, and ultimately, on the type of product being produced, which influences all of the above. The geographic location of the establishment also matters, since even with uniform energy prices across Canada, transportation costs vary between regions. These cross-sectional differences (i.e., for any given year) have been noted in our 3- and 4-digit energy data and have, to some extent, been measured and analyzed. For purposes of this study, however, the differences in industry level energy prices were found unimportant. Our methodology requires that we construct a quantity index for aggregate energy used by each industry and this necessitates a simple price index for each energy type. Such price indices, with base year equal to 1 or 100, convey price levels for each year relative to the base year rather than in absolute terms. Clearly, cross-sectional differences do not affect the values of such indices as long as the ratio of the price of each energy type to its price in the base year (and hence, in other years) does not differ amongst individual industries. Equivalently, all industries will have the same price index for gasoline (PGS) if the (different) prices they pay move up (or down) together and proportionally over time. This condition is taken to hold satisfactorily for the industries under study and justifies our use of sector level prices for individual industries.

A further note is needed on the treatment of "Other Fuel" data. Since no quantity data are published for this category we cannot construct its simple price index and hence, cannot include it in our Paasche or Laspeyres indices of total energy input. The latter indices are formed with simple price indices of the other six energy groups and their shares in expenditure (see 3.1 above) which exclude expenditure on this category. Once the Fisher ideal index of aggregate energy price has been obtained, expenditure on this category is added to that of others to obtain total expenditure on fuel and electricity (VFE) and used to construct the Fisher quantity index via the factor reversal test. Since this procedure involves the ratio of total expenditure on energy to its value in the base year, the resulting quantity index (XFFE) encompasses the Other Fuel category. The above method, in effect, constructs a quantity index which includes a fuel category for which no quantities are reported. This important expenditure series can only be integrated in our aggregation, using the factor reversal test method, if we are willing to assume that had complete data existed and were used, the resulting Fisher Price indices would have been the same as those we have constructed without any Other Fuel data. Equivalently, we are assuming that changes in unit prices of such fuel over time do not differ from a share-weighted average of changes in prices of other types of fuel and electricity. Equations A2.4.1 through A2.4.6 outline the steps necessary to construct the Fisher quantity index for energy.

PGSFB=((VGSFB/QGSFB)/(VALUE(VGSFB,1971)/
VALUE(QGSFB,1971))*100, (A2.4.1)

SGSFB=VGSFB/(VFEFB-VOFFB), (A2.4.2)

PLFEFB=(VALUE(SCCFB,1971)*PCCFB
+VALUE(SNGFB,1971)*PNGFB+VALUE(SGSFB,1971)

```
*PGSFB+VALUE(SFOFB,1971)*PFOFB+VALUE
(SLPGFB,1971)*PLPGFB+VALUE(SELFB,1971)*PELFB),                    (A2.4.3)
PPFEFB=(1/(SCCFB/PCCFB+SNGFB/PNGFB+SGSFB/PGSFB+
SFOFB/PFOFB+SLPGFB/PLPGFB+SELFB/PELFB)),                          (A2.4.4)
PFFEFB=(PLFEFB*PPFEFB)**0.5,                                      (A2.4.5)
XFFEFB=(VFEFB/VALUE(VFEFB,1971)*100/PFFEFB)*100,                  (A2.4.6)
MGSFB= (VGSFB/QGSFB)/(VALUE(VGSFB,1961)/
VALUE(QNGFB,1961)),                                               (A2.4.7)
MLFEFB=CUMPROD(MCCFB/MCCFB(-1)*SCCFB(-1)+
MNGFB/MNGFB(-1)*SNGFB(-1)+MGSFB/MGSFB(-1)
*SGSFB(-1)+MFOFB/MFOFB(-1)*SFOFB(-1)+
MLPGFB/MLPGFB(-1)*SLPGFB(-1)+MELFB/
MELFB(-1)*SELFB(-1))*100,                                         (A2.4.8)
MPFEFB=CUMPROD(1/(MCCFB(-1)/MCCFB*SCCFB+MNGFB(-1)/
MNGFB*SNGFB+MGSFB(-1)/MGSFB*SGCFB+MFOFB(-1)/
MFOFB*SFOFB+MLPGFB(-1)/MLPGFB*SLPGFB+
MELFB(-1)/MELFB*SELFB))*100,                                      (A2.4.9)
MFFEFB=(MLFEFB*MPFEFB)**0.5,                                      (A2.4.10)
QFFEFB=(VFEFB/VFEFB(-1)*1/MFFEFB)*100,.                           (A2.4.11)
```

The first two equations construct, respectively, the simple energy-type price index and expenditure share series for the food and beverage sector of gasoline, our earlier example. These operations are repeated for the five other energy-types for every industry, though simple price indices are only made for the sector as a whole. The third and fourth equation construct the Laspeyres and Paasche price indices for each industry (here shown for the food and beverage sector) and equation A2.4.5 forms the industry's Fisher price index for energy (for a complete exposition of this procedure see 3.1 above). Equation A2.4.6 transforms this index to its corresponding quantity index, XFFEFB, using the ratio of current to base period expenditure on fuel and electricity which includes those in the Other Fuel group. Equations A2.4.7 through A2.4.12 demonstrate the procedure for obtaining these measures using the Chain Principle.

Theoretical questions related to aggregation and the factor reversal test method are discussed in Section 2 above.

A2.4.4 Troll Facilities

As mentioned, raw energy data were grouped by hand and made into the seven series listed in A2.4.3 above. This was done initially for the 1960-1978 period for the food and beverage sector and its nine 3-digit level constituent industries in 1981. The raw data series as well as COMMENTs explaining them were edited in a MACRO named PROD and subsequently written in data archive PROD by executing the MACRO. In order to construct the various price and quantity indices, equations similar to A2.4.1 through A2.4.6 were written for all energy-types and all industries in a MACRO named INDENER1 (FORMERLY PROD2). This MACRO wrote the resulting derived series in data archive PROD2. Subsequently (in 1985) data for the food and beverage sector and 3-digit level industries were obtained for the 1979-1982 period and the recorded data were updated. At this time, data were also obtained, grouped and recorded at the 4-digit level of S.I.C. for the 12 industries for which complete (energy and other) data were attainable. Data series which updated the existing data base at the sector and 3-digit level as well as the new 4-digit level series were entered into a MACRO named RAWENER which, when executed, wrote the data in data archive RAW85. The MACRO also contained COMMENTs for the new 4-digit industry data. The required price and quantity indices for 4-digit industries were constructed by a MACRO named INDENER2 containing equations similar to A2.4.1 through A2.4.6 for all energy-types and industries. This MACRO wrote the resulting derived series in data archive DER85. In order to update price and quantity indices at the sector and 3-digit levels, MACRO INDENER1 was once again executed.

To construct the chain-linked indices for energy, the same raw data was used by MACRO INDENER3, using equations A2.4.7 through A2.2.11 extended to all energy-types and industries. The results were written in data archive DER85.

A2.5 Material Inputs

The data for material inputs used in this study are constant dollar values of gross material inputs used by each industry. Two separate series on each industry were used: a constant 1961 dollar series spanning the 1961-1971 period and a constant 1971 dollar series for the 1971-1983 period with overlapping data for 1971. Both sets of data were obtained from the Industry Product Division of Statistics Canada. Though the data actually used are not published, comparable data at the 3-digit level of S.I.C. are published by Statistics Canada in Systems of National Accounts, Gross Domestic Product by Industry, Catalogue No. 61-213. Since the two series, based on the 1960 and 1970 S.I.C. breakdowns, do not agree on the values of material inputs for 1971, the following procedure was used to link them and obtain one continuous series on material inputs used by each industry.

VINTFBK=OVERLAY(VINTFBK7,VINTFBK6*
VALUE(VINTFBK7,1971)/VALUE(VINTFBK6,1971)). (A2.5.1)

Here, VINTFBK7 is the material input series spanning the 1970s and VINTFBK6 is the corresponding data series for the 1960s. The desired, continuous series VINTFBK which runs from 1961 to 1983 is obtained by transforming VINTFBK6 and attaching it to the 1970s series (VINTFBK7) such that the two series have the same values for 1971. The transformation involves multiplying the 1960s series by a constant obtained by dividing the value of VINTFBK7 in 1971 by the value of VINTFBK6 in the same year. This operation changes the last (1971) element of VINTFBK6 to that of the first (1971) element in VINTFBK7 and the OVERLAY function simply integrates them into one (23-element) vector by giving it a new mnemonic.

The series obtained above are for all material inputs used in production, including fuel and electricity. Since our analysis treats fuel and electricity (energy) as a separate productive input by including it in the production function as an argument, material input series must be modified to avoid double-counting. In order to net out current dollar expenditures on fuel and electricity from constant dollar material input series, we must first convert the former to constant (1971) dollar values. Using TROLL's DO Command, the procedure is:

VMAFBK=VINTFBK-VFEFB/PFFEFB/10 (A2.5.2)

and

VMIFBK=VINTFBK-VFEFB/MFFEFB/10 (A2.5.3)

where VMAFBK is the value of material inputs series net of energy expenditures. Since the VFEFB series is in thousands of dollars, whereas the VINTFBK is in millions of dollars, the former is divided by 1000 and then multiplied by 100 (PPFEFB has a 100 scale); thus VFEFB/PPFEFB/10 is constant dollar fuel and electricity expenditure in millions of dollars. Equation (A2.5.3) produces the same series but uses the chain-linked energy price index to convert energy expenditures to their constant (1961) dollar values.

Before being used for productivity measurement, net material input series for all industries are normalized by their 1971 or 1961 values (depending on the fixed-base or chain-linked indices with which they are used). The series are then scaled to 100 to produce 1971 or 1961 based indices of net material inputs. Using the DO command in TROLL, the indices are produced by:

MAFB=VMAFBK/VALUE(VMAFBK,1971)*100 (A2.5.4)

and

MIFB=VMIFBK/VALUE(VMIFBK,1961)*100 (A2.5.5)

where MAFB and MIFB are indices of material inputs net of energy for the food and beverage sector such that (MAFB,1971)=100 and (MIFB,1961)=100.

The above procedure is performed for the food and beverage sector as well as its 17 constituent (3- and 4-digit level) industries using TROLL's MACRO facility. The MACROs used for this operation are RAWIO1, INDIO1 and INDIO2. The first MACRO, RAWIO1, contains separate raw data series for the 1960s and the 1970s on material inputs and OVERLAY equations (A2.5.1) to link the series. The MACRO then adds COMMENTs to the resulting (continous) series to supplement their identification with mnemonics and writes them in TROLL data archive RAW85. The second MACRO, INDI01, produces material input series net of fuel and electricity expenditure using equation (A2.5.2), and indices of net material inputs using (A2.5.4) for each linked series constrcted by RAWI01. The resulting series are then written in TROLL data archive DER85. This MACRO also performs similar operations on gross output data (see A2.1 above). The third MACRO consists of equations to find net material inputs (A2.5.3) using the chain-linked fuel and electricity price index and equations to index such series based on 1961 values (A2.5.5). This MACRO also writes the resulting series in DER85.

All above MACROs perform similar operations on gross output data (see A2.1 above).

A2.6 Capacity Utilization Indices

The series on measures of capacity utilization used in this study are those constructed at Bank of Canada.

For the food and beverage sector, the series, which are available from Cansim, were drawn from Minibase B60004 and written directly into TROLL data archive RAW85. Since the above series is quarterly, the following procedure was used to transform it into an annual series within TROLL.

ICUFB=COMPACT(B60004,0,1). (A2.6.1)

This function produces our annual index of capacity utilization for the food and beverage sector ICUFB by taking an unweighted arithmetic average (specified by ",0" after Minibase file number) of the four data for each year and giving the series an annual periodicity (specified by ",1"). The new series are subsequently written in TROLL data archive DER85 where other derived data are stored. The series obtained range from 1961 to 1984.

Bank of Canada, however, does not publish capacity utilization data at the 3- or 4-digit level of Standard Industrial Classification, which are the levels of disaggregation required for this study. The series for the 17 constituent industries of this sector were obtained from Gerald Stuber of Bank of Canada who had earlier constructed them. They were written into TROLL data archive RAW85 using a MACRO named RAWICU in which they were first entered. The MACRO also contains a COMMENT for all series to supplement their identification by their mnemonics. The mnemonics used for industry level series are, as with the sector, C but are followed by the last two digits of each industry's S.I.C. number.

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The method of constructing the above measures differs substantially from those used by Statistics Canada or the Department of Industry, Trade and Commerce. As such, Bank of Canada Review refers the reader to Gordon Schaefer's article in its May 1980 issue for evaluation and interpretation of the data. On the underlying data treatment, sources, as well as a technical exposition of the concept, the reader is referred to "Perspectives on Capacity Utilization in Canada" by Guy Glorieux and Paul Jenkins, particularly their Technical Appendix, in the September 1974 issue of the Review.

APPENDIX 3

GUIDE TO MNEMONICS

S.I.C.	INDUSTRY NAME	MNEMONIC SUFFIX
1Ø	FOOD AND BEVERAGE SECTOR	FB
1Ø11	SLAUGHTERING and MEAT PROCESSING INDUSTRIES	11
1Ø12	POULTRY PROCESSORS	12
1Ø2Ø	FISH PRODUCTS INDUSTRY	2Ø
1Ø3Ø	FRUIT and VEGETABLE PROCESSING INDUSTRIES	3Ø
1Ø4Ø	DAIRY PRODUCTS INDUSTRY	4Ø
1Ø5Ø	FLOUR and BREAKFAST CEREAL PRODUCTS INDUSTRY	5Ø
1Ø6Ø	FEED INDUSTRY	6Ø
1Ø71	BISCUIT MANUFACTURERS	71
1Ø72	BAKERIES	72
1Ø81	CONFECTIONERY MANUFACTURERS	81
1Ø82	CANE and BEET SUGAR PROCESSORS	82
1Ø83	VEGETABLE OIL MILLS	83
1Ø89	MISCELLANEOUS FOOD PROCESSORS, NES	89
1Ø91	SOFT DRINK MANUFACTURERS	91
1Ø92	DISTILLERIES	92
1Ø93	BREWERIES	93
1Ø94	WINERIES	94

TABLE A3.1

O U T P U T

RAW85

VGO__C6 CURRENT DOLLAR VALUE OF GROSS OUTPUT, 1960s SERIES
($'000,000) RANGE : 1961-1971

VGO__K6 CONSTANT 1961 DOLLAR VALUE OF GROSS OUTPUT, 1960s SERIES
($'000,000) RANGE : 1961-1971

VGO__C7 CURRENT DOLLAR VALUE OF GROSS OUTPUT, 1970s SERIES
($'000,000) RANGE : 1971-1982

VGO__K7 CONSTANT 1971 DOLLAR VALUE OF GROSS OUTPUT, 1970s SERIES
($'000,000) RANGE : 1971-1983

VGO__C CURRENT DOLLAR VALUE OF GROSS OUTPUT

($'000,000) RANGE : 1961-1982
VGO__C=OVERLAY(VGO__C7,VGO__C6*
VALUE(VGO__C7,1971)/VALUE(VGO__C6,1971))

VGO__K CONSTANT 1971 DOLLAR VALUE OF GROSS OUTPUT
($'000,000) RANGE : 1961-1983
VGO__K=OVERLAY(VGO__K7,VGO__K6*
VALUE(VGO__K7,1971)/VALUE(VGO__K6,1971))

DER85

GO__ INDEX OF CONSTANT DOLLAR GROSS OUTPUT, 1971=100
GO__=VGO__K/VALUE(VGO__K,1971)*100

C A P I T A L

RAW85

PCONFB IMPLICIT PRICE INDEX FOR TOTAL CONSTRUCTION CAPITAL
IN THE FOOD AND BEVERAGE SECTOR, CANADA (1971=100)

PMEFB IMPLICIT PRICE INDEX FOR MACHINERY AND EQUIPMENT
CANADA (1971=100)

PCOMFB IMPLICIT PRICE INDEX FOR ALL COMPONENTS OF CAPITAL
IN THE FOOD AND BEVERAGE SECTOR, CANADA (1971=100)

NSCON__K MID-YEAR NET STOCK OF CONSTRUCTION CAPITAL IN
CONSTANT 1971 DOLLARS, CANADA ($'000)

```
NSME__K   MID-YEAR NET STOCK OF MACHINERY AND EQUIPMENT
          CAPITAL IN CONSTANT 1971 DOLLARS, CANADA ($'000)


DER85
----------
NSCONFB   MID-YEAR NET STOCK OF CONSTRUCTION CAPITAL IN CONSTANT
          1971 DOLLARS, FOOD AND BEVERAGE SECTOR, CANADA ($'000)
          NSCONFB=NSCON10K+NSCON20K+NSCON30K+NSCON40K+NSCON50K+
                  NSCON60K+NSCON70K+NSCON80K+NSCON90K,

NSMEFB    MID-YEAR NET STOCK OF MACHINERY AND EQUIPMENT CAPITAL
          IN CONSTANT 1971 DOLLARS, FOOD AND BEVERAGE SECTOR,
          CANADA ($'000)
          NSMEFB=NSME10K+NSME20K+NSME30K+NSME40K+NSME50K+
                 NSME60K+NSME70K+NSME80K+NSME90K,

SCON__    SHARE OF CURRENT DOLLAR VALUE OF CONSTRUCTION
          CAPITAL IN TOTAL CAPITAL STOCK
          SCON__=NSCON__K*PCONFB/(NSCON__K*PCONFB+NSME__K*PMEFB),

SME__     SHARE OF CURRENT DOLLAR VALUE OF MACHINERY AND
          EQUIPMENT CAPITAL IN TOTAL CAPITAL STOCK
          SME__=NSME__K*PMEFB/(NSCON__K*PCONFB+NSME__K*PMEFB),

XLK__     LASPEYRES QUANTITY INDEX OF TOTAL CAPITAL STOCK,
          1971=100
          XLK__=(NSCON__K/VALUE(NSCON__K,1971)*VALUE(SCON__,1971)+
                NSME__K/VALUE(NSME__K,1971)*VALUE(SME__,1971))*100,

XPK__     PAASCHE QUANTITY INDEX OF TOTAL CAPITAL STOCK,
          1971=100
          XPK__=(1/(VALUE(NSCON__K,1971)/NSCON__K*SCON__+
                VALUE(NSME__K,1971)/NSME__K*SME__)*100,
XFK__     FISHER QUANTITY INDEX OF TOTAL CAPITAL STOCK,
          1971=100
          XFK__=(XLK__*XPK__)**0.5,
```

L A B O U R

RAW85

```
QPW__   MAN-HOURS WORKED BY PRODUCTION WORKERS, ('000)

VPW__   WAGES OF PRODUCTION WORKERS, ($'000)

QNPW__  EMPLOYMENT OF SALARIED EMPLOYEES

VNPW__  SALARIES OF SALARIED EMPLOYEES, ($'000)
```

DER85

```
PPW__   INDEX OF WAGES OF PRODUCTION WORKERS, 1971=100
        PPW__=((VPW__/QPW__)/(VALUE(VPW__,1971)/VALUE(QPW__,1971))*100

PNPW__  INDEX OF SALARIES OF SALARIED EMPLOYEES, 1971=100
        PNPW__=((VNPW__/QNPW__)/(VALUE(VNPW__,1971)/VALUE(QNPW__,1971))*100

PW__    INDEX OF HOURS WORKED BY PRODUCTION WORKERS, 1971=100
        PW__=QPW__/VALUE(QPW__,1971)*100

NPW__   INDEX OF NUMBER OF SALARIED EMPLOYEES, 1971=100
        NPW__=QNPW__/VALUE(QNPW__,1971)

SPW__   SHARE OF PRODUCTION WORKERS IN THE TOTAL WAGE BILL
        SPW__=VPW__/(VPW__+VNPW__)

SNPW__  SHARE OF SALARIED EMPLOYEES IN THE TOTAL WAGE BILL
        SNPW__=1-SPW__

PLLA__  LASPEYRES PRICE INDEX OF TOTAL LABOUR INPUT, 1971=100
        PLLA__=VALUE(SPW__,1971)*PPW__+VALUE(SNPW__,1971)*PNPW__

PPLA__  PAASCHE PRICE INDEX OF TOTAL LABOUR INPUT, 1971=100
        PPLA__=(1/(SPW__/PPW__+SNPW__/PNPW__))

PFLA__  FISHER PRICE INDEX OF TOTAL LABOUR INPUT, 1971=100
        PFLA__=(PLLA__*PPLA__)**0.5

XFLA__  FISHER QUANTITY INDEX OF TOTAL LABOUR INPUT, 1971=100
        XFLA__=((VPW__+VNPW__)/(VALUE(VPW__,1971)+
              VALUE(VNPW__,1971))*100)/PFLA__*100
```

E N E R G Y

RAW85

VCC__ VALUE OF EXPENDITURES ON COAL AND COKE, ($'000)

VNG__ VALUE OF EXPENDITURES ON NATURAL GAS, ($'000)

VGS__ VALUE OF EXPENDITURES ON GASOLINE, ($'000)

VFO__ VALUE OF EXPENDITURES ON FUEL OILS, ($'000)

VLPG__ VALUE OF EXPENDITURES ON LIQUIFIED PETROLEUM GASES, ($'000)

VEL__ VALUE OF EXPENDITURES ON ELECTRICITY, ($'000)

VOF__ VALUE OF EXPENDITURES ON OTHER FUEL, ($'000)

VFE__ VALUE OF EXPENDITURES ON FUEL AND ELECTRICITY, ($'000)

QCCFB QUANTITY OF COAL AND COKE PURCHASED BY THE FOOD AND BEVERAGE SECTOR (TONS'000)

QNGFB QUANTITY OF NATURAL GAS PURCHASED BY THE FOOD AND BEVERAGE SECTOR (CUBIC FEET'000)

QGSFB QUANTITY OF GASOLINE PURCHASED BY THE FOOD AND BEVERAGE SECTOR (IMPERIAL GALLONS'000)

QFOFB QUANTITY OF FUEL OILS PURCHASED BY THE FOOD AND BEVERAGE SECTOR (IMPERIAL GALLONS'000)

QLPGFB QUANTITY OF LIQUEFIED PETROLEUM GAS PURCHASED BY THE FOOD AND BEVERAGE SECTOR (IMPERIAL GALLONS'000)

QELFB QUANTITY OF ELECTRICITY PURCHASED BY THE FOOD AND BEVERAGE SECTOR (MEGAWATT HOURS)

DER85

PCCFB PRICE INDEX OF COAL AND COKE,
FOOD AND BEVERAGE SECTOR, 1971=100
PCCFB=(VCCFB/QCCFB)/(VALUE(VCCFB,1971)/VALUE(QCCFB,1971))

PNGFB PRICE INDEX OF NATURAL GAS,
FOOD AND BEVERAGE SECTOR, 1971=100
PNGFB=(VNGFB/QNGFB)/(VALUE(VNGFB,1971)/VALUE(QNGFB,1971))

```
PGSFB   PRICE INDEX OF GASOLINE,
        FOOD AND BEVERAGE SECTOR, 1971=100
        PGSFB=(VGSFB/QGSFB)/(VALUE(VGSFB,1971)/VALUE(QNGFB,1971))

PFOFB   PRICE INDEX OF FUEL OILS,
        FOOD AND BEVERAGE SECTOR, 1971=100
        PFOFB=(VFOFB/QFOFB)/(VALUE(VFOFB,1971)/VALUE(QFOFB,1971))

PLPGFB  PRICE INDEX OF LIQUEFIED PETROLEUM GASES,
        FOOD AND BEVERAGE SECTOR, 1971=100
        PLPGFB=(VLPGFB/QLPGFB)/(VALUE(VLPGFB,1971)/VALUE(QLPGFB,1971)

PELFB   PRICE INDEX OF ELECTRICITY,
        FOOD AND BEVERAGE SECTOR, 1971=100
        PELFB=(VELFB/QELFB)/(VALUE(VELFB,1971)/VALUE(QELFB,1971)

SCC__   EXPENDITURE SHARE OF COAL AND COKE IN FUEL AND ELECTRICITY
        EXCEPT "OTHER FUEL"
        SCC__=VCC__/(VFE__-VOF__)

SNG__   EXPENDITURE SHARE OF NATURAL GAS IN FUEL AND ELECTRICITY
        EXCEPT "OTHER FUEL"

        SNG__=VNG__/(VFE__-VOF__)

SGS__   EXPENDITURE SHARE OF GASOLINE IN FUEL AND ELECTRICITY
        EXCEPT "OTHER FUEL"
        SGS__=VGS__/(VFE__-VOF__)

SFO__   EXPENDITURE SHARE OF FUEL OILS IN FUEL AND ELECTRICITY
        EXCEPT "OTHER FUEL"
        SFO__=VFO__/(VFE__-VOF__)

SLPG__  EXPENDITURE SHARE OF LIQUIFIED PETROLEUM GASES IN
        FUEL AND ELECTRICITY EXCEPT "OTHER FUEL"
        SLPG__=VLPG__/(VFE__-VOF__)

SEL__   EXPENDITURE SHARE OF ELECTRICITY IN FUEL AND ELECTRICITY
        EXCEPT "OTHER FUEL"
        SEL__=VEL__/(VFE__-VOF__)

PLFE__  LASPEYRES PRICE INDEX OF FUEL AND ELECTRICITY, 1971=100
        PLFE__=(VALUE(SCC,1971)*PCCFB+VALUE(SNG,1971)*PNGFB+
               VALUE(SGS,1971)*PGSFB+VALUE(SFO,1971)*PFOFB+
               VALUE(SLPG,1971)*PLPGFB+VALUE(SEL,1971)*PELFB)

PPFE__  PAASCHE PRICE INDEX OF FUEL AND ELECTRICITY, 1971=100
        PPFE__=(1/(SCC__/PCCFB+SNG__/PNGFB+SGS__/PGSFB+
               SFO__/PFOFB+SLPG__/PLPGFB+SEL__/PELFB))

PFFE__  FISHER PRICE INDEX OF FUEL AND ELECTRICITY, 1971=100
        PFFE__=(PLFE__*PPFE__)**0.5

XFFE__  FISHER QUANTITY INDEX OF PURCHASED FUEL AND ELECTRICITY,
        1971=100
        XFFE__=(VFE__/VALUE(VFE__,1971)*100/PFFE__)*100
```

M A T E R I A L   I N P U T S

VINT__C6 CURRENT DOLLAR VALUE OF INTERMEDIATE INPUTS, 1960s SERIES ($'000,000) RANGE : 1961-1971

VINT__K6 CONSTANT 1961 DOLLAR VALUE OF INTERMEDIATE INPUTS, 1960s SERIES($'000,000) RANGE : 1961-1971

VINT__C7 CURRENT DOLLAR VALUE OF INTERMEDIATE INPUTS, 1970s SERIES, ($'000,000) RANGE : 1971-1982

VINT__K7 CONSTANT 1971 DOLLAR VALUE OF INTERMEDIATE INPUTS, 1970s SERIES($'000,000) RANGE : 1971-1982

VINT__C CURRENT DOLLAR VALUE OF INTERMEDIATE INPUTS ($'000,000) RANGE : 1961-1982

```
VINT__C=OVERLAY(VINT__C7,VINT__C6*
        VALUE(VINT__C7,1971)/VALUE(VINT__C6,1971))
```

VINT__K CONSTANT 1971 DOLLAR VALUE OF INTERMEDIATE INPUTS ($'000,000) RANGE : 1961-1983

```
VINT__K=OVERLAY(VINT__K7,VINT__K6*
        VALUE(VINT__K7,1971)/VALUE(VINT__K6,1971))
```

DER85

VMA__C CURRENT DOLLAR VALUE OF MATERIAL INPUTS NET OF ENERGY ($'000,000)

```
VMA__C=VINT__C-VFE__/1000
```

VMA__K CONSTANT 1971 DOLLAR VALUE OF MATERIAL INPUTS NET OF ENERGY ($'000,000)

```
VMA__K=VINT__K-VFE__/PPFE__/10
```

MA__ INDEX OF MATERIAL INPUTS, 1971=100

```
MA__=VMA__K/VALUE(VMA__K,1971)*100
```

C A P A C I T Y   U T I L I Z A T I O N

RAW85

ICU__ INDEX OF CAPACITY UILIZATION
SOURCE: BANK OF CANADA

P R O D U C T I V I T Y   I N D I C E S

DER85

IKP__	INDEX OF CAPITAL PRODUCTIVITY IKP__=GO__/XFK__
ILP__	INDEX OF LABOUR PRODUCTIVITY ILP__=GO__/XFLA__
IEP__	INDEX OF ENERGY PRODUCTIVITY IEP__=GO__/XFFE__
IMP__	INDEX OF MATERIAL INPUTS' PRODUCTIVITY IMP__=GO__/MA__
GLP__	INDEX OF GROWTH RATE OF LABOUR PRODUCTIVITY GLP__=GGO__-GXFLA__

V A R I A B L E S   D E R I V E D   F O R   T H E
P R O D U C T I V I T Y   M O D E L

DER85

GGO__	RATE OF GROWTH OF THE GROSS OUTPUT INDEX GGO__=DEL(1 : GO__)/GO__(-1),
GXFLA__	GROWTH RATE OF THE INDEX OF AGGREGATE LABOUR INPUT GXFLA__=DEL(1 : XFLA__)/XFLA__(-1),
RSKLA__	RATIO OF THE INDEX OF AGGREGATE CAPITAL TO THE INDEX OF AGGREGATE LABOUR INPUT RSKLA__=XFK__/XFLA__,
RFELA__	RATIO OF THE INDEX OF AGGREGATE ENERGY TO THE INDEX OF AGGREGATE LABOUR INPUT RFELA__=XFFE__/XFLA__,
RMALA__	RATIO OF THE INDEX OF MATERIAL INPUTS TO THE INDEX OF AGGREGATE LABOUR INPUT RMALA__=MA__/XFLA__,

GRSKLA__	RATE OF GROWTH OF THE RATIO AGGREGATE CAPITAL INDEX TO THE AGGREGATE LABOUR INDEX GRSKLA__=DEL(1 : RSKLA__)/RSKLA__(-1),
GRFELA__	RATE OF GROWTH OF THE RATIO OF AGGREGATE ENERGY INDEX TO THE AGGREGATE LABOUR INDEX GRFELA__=DEL(1 : RFELA__)/RFELA__(-1),
GRMALA__	RATE OF GROWTH OF THE RATIO OF THE MATERIAL INPUTS INDEX TO THE AGGREGATE LABOUR INDEX GRMALA__=DEL(1 : RMALA__)/RMALA__(-1),
EL__	ELASTICITY OF GROSS OUTPUT WITH RESPECT TO AGGREGATE LABOUR INPUT ELFB=MEAN((VPWFB+VNPWFB)/VGOFBC/1000),
EE__	ELASTICITY OF GROSS OUTPUT WITH RESPECT TO AGGREGATE ENERGY INPUT EEFB=MEAN(VFEFB/VGOFBC/1000),
EM__	ELASTICITY OF GROSS OUTPUT WITH RESPECT TO MATERIAL INPUTS
T	TIME TREND OF DATA USED IN REGRESSION T=TREND(GOFB),

[EOB]

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