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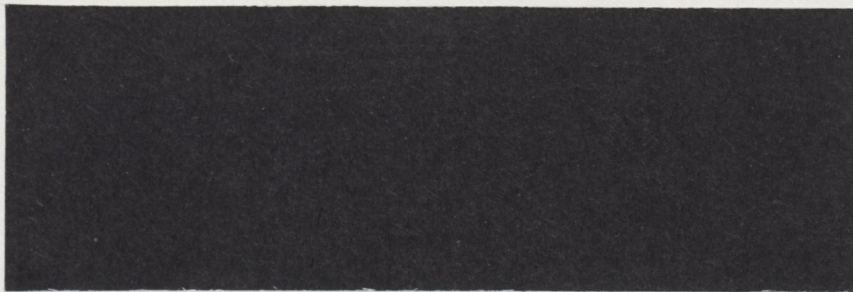
PERFORMANCE OF CANADIAN AND AMERICAN FOOD AND BEVERAGE INDUSTRIES: 1961-1982

(Working Paper 3/87)

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PERFORMANCE OF CANADIAN AND AMERICAN

FOOD AND BEVERAGE INDUSTRIES:

1961 - 1982

This paper presents several measures to compare the productive performance of the Canadian food and beverage industry[1] with its American counterpart[2] and draw some inferences about its future competitiveness. The analysis covers the 1961-1982 period for both industries and deals with each at the aggregate, 2-digit level of Standard Industrial Classification.

To compare the overall technological performance of the two industries we have constructed various productivity measures based on different formulations of multifactor productivity. Our findings of gains in productivity reveal the extent to which technological and organizational improvements have resulted in greater production being obtained per unit of factor inputs used by the industries. The levels of industries' gross annual production and their changes over time are also briefly examined.

CONCEPTS AND DEFINITIONS

Multifactor productivity is an indicator of technical performance of a production unit such as a plant, enterprise or industry. It concerns the relationship between the final product and all associated purchased inputs in real, physical terms. In this study "inputs" encompass fixed capital equipment

and structures, all forms of purchased fuel and electricity, services of production workers and administrative employees and raw or semi finished intermediate materials and services. For our purposes, we have grouped inputs into four broad aggregates of capital, labour, energy and materials. In multifactor productivity analysis we compare "output" -- the total volume of production -- with the combined use of all inputs for a given period to discover how much more was produced for any given level of combined inputs compared to the past. In its simplest form, a multifactor productivity index is the ratio of outputs produced to the combination of all inputs used both in real terms. Changes in the MFP index over time measure enhancements of the process of transforming all inputs into products and services.

The gains in productive efficiency measured by changes in the MFP index accrue from various sources. The most empirically significant sources are improvements due to technological and organizational factors, together known as "technical progress", and gains or losses in efficiency resulting from changes in the industry's production size. For a given industry and time period, an estimate of its technical progress indicates that portion of growth in its production which is accounted for by a better productive or administrative organization, enhanced factor input quality and adopted technological innovations. Technical progress may, however, be augmented or offset by other gains (or losses) related to changes in the industry's production size, depending on whether it operates under

increasing or decreasing returns to scale. Changes in the industry's capacity utilization rate and other factors may also affect changes in the MFP index. The growth rate of the simple MFP index -- i.e., the growth rate of the ratio of the industry's output to its aggregate input -- is the sum of the above gains (or losses) in productive efficiency.

Increases in the MFP index imply a diminution in the unit cost of production for any given level of output and given unit costs of all inputs (Ohta, 1974). This follows from the definition of MFP which implies that a given level of output can be produced by less of some or all factor inputs. Growing MFP then is synonymous with growing cost efficiency. A one percent improvement in cost efficiency for an industry implies that it can absorb up to a one percent increase in unit costs of all inputs without being compelled to either reduce profit margins or increase its product prices. Alternatively, these gains mean that, in the face of domestic or international price competition, the industry can reduce its prices by one percent without affecting its own financial well-being or the quality of its products.

For the purpose of assessing the vitality and cost competitiveness of the industries in question both their MFP growth rates and technical progress estimates are useful performance indicators. The above discussion identifies the meaning and significance of the two measures. We can interpret a higher rate of technical progress for an industry to indicate

the achievement of greater cost saving technological improvements compared to another over the period considered. Changes in the industries' MFP index (the growth rate of MFP) over a comparable period measure the extent to which the attained technological improvements (measured by technical progress) have been <u>realized</u> by the respective industries, i.e., all efficiency improvements net of gains or losses attributable to their economies or diseconomies of scale. For any given time period, an industry with a higher MFP growth rate saves more of some or all factor inputs in achieving its existing production level and, as such, attains a greater saving in its average unit costs. In the context of international trade where the industries may compete in the same markets, this implies improved competitiveness for any given set of currency exchange rates, tariff rates and other market or trade conditions.

Our productivity findings, although based entirely on industry conditions in the past, are also useful for inferences about their medium-term future performance and competitiveness. As mentioned earlier, realized efficiency improvements originate principally from adopted technical innovations (based on R&D conducted by the industry and other sectors of the economy), improved input quality and a more efficient organizational setup. Although most of these factors can vary from one year to the next (e.g., R&D expenditures), they generally require a long period of time to diffuse their efficiency improving benefits. Other factors are, to a great extent, exogenous to individual industries. For instance, improvements in the quality of inputs

such as labour services or capital equipment (for given unit costs) originate almost entirely from other sectors of the economy and are not much affected by changes in the conditions or the conduct of the members of the industry. With this process in mind, we can attribute a good deal of stability and predictability to the trends of MFP growth over intermediate periods of time although the index itself may display notable fluctuations from one year to the next.

In order to gain greater confidence about the relative efficiency of Canadian and American food and beverage industries, we have obtained productivity results using a number of different statistical and econometric formulations. For each industry two MFP indices are constructed based on the assumptions of a Cobb-Douglas (CD) and a transcendental logarithmic (TL) production technology, respectively. To measure industries' technical progress, scale-adjusted Cobb-Douglas and translog indices have been used which incorporate their estimated rates of returns-to-scale (Cowing et. al., 1981). The returns-to-scale parameter for each industry is econometrically estimated for the entire study period.

It should be emphasized that the crucial criterion of performance is not the level of the productivity index but rather its rate of growth or average annual percentage change, because it indicates gains in production efficiency and cost efficiency.[3] For each productivity index we have computed two measures of productivity gain : (i) the simple average

(arithmetic mean) of annual changes over the entire study period and the last five years (1978-1982), and (ii) an econometric estimation of the trend rate of growth. The latter procedure allows us to test statistically the hypothesis of declining productivity growth for each industry.

EMPIRICAL RESULTS

As Figure 1 shows, the Canadian industry's performance measured by the growth in its production size surpassed that of the U.S. industry. Over the study period, the Canadian industry grew at an average annual rate of 3.3% and produced almost twice as much (198%) in 1982 as it did in 1961. Its U.S. counterpart had an average annual growth rate of 2.1% which allowed it to expand by about 155% over the same period.

Table 1 presents the the first set of productivity results : MFP indices for the two industries. The first two columns are translog (TL) and Cobb-Douglas (CD) based indices of multifactor productivity for the Canadian food and beverage industry and the second two are for the U.S. industry. Although the TL and CD indices are remarkably close to one another for the first half of the study period, they indicate somewhat different overall average annual growth rates. The results in Table 2 are TL and CD indices of the industries' estimated technical progress and their growth rates.

T A B L E 1

INDICES OF MULTIFACTOR PRODUCTIVITY*
1971 = 1

YEAR	CANADA		U. S.	
	(TL)	(CD)	(TL)	(CD)
1961	0.9410	0.9398	0.9890	0.9862
1962	0.9473	0.9471	0.9941	0.9904
1963	0.9534	0.9545	1.0020	0.9985
1964	0.9609	0.9626	0.9948	0.9911
1965	0.9621	0.9629	0.9844	0.9813
1966	0.9681	0.9692	0.9755	0.9730
1967	0.9752	0.9757	0.9816	0.9796
1968	0.9789	0.9789	0.9960	0.9955
1969	0.9847	0.9848	0.9871	0.9868
1970	0.9906	0.9906	0.9835	0.9833
1971	1.0000	1.0000	1.0000	1.0000
1972	1.0100	1.0100	0.9979	0.9975
1973	1.0130	1.0130	0.9851	0.9841
1974	1.0060	1.0050	0.9858	0.9843
1975	1.0030	1.0020	0.9508	0.9505
1976	1.0150	1.0150	1.0200	1.0220
1977	1.0150	1.0150	0.9762	0.9799
1978	1.0100	1.0090	0.9931	0.9967
1979	1.0130	1.0120	1.0050	1.0070
1980	1.0100	1.0080	1.0120	1.0130
1981	1.0130	1.0110	1.0340	1.0360
1982	1.0130	1.0130	1.0430	1.0450

AVERAGE ANNUAL MFP GAINS

1961-1982	0.352%	0.360%	0.280%	0.302%
1978-1982	-0.032%	-0.033%	1.341%	1.305%

* The indices denoted by TL and CD are produced by index formulations which assume, respectively, a translog and a Cobb-Douglas production technology for each industry.

T A B L E   2

INDICES OF TECHNICAL PROGRESS**
1971 = 1

	CANADA		U. S.	
YEAR	(TL)	(CD)	(TL)	(CD)
1961	0.9031	0.9018	0.8942	0.8920
1962	0.9126	0.9122	0.9077	0.9052
1963	0.9217	0.9223	0.9177	0.9150
1964	0.9356	0.9370	0.9313	0.9288
1965	0.9408	0.9414	0.9254	0.9232
1966	0.9518	0.9526	0.9279	0.9259
1967	0.9635	0.9638	0.9559	0.9545
1968	0.9698	0.9697	0.9742	0.9737
1969	0.9783	0.9783	0.9751	0.9748
1970	0.9874	0.9874	0.9770	0.9767
1971	1.0000	1.0000	1.0000	1.0000
1972	1.0140	1.0140	1.0190	1.0200
1973	1.0190	1.0190	0.9955	0.9954
1974	1.0140	1.0130	1.0150	1.0140
1975	1.0120	1.0120	0.9864	0.9869
1976	1.0290	1.0290	1.0590	1.0620
1977	1.0320	1.0330	1.0440	1.0470
1978	1.0310	1.0310	1.0680	1.0710
1979	1.0370	1.0360	1.0710	1.0740
1980	1.0380	1.0370	1.0760	1.0790
1981	1.0440	1.0430	1.1040	1.1070
1982	1.0440	1.0450	1.1150	1.1180

|	AVERAGE ANNUAL GAINS			
1961-1982	0.696%	0.705%	1.076%	1.102%
1978-1982	0.229%	0.229%	1.331%	1.319%

** See notes to Table 1.

These findings indicate that, between 1961 and 1982, the Canadian food and beverage industries performed better than their U.S. counterparts in terms of multifactor productivity. The growth rate of this (TL) index was, on average, 0.35% per year compared to 0.28% per year for the American industries (our Cobb-Douglas index measured them to be 0.36% and 0.30% per year respectively).[4] For the last five years of the study, however, the Canadian industries did not perform as well : their MFP index shows a decline of 0.03 percent per year whereas the U.S. industry's index grew by 1.34 percent per year (using the TL index). It appears that, since 1978, the performance of the Canadian industry has deteriorated rapidly relative to that in the U.S. This finding, however, is based on data for only five years and does not necessarily imply a sharply declining trend in productivity growth for the Canadian industry.

To examine the question of declining productivity growth more carefully, we may statistically test the hypothesis that the trend growth rate of MFP for each industry has declined (or increased) over the study period. For the Canadian industry, the regressions performed on both CD and TL indices do show a declining MFP growth rate. This rate has been declining by about 0.05% every year (on average) over the 1961-82 period. The relevant coefficient is statistically highly significant.[5] The American industry, on the other hand, seems to have had an increasing MFP growth rate over this period, adding about 0.06% per year on average to their MFP growth rate. Unlike the findings for the Canadian industry, the latter estimate is

subject to some qualifications.[6] These tests do indicate, however, that although the Canadian performance has been somewhat better than the U.S. industry, declining productivity growth in the Canadian industry and rising growth in U.S. productivity have reduced our previous productivity advantage leading to better performance by the U.S. industry between 1978 and 1982.

Aggregated input data and output data (reported in the Appendix) were also used to estimate industry returns-to-scale parameters.[7] Estimation of industry production functions indicate that these parameters are approximately 0.55 and 0.88 for the U.S. and Canadian industries respectively. Thus, although both industries operate under decreasing returns and face increasing unit costs as they expand, the Canadian industry is, in this respect, in a more advantageous position than its U.S. counterpart.
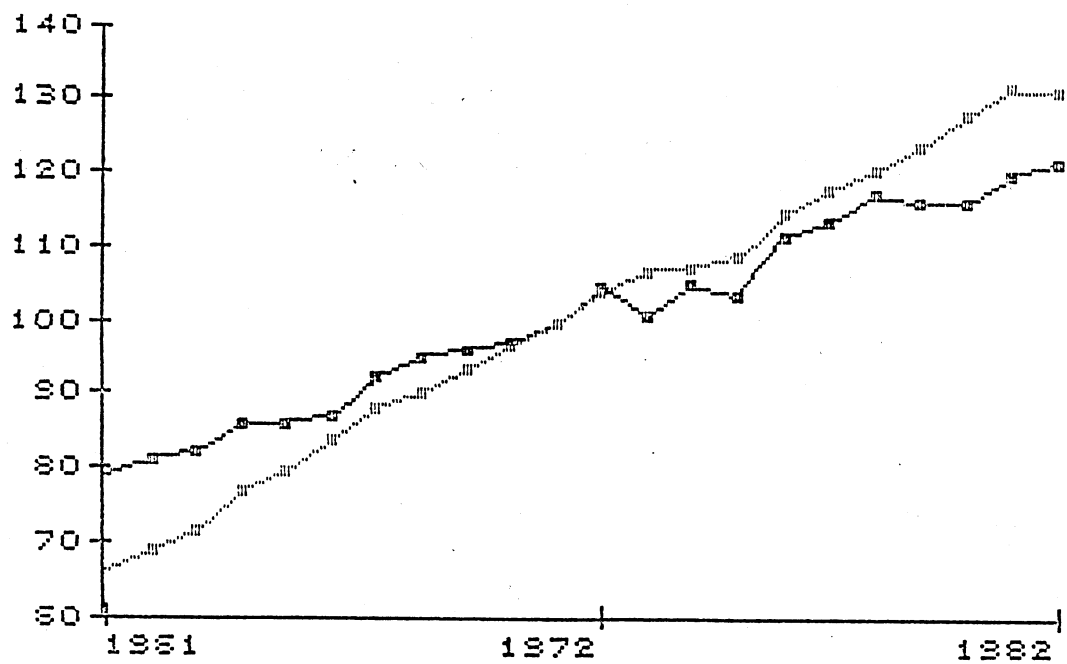
GOFM71P United States
GOFB Canada

Figure 1

INDUSTRY PRODUCTION LEVELS
(1971 = 1)
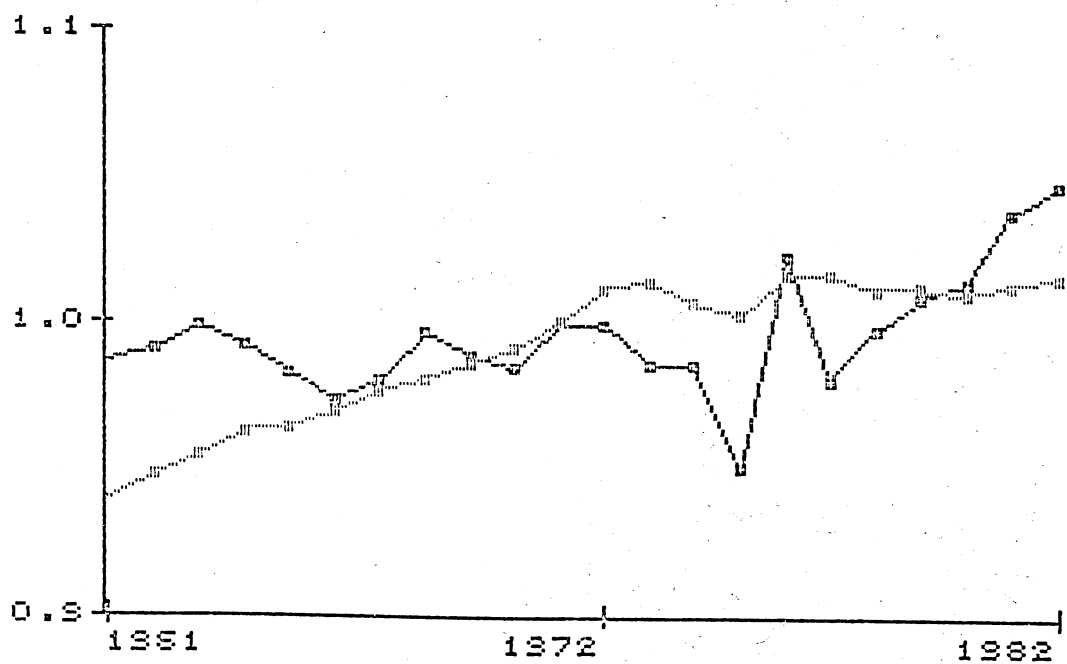
FPFM United States
FPFB Canada

Figure 2

MULTIFACTOR PRODUCTIVITY
(Cobb-Douglas Indices, 1971 = 1)

- 11 -
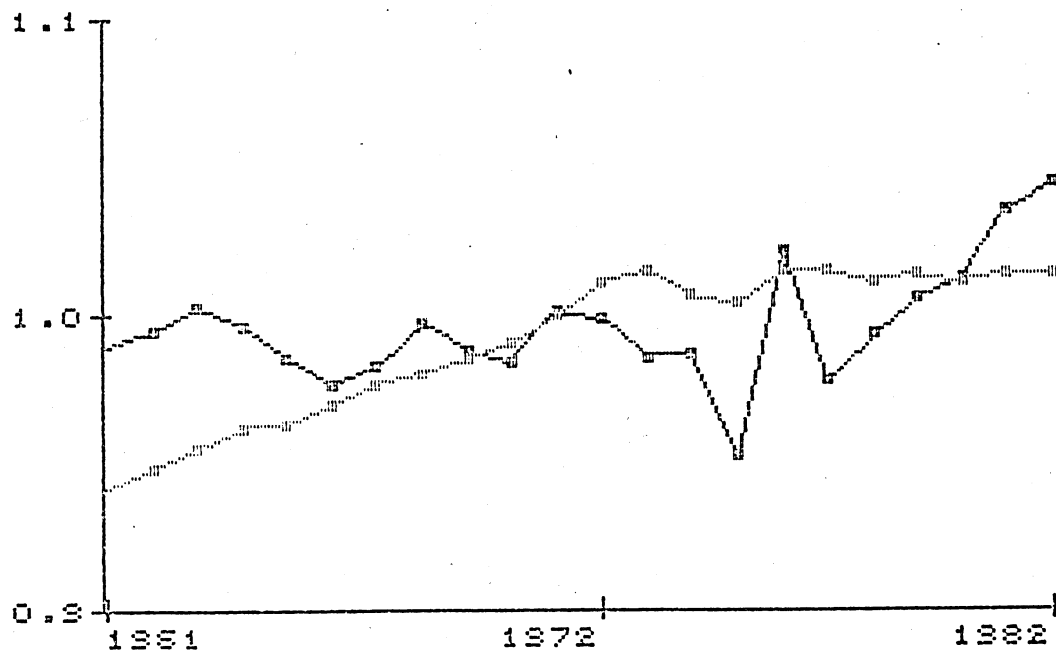
■ ITPFM United States   Figure 3
■ ITPFB Canada

MULTIFACTOR   PRODUCTIVITY
(Translog Indices, 1971 = 1)
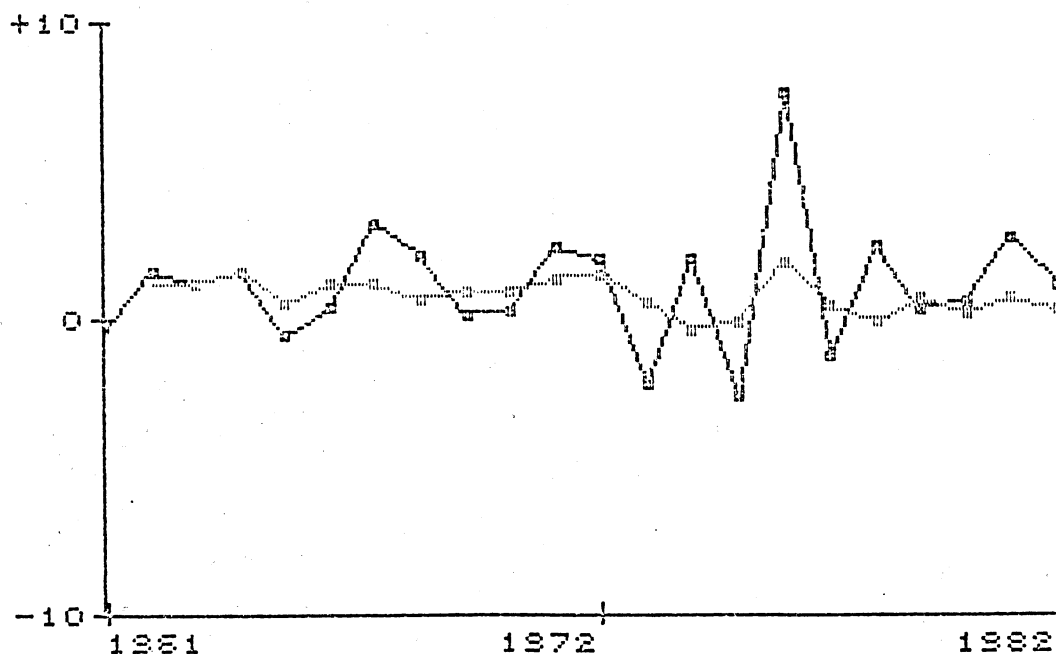
■ GTPFM1P United States   Figure 4
■ GTPFB1P Canada

ESTIMATED TECHNICAL PROGRESS
(growth in percent per year)

- 12 -
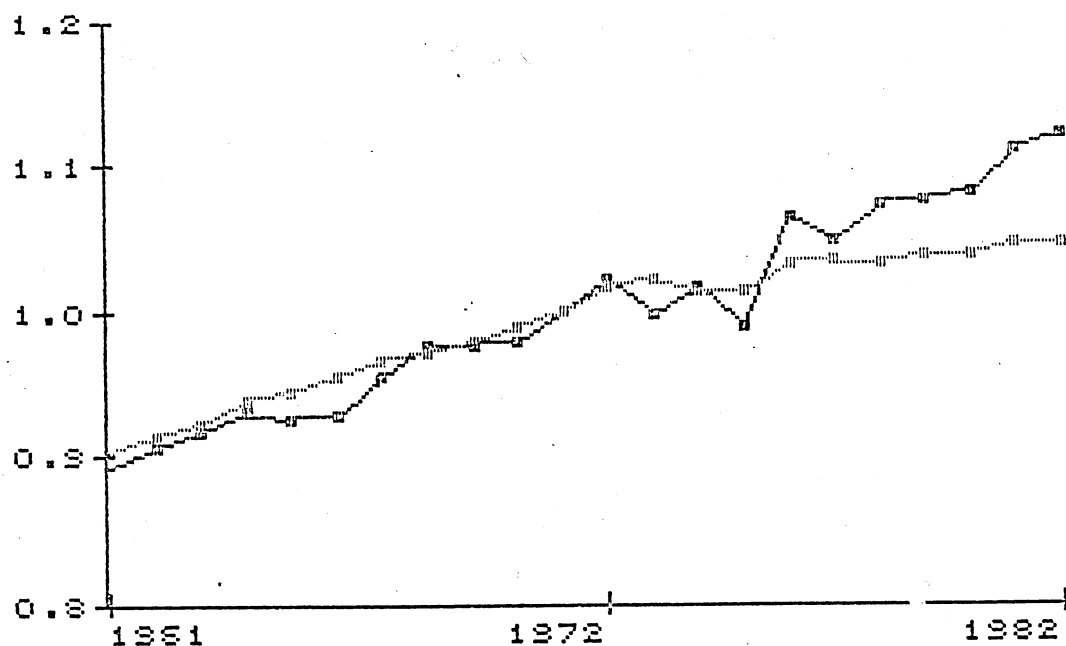
Figure 5

- □ **FPFM1** United States
- ▪ **FPFB1** Canada

ESTIMATED TECHNICAL PROGRESS INDICES
(Cobb-Douglas, 1971 = 1)
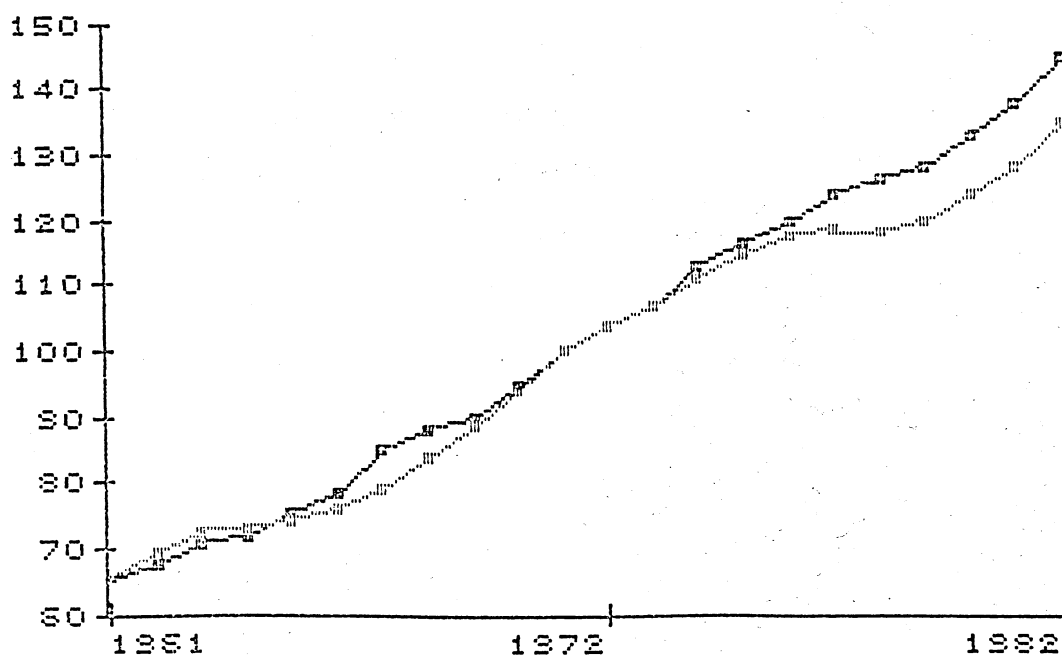
Figure 6

- □ **KLFM71** United States
- ▪ **KLFB** Canada

INDUSTRY CAPITAL-LABOUR RATIOS
(1971 = 1)

APPENDIX

CANADIAN FOOD AND BEVERAGE INDUSTRIES
Output and Factor Input Data
(1971 = 1)

YEAR	OUTPUT	CAPITAL	LABOUR	ENERGY	MATERIALS
1961	0.66296	0.65438	0.99159	0.76283	0.66828
1962	0.68904	0.68769	0.99445	0.78346	0.69185
1963	0.71443	0.71683	0.99251	0.80486	0.71557
1964	0.76595	0.74306	1.01686	0.83735	0.76972
1965	0.79512	0.77119	1.03852	0.89460	0.79964
1966	0.83761	0.80546	1.06396	0.93389	0.84075
1967	0.87975	0.84621	1.07342	0.95701	0.88105
1968	0.90388	0.88528	1.05672	0.98402	0.90515
1969	0.93116	0.92129	1.04290	1.01204	0.93112
1970	0.96397	0.96133	1.02267	0.98762	0.96562
1971	1.00000	1.00000	1.00000	1.00000	1.00000
1972	1.04167	1.03070	0.99803	1.01824	1.03764
1973	1.06466	1.06617	1.00285	1.01616	1.05770
1974	1.07321	1.10834	0.99943	1.04910	1.07332
1975	1.08654	1.14157	0.99756	1.03818	1.09177
1976	1.14543	1.16421	0.99295	1.03130	1.15043
1977	1.17704	1.18940	1.00212	1.03501	1.18736
1978	1.20393	1.21744	1.03261	1.05178	1.22053
1979	1.23997	1.24844	1.04131	1.09747	1.25708
1980	1.27871	1.29098	1.04131	1.08115	1.30799
1981	1.31484	1.32485	1.03193	1.04383	1.34939
1982	1.31253	1.34748	0.99909	1.05799	1.34937

Factor Share Data

YEAR	CAPITAL	LABOUR	ENERGY	MATERIALS
1961	0.11000	0.13867	0.01248	0.73885
1962	0.11179	0.13604	0.01241	0.73976
1963	0.11340	0.13251	0.01210	0.74198
1964	0.11917	0.13061	0.01184	0.73837
1965	0.11829	0.13401	0.01209	0.73561
1966	0.11500	0.13291	0.01154	0.74054
1967	0.11424	0.13558	0.01132	0.73886
1968	0.11404	0.13901	0.01141	0.73555
1969	0.11312	0.13794	0.01097	0.73797
1970	0.10922	0.13979	0.01026	0.74073
1971	0.11196	0.14086	0.01047	0.73671
1972	0.11091	0.13617	0.01002	0.74290
1973	0.11124	0.12346	0.00898	0.75632
1974	0.09516	0.11798	0.00960	0.77727
1975	0.10529	0.12168	0.01022	0.76281
1976	0.11256	0.12996	0.01146	0.74602
1977	0.10823	0.13082	0.01220	0.74876
1978	0.10842	0.12525	0.01207	0.75426
1979	0.10312	0.12112	0.01224	0.76352
1980	0.09675	0.11948	0.01287	0.77090
1981	0.10246	0.11816	0.01390	0.76549
1982	0.11271	0.12265	0.01620	0.74844

AMERICAN FOOD MANUFACTURING INDUSTRIES
Output and Factor Input Data
(1971 = 1)

YEAR	OUTPUT	CAPITAL	LABOUR	ENERGY	MATERIALS
1961	0.78848	0.71732	1.09906	0.72230	0.77266
1962	0.81047	0.73384	1.09062	0.72349	0.79482
1963	0.82199	0.74861	1.05886	0.76712	0.80175
1964	0.85759	0.77088	1.07504	0.77222	0.85256
1965	0.85654	0.79622	1.06094	0.78318	0.85981
1966	0.87120	0.83039	1.06164	0.79794	0.88367
1967	0.92461	0.89329	1.05390	0.87683	0.93757
1968	0.94764	0.91556	1.03871	0.86989	0.94791
1969	0.96021	0.94151	1.04973	0.95518	0.96879
1970	0.96859	0.97219	1.03067	0.99750	0.98040
1971	1.00000	1.00000	1.00000	1.00000	1.00000
1972	1.04712	1.02606	0.99256	1.08519	1.06530
1973	1.00942	1.04833	0.98640	0.95865	1.02706
1974	1.05236	1.08178	0.96030	0.82322	1.08459
1975	1.03351	1.11040	0.95454	0.88942	1.10397
1976	1.11309	1.14201	0.95315	0.96007	1.09716
1977	1.13613	1.17607	0.94878	0.99219	1.19112
1978	1.17068	1.21414	0.96278	1.05003	1.19911
1979	1.16230	1.24379	0.96943	0.92556	1.16267
1980	1.16440	1.27745	0.96030	0.79772	1.14978
1981	1.20105	1.30207	0.94491	0.74704	1.16257
1982	1.21361	1.33419	0.92010	0.85610	1.15692

Factor Share Data

YEAR	CAPITAL	LABOUR	ENERGY	MATERIALS
1961	0.16200	0.13200	0.00900	0.69600
1962	0.15300	0.13400	0.00900	0.70500
1963	0.14800	0.13400	0.01000	0.70900
1964	0.15000	0.13300	0.00900	0.70800
1965	0.14900	0.13000	0.00900	0.71200
1966	0.14500	0.12600	0.00900	0.72000
1967	0.15600	0.12600	0.00900	0.70800
1968	0.17900	0.12300	0.00900	0.68900
1969	0.18500	0.12200	0.00900	0.68500
1970	0.18800	0.12200	0.00900	0.68100
1971	0.18900	0.12100	0.01000	0.68100
1972	0.18500	0.11400	0.01000	0.69200
1973	0.16700	0.10300	0.00800	0.72100
1974	0.16100	0.09400	0.00900	0.73600
1975	0.16500	0.09500	0.01100	0.72900
1976	0.18900	0.09200	0.01300	0.70500
1977	0.18000	0.09800	0.01300	0.70900
1978	0.17700	0.09600	0.01400	0.71300
1979	0.18500	0.09400	0.01400	0.70800
1980	0.20400	0.09200	0.01500	0.68900
1981	0.20300	0.09100	0.01600	0.69000
1982	0.21300	0.09400	0.01800	0.67500

NOTES

1) All of the data relevant to the Canadian food and beverage industry at the 2 digit SIC level of aggregation (see Appendix) were drawn from the data base of the Processing and Retail Section, Food Markets Analysis Division and are described in Salem (1987).

2) The output, factor input and factor share data for the U.S. food manufacturing industries were drawn from Lee (1986) Tables 2 and 3. They refer to the Food and Kindred Products sector, S.I.C. 2Ø. The set of products covered by this classification is quite comparable to that of the Canadian Food and Beverage sector, S.I.C. 1Ø. Exceptions, however, include rice, cotton seed oil and manufactured ice production which are included only in the U.S. sector data.

3) It has not been an objective of this study to compare levels of productivity between the two industries, if such comparison could reliably be made. The indices constructed allow us to compare levels between any two points in time for the same industry but not across industries. They have been scaled to take the value of 1 for the year 1971.

4) A study of the productivity of the Canadian industry at the more disaggregate 3-and 4-digit S.I.C. level found substantial variation among their productivity growth rates (Salem, 1987, p.6). For the 1961-82 period, average annual productivity growth ranged from 1.12% and 1.Ø2% for the Breweries and Fruit and Vegetable Processors respectively to -Ø.24% for Poultry Processors and -Ø.27% for the Fish Products industry.

5) The procedure consists of assuming an exponential form for the MFP index so that

$$MFP(t) = A.e^{(r_1t+r_2t^2)} \text{ and}$$

$$\mathit{ln}\ MFP(t) = \mathit{ln}\ A + r_1t + r_2t^2.$$

The trend growth rate of MFP is then given by r_1+2r_2t which varies according to the time period. The hypothesis of declining productivity growth can then be tested by estimating the two parameters and subjecting them to an F test and a t test. A statistically significant negative estimate for r_2 indicates declining productivity growth. For the Canadian industry's (CD) MFP, the regression statistics were

$r_1 = Ø.889E-Ø2$ (14.Ø8)	$r_2 = -Ø.231E-Ø3$ (8.68)
$R^2 = Ø.971$	Adj. $R^2 = Ø.968$
$F = 317$	D.W. = 1.175

where r_1 and r_2 are O.L.S. estimates. The D.W. statistic falls in the indeterminate region for the 22 observations. Both estimates are significant at the 99% level.

6) The hypothesis test is outlined in note 5 above. For the U.S. industries, the regression statistics were

$$r_1 = -0.492E-02 \qquad\qquad r_2 = 0.285E-03$$
$$(2.28) \qquad\qquad\qquad (3.12)$$
$$R^2 = 0.511 \qquad\qquad\qquad \text{Adj. } R^2 = 0.460$$

$$F = 9.95 \qquad\qquad\qquad D.W. = 2.238$$

Estimates are significant at the 95% and 99% levels for r_1 and r_2. The low R^2 statistic in this regression indicates that about 48.9% ($=1-R^2$) of MFP changes remain unexplained.

7) The estimation procedure used for estimating rates of returns-to-scale are detailed in Salem (1987).

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No. 1F   Modèle économétrique du boeuf. Pierre Charlebois. March 1987.

No. 2   Productivity and Technical Change in Canadian Food and Beverage Industries: 1961-1982. M. Salem. February 1987.

No. 3   Performance of Canadian and American Food and Beverage Industries: 1961-1982. M. Salem. February 1987.