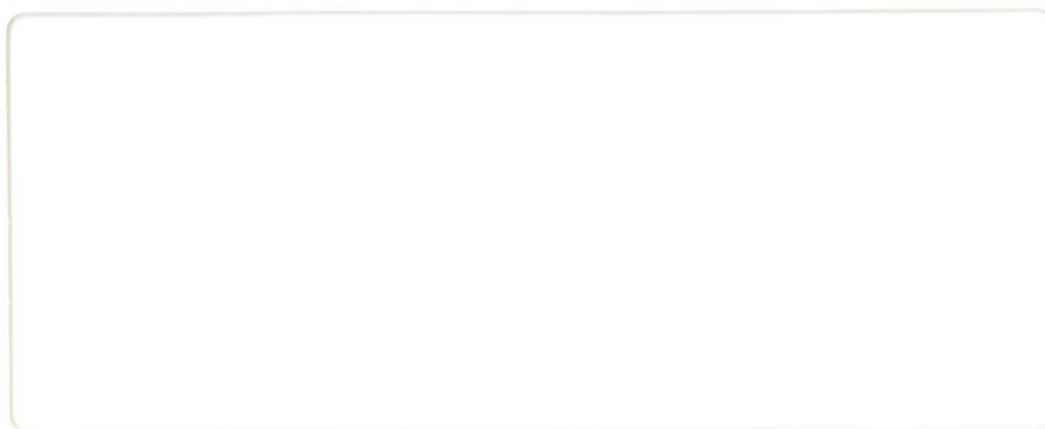


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**Simulating Productivity Gains with an
Input-Output Model**

By

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77

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Simulating Productivity Gains With An Input-Output Model

Abstract

This paper introduces a new input-output simulation model that computes the multifactor productivity gains associated with any resource allocation resulting from a shock given to the final demand of the economy. The model may be used to simulate *what if* questions as well as to compute the contribution of various categories of final expenditures to the growth of productivity in the Canadian economy over the historical record. Both types of questions are illustrated in the paper, including the impact of Canadian exports, broken down into 35 commodity groupings.

1 - Introduction

Input-output models have traditionally been used in Western countries to estimate the impact of various shocks given to the economy in terms of income generated and jobs created. That use of input-output models for macro-economic impact analysis has been criticized at times as exceeding their capabilities¹. In particular, contrary to macroeconomic models, simple input-output models do not specify properly the supply response of the economy taking into account capacity shortage in both physical and human capital, inflation and change in interest rates. Rather, supply is supposed to be perfectly elastic and adjust to a shock of any size.

Indeed, the standard input-output model can only trace the impact of a shock given to final demand through the various industrial sectors of the economy, accounting for the resources which are required to satisfy that demand without imposing any restriction on supply. Nothing insures that jobs accounted for by the model will actually be created if a shock is in fact given to the economy as is the case, for instance, when a new factory starts producing goods that are already sold by other factories. The new supply may simply substitute for existing supply without any new jobs being created either directly or indirectly by that activity.

Simulation results of input-output models are more rarely examined in light of the productivity gains associated with the resource allocation corresponding to a given final demand shock. Analysts will look at times at the distribution of the impact by industry and, in particular, at the distribution of wages. They will judge that, other things being equal, the economy is better off if jobs are created in high tech industries which pay high wages. Applications in which true assessments based on a full characterization of the impact in

1. For the Canadian case, see for instance Grady, P. and R.A. Muller (1988).

terms of productivity gains as measured by total factor productivity are unknown to the authors. However, it is a simple matter to extend the traditional specification of open input-output models to measure the productivity gains associated with a given resource allocation provided that some standard productivity gains estimates are readily available that match the associated production activities.

In the case of the Canadian economy, such estimates of productivity gains are available. These estimates are elaborated within the framework of the annual input-output tables and constitute a regular component of the Canadian System of National Accounts². They are thus perfectly consistent with the simulation results of the input-output model. Section 2 below builds on these developments and shows how the Canadian Productivity Accounts can be profitably utilized to develop an input-output productivity gains simulation model (IOPG).

The IOPG model can be used to simulate questions on the historical record such as: how much of the productivity gains in the Canadian economy came from the expansion of exports through time as opposed to, say, government expenditures? This question is answered in Section 3 of this article in order to illustrate the potential of the model. Simulations over the historical records associated with all specific categories of final demand may be seen as an accounting exercise. Productivity numbers that are associated with measures of output by industry are thereby transformed into productivity indices attached to specific baskets of goods corresponding to the various categories of consumer, government and non-resident expenditure. Thus the IOPG model may be used to extend the basic productivity accounts.

Of course, more detailed and specific questions of both an historical or a hypothetical nature can be simulated with the model such as illustrated in Section 4 where Canadian exports, broken down into 35 commodity groups, are scrutinized. When simulating *what if* questions, the user of the model is allowed to specify the productivity parameters at arbitrary values as it may be useful to explore the consequences of potential changes in the productivity regime. Given that estimated past productivity gains remain highly cyclical, despite some correction done for that purpose, it may sometimes be preferable, in hypothetical simulations, to also replace estimated productivity gains for a particular year by some average computed over the course of associated business cycle. Average productivity gains would give a better measure of the long-run impact of a specific resource allocation.

2 - The Structure of the Model

In Canada, annual rectangular input-output tables in current and constant prices are available starting in 1961. Comprehensive multifactor productivity accounts have been developed based on the use of the outputs and inputs data from these tables and from estimates of hours and capital stock by industry. Alternative annual productivity gains

2. For a description, see Durand, R. (1995).

have been estimated corresponding to industry gross output, gross output net of intra-industry sales and value-added, and finally, corresponding to final demand deliveries. These indices are related to each other by the usual linear input-output relationships (see Durand, 1995). It is only necessary, therefore, to use any one of these sets of indices in the development of the productivity gains simulation model as the results obtained would be identical whatever set of indices would be chosen. Consequently, we have decided to use the standard productivity indices based on gross output as they are the most commonly encountered. These indices may be written as:

$$\tau_g = (C \cdot \dot{V})i - (B^T \cdot \dot{U}^T)i - (H_L^T \cdot \dot{L}^T)i - (H_K^T \cdot \dot{K}^T)i \quad (1)$$

where τ_g is the vector of rates of growth of productivity on gross output, C is the usual product mix matrix of industries in current prices which is used to weight the growth rate of the many commodity outputs of industries recorded in the rectangular make matrix V and estimate their Divisia indices, B is the intermediate input coefficient matrix in current prices whose elements weight growth rates in real intermediate input uses recorded in the input matrix U and H_L and H_K are similar matrices for corresponding matrices of primary inputs of labour L and capital K . A dot over a symbol is used to denote its percentage rate of growth through time and the dot operator is used to denote the element by element product of two matrices. The summation vector of appropriate size is indicated by i and T is a superscript indicating the transposition of vectors and matrices.

Hence, equation (1) reads: the multifactor productivity growth rates of industries are given by subtracting the weighted growth rates of primary and intermediate inputs from the weighted growth rates of their commodity outputs. In continuous time, they are Divisia indices. The Divisia multifactor productivity indices measure technical progress under competitive market conditions and constant returns to scale. In the Canadian Productivity Accounts, Divisia indices are approximated in discrete (annual) time by chained Törnqvist indices.

Aggregate productivity gains for all industries of the business sector, τ , are obtained following Domar's (1961) rule by³:

$$\tau = \beta^T \tau_g \quad (2)$$

where the aggregation weights, β , are given by dividing the industries' nominal gross output by the aggregate business sector nominal value-added. Note that, as shown by Domar, these weights sum to more than one as productivity gains measured on the gross output of industries do not account for the productivity gains made in the production of intermediate inputs while productivity gains measured on aggregate value-added do account for these gains⁴.

3. Presently, productivity gains can only be estimated for the business sector industries of the economy.

4. See also Hulten (1978).

The weights β can easily be compiled from the simulation results of the traditional open input-output model as explained below. Applying these weights to the gross output productivity indices for a given year gives the aggregate productivity gains associated with the particular resource allocation resulting from a specific shock given to final demand in that year.

Productivity gains by industry are assumed to be exogenous and, in particular, independent of the level of output. Alternatively, it is assumed that the shock given to the economy in that particular year would not have been large enough to change significantly the average productivity gains observed in each industry as recorded in the Productivity Accounts.

The average productivity gains associated with a shock can be compared to the average productivity gains observed in the economy for that same year. A shock improves the overall productivity of the economy if its associated productivity gains exceed the average gains registered by the economy. The improvement in productivity does not stem from better use of resources in each industry but from their allocation to industries with higher than average productivity gains. Hence, the IOPG model focusses the attention strictly on the productivity of alternative resource allocations in the economy.

The impact equation used to assess a final demand shock in the Canadian open input-output model is given by:

$$g = \{[I - D(I - \hat{\mu} - \hat{\alpha} - \hat{\gamma})B]^{-1} D(I - \hat{\mu} - \hat{\alpha} - \hat{\gamma})\} e \quad (3)$$

where g is the vector of nominal gross output by industry, e the vector of final demand expenditure by commodity, and the expression between the braces is the "impact matrix"⁵. That matrix takes into account direct and indirect leakages - non-domestic-business supply sources - through a set of parameters - imports, μ , government supply of goods and services, α , and withdrawals from inventories, γ - as well as it takes into account the industries' market shares of the various commodities embedded in the matrix D . The vector of final demand e is itself an aggregation of the final demand matrix E of the Canadian input-output tables (its positive columns only) covering household consumption, private and public investment, government expenditure, additions to inventories and exports. There are 128 such columns at the most detailed level. These were aggregated into 11 categories listed below for the present exercise, corresponding to the categories used in the *S small* level of aggregation of input-output tables. In order to write the impact equation in terms of these categories of final demand rather than in terms of the commodities of e , let s be the vector of final demand categories or column totals of E , that is:

$$s^T = i^T E \quad (4)$$

5. A brief description of the Canadian input-output model can be found in Durand and Rioux (1994).

If P is a parameter matrix giving the commodity structure of the categories of final demand expenditures defined by:

$$P = E\hat{S}^{-1} \quad (5)$$

then

$$e = Ei = Ps \quad (6)$$

The *matrix* of vectors of gross output G associated with each category of final demand, may be obtained by replacing e by Ps in equation (3) and then replacing s by its diagonal matrix:

$$G = \{[I - D(I - \hat{\mu} - \hat{\alpha} - \hat{\gamma})B]^{-1} D(I - \hat{\mu} - \hat{\alpha} - \hat{\gamma})\} P\hat{S} \quad (7)$$

Note from (5) that $P\hat{S}$ is simply the final demand matrix E itself. The vector of value added by industry, y can be computed as a fraction, say λ , of gross output so that the matrix of value added, Y associated with G is given by:

$$Y = \hat{\lambda}G \quad (8)$$

Equations (7) and (8) were simulated over the historical record to generate the weights β by industry that are necessary to aggregate the productivity indices τ_g according to Domar's rule given by equation (2) above. The result of each simulation corresponding to each category of final demand may be considered as an estimate of productivity gains associated with the production of all goods included in that category. The model thus generates productivity gains by final demand category τ_s .

Were it not for the presence of leakages, these estimates could themselves be weighted by final demand expenditures to generate the contribution of each final demand category to aggregate productivity growth. However, in an open economy, the imports of final goods and the import *content* of domestically produced goods have to be removed from these final demand expenditures. The latter is composed of the real income shares of imported inputs used by each industry. Other leakages including commodity indirect taxes have also to be taken into account. All these factors are easily taken care of by noting that the required net final sales have the same value as the simulated business sector value-added. Let σ be the vector of weights defined as the business sector value-added share generated by final demand expenditure category s , y_s in total business sector value added, y :

$$\sigma = \frac{y_s}{i^T y_s} = \frac{y_s}{y} \quad (9)$$

The weighted productivity gains $\hat{\sigma}\tau_s$ gives the contributions of final demand categories to aggregate productivity growth to which they exactly sum:

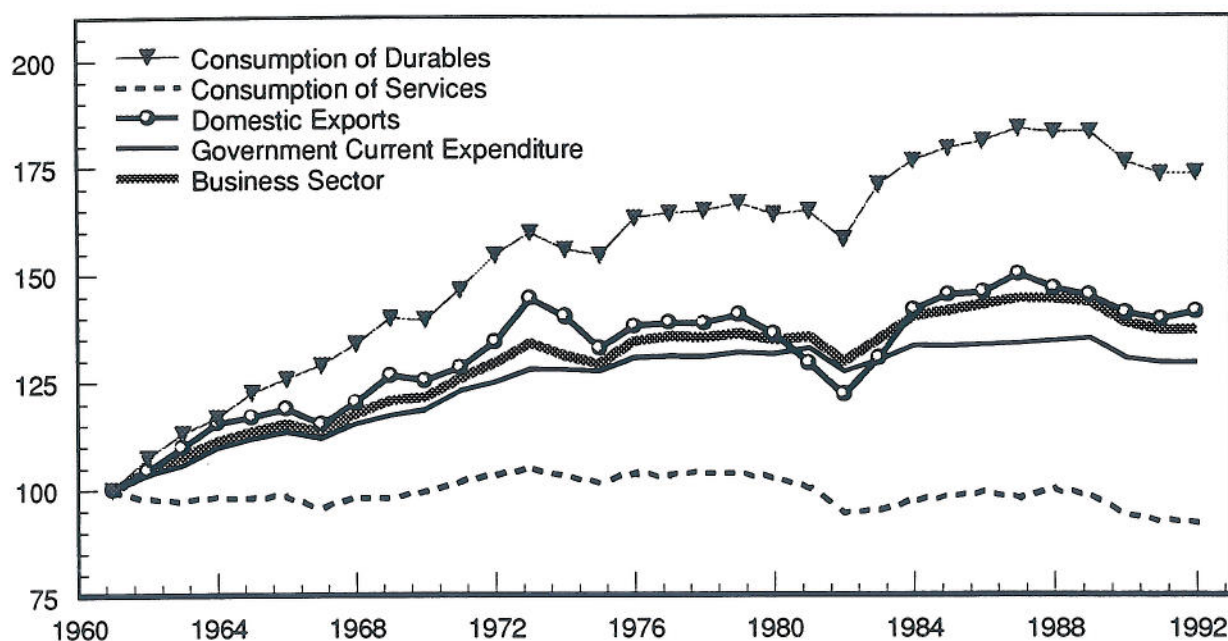
$$\tau = \sigma^T \tau_s \quad (10)$$

When a shock is given to a specific category k of final demand, the separate contribution of each commodity i , e_{ik} , to the overall productivity gains of the category k may similarly be computed. In that case, one uses the impact equation (3) rather than (7) with \hat{e}_k replacing e . Equations (9) and (10) are modified accordingly.

3 - Simulating the Impact of Final Demand Expenditure by Category on Productivity Growth in the Canadian Economy

What have been the productivity gains over the last three decades originating from the expansion of the various categories of final demand? What has been the relative contribution of these components to the overall productivity growth of the business sector? Do shifting shares impact on overall productivity gains?

Figure 1 - Productivity indices for selected final demand categories and for the business sector, 1961-1992, 1961=100



To answer these questions, we have calculated the total factor productivity index levels, over time, of deliveries to 11 final demand categories and compared them to the productivity growth of the entire business sector. The complete set of results are reported in Table 1. The percentage distribution of value added (final sales net of leakages)

Table 1 - Productivity indices by final demand category, selected years (1961=100)

	1962	1967	1972	1977	1982	1987	1992
Personal expenditure on durable goods	107.4	128.9	154.5	164.0	157.8	183.7	173.3
Personal expenditure on semi-durable goods	106.0	117.8	138.2	152.4	150.3	174.6	163.5
Personal expenditure on non-durable goods	107.7	121.3	141.5	149.2	141.5	158.7	152.1
Personal expenditure on services	97.9	95.9	103.4	103.2	94.2	98.0	92.3
Business construction	103.7	110.0	124.3	134.2	150.0	152.3	147.0
Government construction	105.0	112.7	126.7	135.7	155.2	157.1	151.7
Business machinery & equipment	107.8	126.8	150.1	164.1	159.7	184.2	172.6
Government machinery & equipment	107.1	124.3	143.9	154.7	149.5	170.6	168.0
Inventories	109.3	118.0	135.3	139.6	129.6	157.8	153.3
Domestic exports	104.4	115.2	134.2	138.5	121.7	149.8	141.1
Government current expenditure	103.4	111.9	124.9	130.8	127.1	133.7	129.2
Business sector	104.3	113.3	129.3	135.4	129.4	144.2	136.9

Table 2 - Percentage distribution of net final sales by final demand category, selected years

	1962	1967	1972	1977	1982	1987	1992
Personal expenditure on durable goods	6.93	6.56	6.47	5.80	5.04	5.67	5.18
Personal expenditure on semi-durable goods	7.63	6.89	6.51	5.93	5.56	5.31	4.39
Personal expenditure on non-durable goods	21.11	18.59	17.02	15.53	16.53	15.28	14.92
Personal expenditure on services	18.34	19.22	19.24	19.16	19.62	20.95	22.42
Business construction	11.88	12.62	13.24	15.08	13.73	13.73	12.15
Government construction	4.20	4.16	3.74	3.10	2.82	2.16	2.20
Business machinery & equipment	4.21	5.12	4.17	4.08	4.18	3.16	2.89
Government machinery & equipment	0.33	0.32	0.25	0.25	0.22	0.23	0.25
Inventories	2.24	1.58	1.50	1.53	0.71	0.74	0.47
Domestic exports	18.16	19.53	21.27	22.42	23.30	24.65	25.38
Government current expenditure	4.96	5.40	6.59	7.10	8.28	8.13	9.75

Table 3 - Productivity growth contributions by final demand category, selected years

	1962	1967	1972	1977	1982	1987	1992
Personal expenditure on durable goods	0.49	0.16	0.34	0.04	-0.21	0.09	0.00
Personal expenditure on semi-durable goods	0.44	-0.05	0.30	0.11	-0.24	0.17	-0.02
Personal expenditure on non-durable goods	1.57	-0.54	0.40	0.13	-0.44	0.33	-0.07
Personal expenditure on services	-0.40	-0.48	0.33	-0.08	-1.22	-0.27	-0.13
Business construction	0.45	-0.06	0.16	0.38	-0.13	-0.05	0.03
Government construction	0.20	-0.02	0.03	0.08	0.03	0.00	0.01
Business machinery & equipment	0.31	-0.06	0.19	0.06	-0.35	0.02	0.01
Government machinery & equipment	0.02	-0.00	0.01	0.01	-0.02	0.00	0.00
Inventories	0.17	-0.13	0.04	0.01	-0.07	0.02	0.01
Domestic exports	0.76	-0.61	0.96	0.11	-1.41	0.72	0.32
Government current expenditure	0.17	-0.07	0.11	0.02	-0.33	0.02	0.00

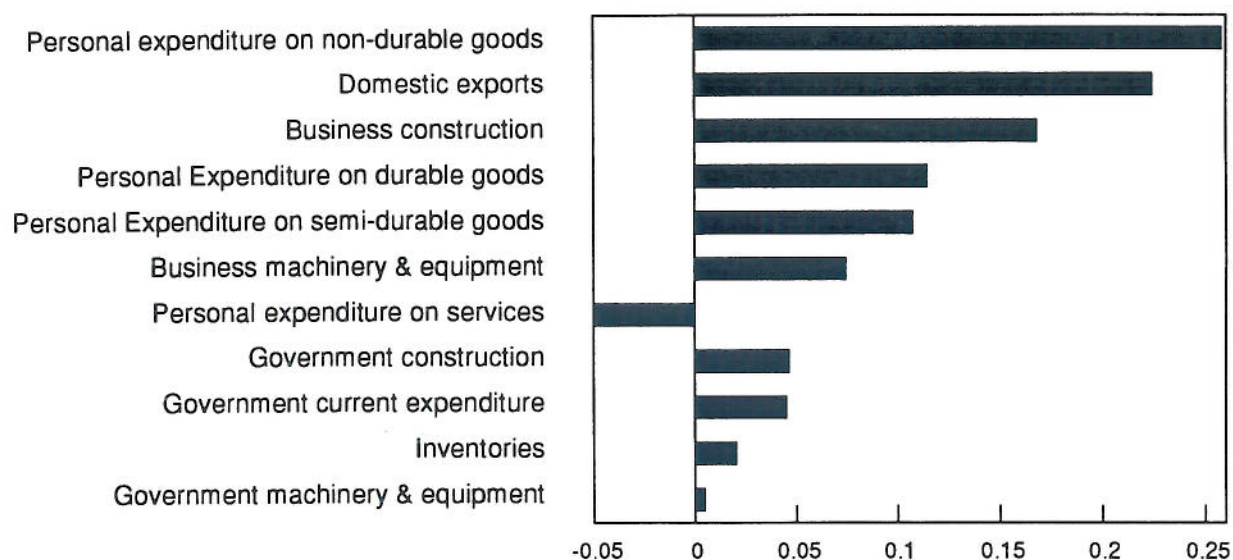
associated with final demand deliveries by category is reported in Table 2. Table 3 gives the weighted productivity gains or contributions. Figure 1 shows the productivity indices of 4 of the 11 categories together with the average for the total business sector.

In our illustration, it can be seen that consumer durable goods have exhibited the fastest productivity growth. For this category, productivity levels have reached as much as 80 per cent more than those of 1961 during the late 1980's. The cumulative productivity gains of consumer durable goods are also representative of the business sector investment in machinery and equipment not illustrated in Figure 1. These results emphasize the outstanding performance of durable goods manufacturing in the Canadian economy.

Together, exports, consumption of services and consumption of non-durable goods accounted for 58% of net final sales in 1961 and 62% in 1992. While the shares of these categories were fairly comparable to each other in 1961, they diverged considerably by 1992. The share of exports rose from 18% to 25% during the period, while that of consumption of non-durable goods dropped from 21% to 15%. Their productivity index reached 141 and 152 respectively in 1992, so that the observed shift in shares was not conducive to the highest productivity growth.

The cumulative productivity gains associated with exports show that they were slightly ahead of those of the business sector average since 1962, except from 1981 to 1983. But we cannot readily claim that exports on average are dominated by production processes that clearly lead to higher than average productivity growth of the Canadian economy.

Figure 2 - Average annual percentage contributions of final demand categories to aggregate productivity growth, 1961 to 1992



Similarly, the shares of the consumption of services and government current expenditure on goods and services have widened somewhat since 1961. As can also be seen in Figure 1, the productivity gains associated with the business sector deliveries to governments for their current expenditure have consistently fallen short of the average productivity growth of the Canadian economy. For consumer services, productivity has even declined. Although there may be some downward bias in the measurement of the output of many services industries, their productivity growth is nevertheless likely to be much below the average of other activities. The lower performance of the production activities related to these categories of expenditure have contributed to reduce the average aggregate productivity growth of the Canadian economy.

As explained in Section 2, weighting the productivity gains with the expenditure shares net of leakages gives their contributions to overall productivity growth. The average of these contributions over the historical record are depicted on Figure 2. As can be seen, personal expenditure on non-durable goods contributed the most to productivity growth, followed closely by exports. The category of consumer durable goods only occupies rank 4 and business investment in machinery and equipment, rank 5. Nevertheless, the productivity of durable goods industries, as seen above, ranks first. Therefore, weighted productivity gains reveal quite a different picture on the origin of productivity growth than non-weighted figures. It may also be concluded that any policy or other events that would favour an increase in the share of durable goods industries would be conducive of higher aggregate productivity growth.

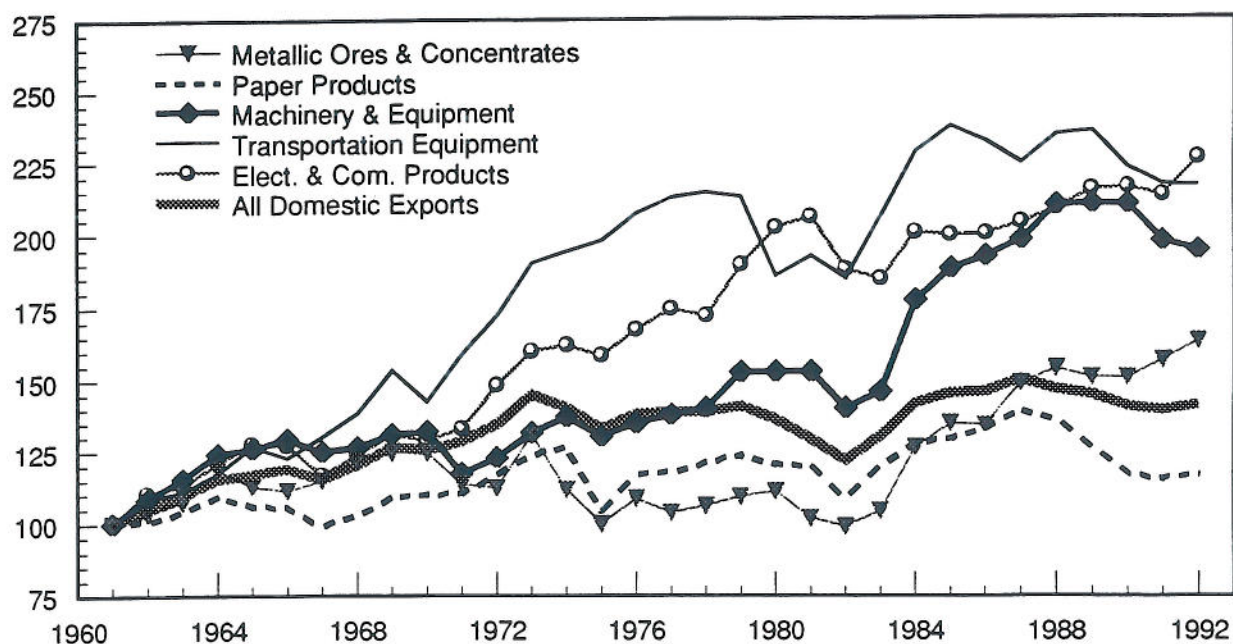
Since the shares of final demand categories varied over the historical record and since the productivity gains associated with the final demand categories also show wide discrepancies as illustrated in this section, we may expect that part of the productivity changes in the Canadian economy resulted from the shifting shares. To illustrate this *what if* type of simulations, we therefore asked the following simple question: would Canadian aggregate productivity have grown slower or faster, had the shares of the total final demand categories remained at their 1961 level?

Surprisingly, our results indicate that Canadian productivity growth with final demand category shares fixed at their 1961 level would have reached 1.04% on average compared to the observed 1.02%. Hence, had final demand category shares remained fixed over time, the overall business sector average productivity growth would not have followed a much different path.

4 - A Finer Look at Exports

To further illustrate the potential of the model, we have broken down the analysis of the productivity growth of exports into 35 different commodity groups. Again, we have tabulated the associated index levels (Table 4) and their shares based on simulated value-added content (Table 5). Contributions are reported in Table 6. Figure 3 illustrates

Figure 3 - Productivity indices of selected export categories, 1961-1992, 1961=100



productivity levels of selected commodity bundles delivered to exports and Figure 4 illustrates the contributions of all categories to the overall productivity growth originating from exports.

Looking first at the productivity indices, one may notice wide variations among the 35 different commodity groups. Transportation equipment, the most important exported commodity bundle since the inception of the Auto Pact between Canada and United-States in 1965, has shown a tremendous increase in productivity, its index having more than doubled from 1961 to 1976. However, it has made little progress since then. The next two most important exported commodities, paper and paper products and primary metal products have consistently exhibited slower productivity gains than the average export deliveries. Figure 3 also reveals the relatively large productivity growth attained in the production of machinery and equipment and electrical and communication products. On the other hand, Table 4 indicates that mineral fuels extraction registered a significant productivity drop. This is partly related to the difficulties encountered in the measurement of productivity growth for primary industries in which natural resources play an important role that is not properly accounted for at the present time.

Looking at the shares, one may notice the outstanding growth in the shares of transportation equipment since the implementation of the Auto Pact. No other commodity bundle has shown such a significant increase in its share of exports over the historical record. Other commodity groups having shown an increasing share of export deliveries are electrical and communications products and miscellaneous manufactured products.

Table 4 - Productivity indices of exports by commodity groups, selected years (1961=100)

Commodities	1962	1967	1972	1977	1982	1987	1992
Grains	120.1	123.5	139.2	145.0	146.3	167.8	182.9
Other agricultural products	120.0	123.5	139.2	145.1	148.4	170.4	188.7
Forestry products	105.3	113.1	152.6	156.1	163.0	236.6	228.3
Fishing & trapping products	96.3	83.6	86.5	92.0	81.5	97.5	100.1
Metallic ores & concentrates	103.1	114.8	112.2	103.7	98.9	148.6	163.2
Mineral fuels	99.2	106.1	142.4	102.4	54.2	59.8	76.8
Non-metallic minerals	98.1	114.9	113.7	90.5	62.2	72.1	78.8
Meat, fish & dairy products	107.4	102.5	112.5	114.1	115.7	128.0	116.9
Fruit, veg., feed, misc. food products	108.1	121.6	142.4	151.4	151.3	167.1	168.0
Beverages	103.9	152.6	152.4	186.9	157.8	155.0	148.1
Tobacco & tobacco products	114.2	120.3	154.3	179.2	167.8	169.7	166.0
Rubber, leather, plastic fab. products	111.0	124.4	144.5	159.6	155.9	193.5	188.2
Textile products	112.1	115.5	160.5	179.1	191.4	262.4	237.2
Knitted products & clothing	107.1	113.1	137.4	162.8	173.0	200.8	185.1
Lumber, sawmill, other wood products	105.4	121.0	137.3	150.1	160.5	230.2	219.1
Furniture & fixtures	105.3	119.1	142.2	146.9	128.5	144.0	133.1
Paper & paper products	100.2	99.2	117.2	117.3	108.0	139.2	117.3
Printing & publishing	102.2	104.9	115.9	136.2	128.6	140.4	110.1
Primary metal products	101.2	106.6	106.3	107.8	93.3	138.8	136.1
Metal fabricated products	110.4	125.2	141.8	145.8	130.3	162.3	152.4
Machinery & equipment	108.3	124.5	122.6	137.4	139.5	198.0	194.7
Transportation equipment	108.4	129.8	171.6	212.5	184.5	224.6	217.4
Elec. & communications products	110.5	116.7	147.4	173.8	187.7	203.8	226.5
Non-metallic mineral products	108.9	128.3	166.7	167.4	133.1	190.6	169.9
Petroleum & coal products	109.1	126.3	157.6	126.6	75.5	81.2	96.8
Chemicals, chemical products	108.1	128.8	149.0	153.7	141.3	185.5	196.2
Misc. manufactured products	104.3	110.4	136.2	149.2	151.0	164.9	164.6
Transportation & storage	102.0	141.2	189.2	188.6	176.0	211.1	209.1
Communication services	101.7	112.1	132.7	162.8	202.0	249.3	290.8
Other utilities	101.8	119.8	142.6	150.2	143.7	168.4	143.1
Wholesale margins	105.0	124.1	145.3	151.1	155.7	184.8	183.1
Other finance, ins., real estate	91.3	82.4	83.4	82.9	76.8	94.2	82.2
Business services	96.9	101.6	110.8	108.1	109.4	110.6	107.0
Personal & other misc. services	98.7	94.8	109.4	111.3	104.4	106.7	95.9
Transportation margins	100.9	126.0	165.6	168.9	174.0	223.3	235.1

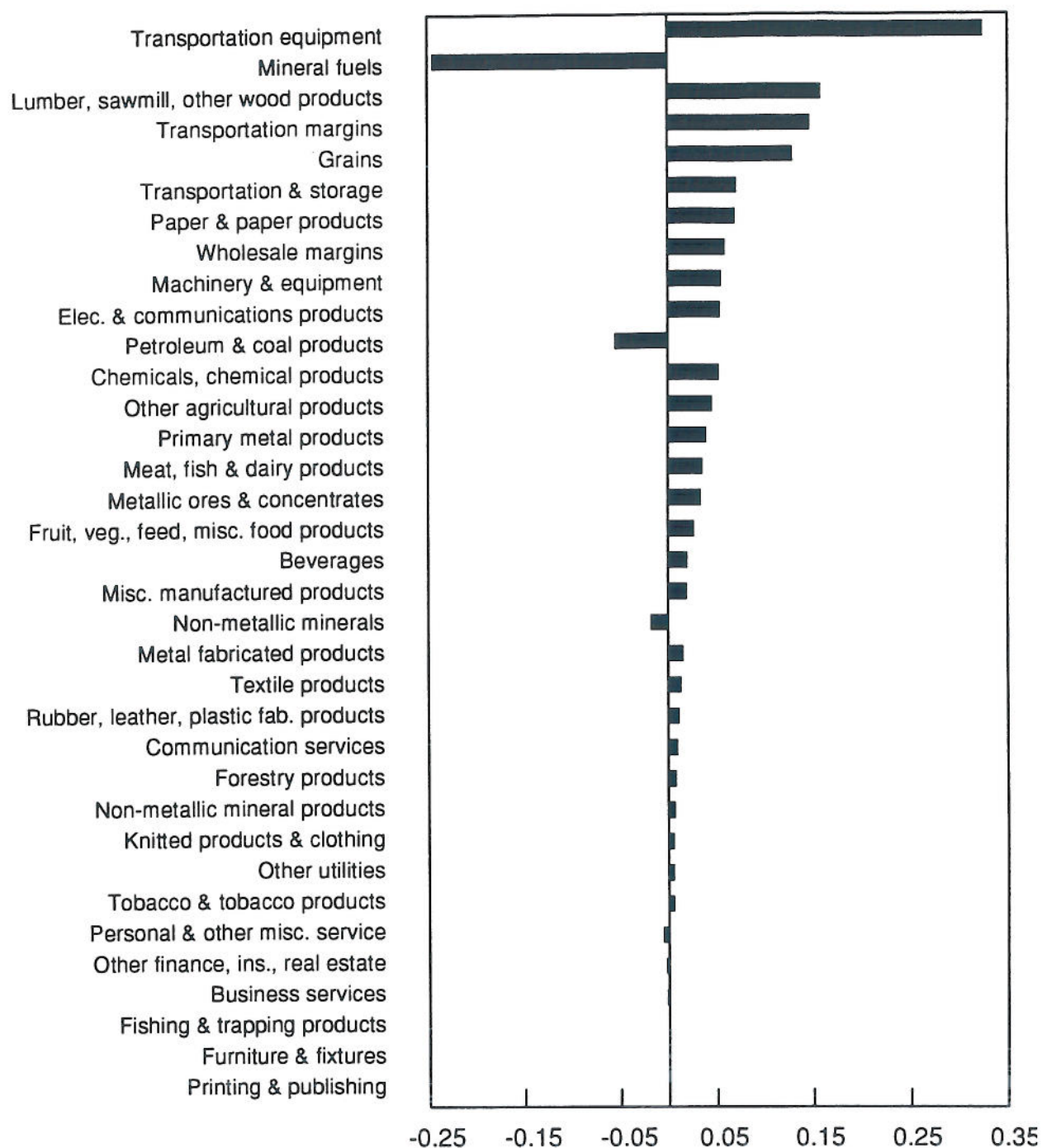
Table 5 - Percentage distribution of exported net final sales by commodity groups, selected years

Commodities	1962	1967	1972	1977	1982	1987	1992
Grains	8.23	5.38	3.46	4.87	6.43	2.20	2.31
Other agricultural products	2.76	1.71	1.64	1.79	1.70	1.52	1.99
Forestry products	0.63	0.45	0.16	0.16	0.16	0.30	0.11
Fishing & trapping products	0.61	0.42	0.41	0.28	0.35	0.53	0.35
Metallic ores & concentrates	9.00	6.48	5.17	5.49	5.05	4.76	3.26
Mineral fuels	4.13	3.92	6.20	7.66	9.28	6.48	6.70
Non-metallic minerals	2.50	2.27	1.43	1.74	1.18	0.80	0.51
Meat, fish & dairy products	3.16	2.80	2.80	2.98	3.66	3.27	2.61
Fruit, veg., feed, misc. food products	1.74	1.55	1.15	1.28	1.31	1.23	1.51
Beverages	1.40	1.44	1.16	0.87	0.68	0.51	0.68
Tobacco & tobacco products	0.49	0.44	0.26	0.16	0.15	0.10	0.36
Rubber, leather, plastic fab. products	0.42	0.39	0.46	0.61	0.86	1.23	1.53
Textile products	0.56	0.41	0.41	0.35	0.41	0.53	0.68
Knitted products & clothing	0.16	0.27	0.36	0.27	0.29	0.37	0.53
Lumber, sawmill, other wood products	6.71	5.32	6.77	6.99	4.43	5.58	4.94
Furniture & fixtures	0.05	0.08	0.23	0.22	0.41	0.72	0.65
Paper & paper products	17.09	13.41	10.94	11.62	10.15	11.29	7.85
Printing & publishing	0.10	0.16	0.22	0.25	0.35	0.54	0.41
Primary metal products	13.89	13.36	9.65	8.10	5.71	6.59	5.84
Metal fabricated products	0.68	1.02	1.59	1.58	1.43	1.69	1.45
Machinery & equipment	2.41	3.30	3.77	3.40	3.43	3.77	3.39
Transportation equipment	2.85	12.81	17.92	16.48	13.86	17.48	16.27
Elec. & communications products	1.33	2.15	2.47	1.86	2.61	3.30	3.65
Non-metallic mineral products	0.51	0.43	0.76	0.56	0.63	0.87	0.64
Petroleum & coal products	0.22	0.29	0.90	1.62	2.98	1.62	1.64
Chemicals, chemical products	2.85	3.02	2.63	2.91	3.53	3.77	4.27
Misc. manufactured products	0.73	0.83	1.10	0.71	1.45	1.74	2.06
Transportation & storage	4.22	4.36	3.62	2.61	2.77	1.92	3.53
Communication services	0.21	0.25	0.27	0.30	0.40	0.52	0.54
Other utilities	0.27	0.16	0.38	1.12	1.74	1.18	0.57
Wholesale margins	2.20	3.15	3.56	3.24	3.81	4.19	4.80
Other finance, ins., real estate	0.50	0.43	0.53	0.51	0.72	1.19	1.75
Business services	1.15	1.32	1.36	1.60	2.26	2.36	3.63
Personal & other misc. services	0.10	0.51	0.35	0.32	0.35	0.53	4.10
Transportation margins	6.11	5.73	5.93	5.49	5.49	5.31	4.85

Table 6 - Productivity growth contributions of exports by commodity groups, selected years

Commodities	1962	1967	1972	1977	1982	1987	1992
Grains	1.256	-1.219	-0.214	-0.129	0.018	-0.007	-0.006
Other agricultural products	0.508	-0.344	-0.098	-0.036	0.019	-0.009	-0.004
Forestry products	0.035	-0.014	0.017	0.005	-0.003	0.008	0.002
Fishing & trapping products	-0.023	-0.018	-0.009	0.022	0.041	-0.023	0.018
Metallic ores & concentrates	0.285	0.216	-0.066	-0.273	-0.161	0.436	0.116
Mineral fuels	-0.032	0.016	0.710	-0.454	-0.924	0.547	0.329
Non-metallic minerals	-0.051	-0.037	-0.032	-0.124	-0.255	0.067	-0.001
Meat, fish & dairy products	0.237	-0.219	-0.051	0.096	0.244	-0.092	-0.009
Fruit, veg., feed, misc. food products	0.131	-0.067	0.022	0.004	-0.017	0.001	0.014
Beverages	0.056	0.028	-0.010	0.071	-0.067	0.005	0.009
Tobacco & tobacco products	0.064	-0.065	-0.003	0.014	-0.003	0.007	-0.009
Rubber, leather, plastic fab. products	0.043	-0.007	0.014	0.046	-0.067	0.044	0.090
Textile products	0.064	0.000	0.038	0.026	-0.057	0.006	0.015
Knitted products & clothing	0.010	-0.006	0.019	0.013	-0.020	0.004	0.002
Lumber, sawmill, other wood products	0.354	0.065	-0.012	0.340	-0.079	0.299	0.078
Furniture & fixtures	0.002	-0.002	0.017	0.006	-0.066	-0.037	0.026
Paper & paper products	0.045	-0.989	0.664	0.027	-1.121	0.431	0.089
Printing & publishing	0.002	-0.001	0.011	0.011	-0.029	-0.010	-0.019
Primary metal products	0.179	-0.640	0.659	0.214	-0.497	0.544	0.179
Metal fabricated products	0.062	-0.028	0.056	0.022	-0.151	0.017	0.033
Machinery & equipment	0.190	-0.121	0.159	0.082	-0.339	0.104	-0.043
Transportation equipment	0.211	0.666	1.397	0.457	-0.531	-0.561	-0.014
Elec. & communications products	0.118	-0.177	0.255	0.084	-0.236	0.058	0.160
Non-metallic mineral products	0.047	-0.019	0.061	-0.009	-0.080	0.048	0.022
Petroleum & coal products	0.018	-0.007	0.064	-0.025	-0.258	0.118	0.071
Chemicals, chemical products	0.243	-0.104	0.180	0.008	-0.539	0.211	0.079
Misc. manufactured products	0.030	-0.045	0.092	0.020	-0.082	0.039	0.016
Transportation & storage	0.083	0.085	0.279	0.135	-0.140	0.162	-0.021
Communication services	0.005	0.000	0.011	0.002	-0.006	0.013	0.010
Other utilities	0.005	0.002	0.027	-0.007	-0.101	0.040	-0.021
Wholesale margins	0.112	0.042	0.099	-0.088	-0.193	0.075	0.002
Other finance, ins., real estate	-0.052	-0.001	0.016	-0.008	-0.038	0.013	-0.025
Business services	-0.036	-0.068	0.022	-0.047	-0.020	0.057	0.016
Personal & other misc. services	-0.001	-0.005	0.010	-0.001	-0.021	-0.007	0.025
Transportation margins	0.060	-0.025	0.134	-0.005	-0.080	0.292	0.058

Figure 4 - Average annual percentage contributions of commodity groups to aggregate exports productivity growth, 1961 to 1992



Among the commodity groups that have shown a decreasing trend in their shares are paper and paper products, primary metal products, metallic ores & concentrates and grains.

Combining again the productivity indices of the various commodity groups with their value-added shares one can see, once more, that their contributions to aggregate productivity growth gives a quite different picture than when looking only at the productivity numbers. The contribution of transportation equipment is by far the most important one followed by the negative contribution of mineral fuels. On the other hand, the contribution of a commodity group with a fast growing productivity such as electrical and communication products ranks tenth. It has barely any impact on aggregate productivity growth originating from Canadian exports as its share is negligible.

5 - Conclusion

Simulating productivity gains is a more useful application of input-output models in market economies than traditional impact studies. Indeed, the input-output accounts are particularly well suited for the analysis of resource allocation in the economy as opposed to aggregate measures bearing on the level of employment or, more generally, on the level of utilization of resources. That latter issue is best dealt with using modern macro-econometric models, which may themselves, if fairly disaggregated, include an input-output module that allocate demand by sector and commodity to specific industries.

It may be argued at length, indeed, that productivity gains associated with given resource allocations are at the heart of long-run economic growth and welfare analysis. Technical progress is one of the main ingredients supporting economic growth and the only factor that has a lasting influence on the standard of living. One might even argue that welfare should be measured by the level of income that society may reach at a given cost in terms of leisure and savings, which amounts to a measure of productivity⁶.

Productivity gains are also at the root of any study of competitiveness. Competitive societies are societies that are able to face international competition in an open free trade world through increases in the productivity of both front line industries and supporting industries. Some authors (Markusen, 1992) even define a country's competitiveness by its ability to increase its productivity and the standard of living of its citizens while facing international competition.

It is therefore crucial to have analytical tools that allow for the close examination of productivity gains in the economy from various perspectives. The perspective chosen in this article is to identify the productivity gains that are associated with the production of commodities meeting the needs of various categories of final demand. This is an

6. This idea is not new and can be traced back at least as far as Ricardo. As reported by Blaug (1962 and 1968, p.118): "For Ricardo, 'value' is an inverse index of the average productivity of labour and therefore of economic welfare; welfare is a matter of minimizing human effort per unit of output".

extremely important perspective, not hitherto covered in the literature, in that technical progress results as much from the development of wants as from the development of new production processes. Indeed, demand plays an important role in the allocation of productive resources and, given the wide discrepancies in the relative productivity of the economy's production processes, in the overall productivity gains of the economy.

Looking at the demand side also opens new perspectives for the management of economic policies. Encouraging final demand users to buy goods and services originating from highly efficient industries is conducive to fast growth and improved welfare. This applies particularly to the export categories and to policies on how a country should specialize in international markets.

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