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1 Introduction

The measurement of total factor productivity (TFP)-growth constitutes a conceptual puzzle. It involves the use of wage and rental rates to construct an input aggregate. The growth rate of the latter is compared with the growth rate of output. When output grows faster than input, there is productivity growth, room for increases in factor rewards. Indeed, estimates of productivity growth are used to define the 'room' in collective wage bargaining. However, since the underlying TFP measure hinges on wage and rental rates, there is some circularity in the reasoning.

The puzzle is resolved for perfectly competitive economies. In such economies factor inputs are rewarded according to their marginal productivities. . TFP can be conceived as the sum of these marginal productivities taken over all factor inputs. The consequent growth rate agrees with the so called Solow residual measure of TFP-growth. Jorgenson and Griliches (1967) and Solow (1957) have shown the equivalence with the shift of the production possibility frontier. The trouble is, however, that observed economies are not perfectly competitive. They are not even on their production possibility frontiers. If we nonetheless stick to the conventional measures of TFP-growth, employing observed value shares for labor and capital, it is not clear what we get. The residual no longer isolates technical change effects, but also captures variations of the economy about the competitive benchmark, such as changes in market power, returns to scale or the business cycle. The approach of the literature is to correct the Solow residual for those effects, using information on the degrees that the economy departs from the competitive benchmark (Lerner index, returns-to-scale index or utilization rates) and modifying the formula for the residual (Hall, 1990).

Rather than trying to get a handle on the various departures from perfect competition or refining Solow residual expressions by means of inference, this paper attempts to measure factor productivities directly on the basis of the fundamentals of the economy, without recourse to market derivatives, such as factor shares, in the use of weights. The fundamentals are the usual ones: endowments, technology, and preferences. Endowments are represented by a labor force and stocks of capital. Technology is given by the combined inputs and outputs of the sectors of the economy. Preferences are reflected by the pattern of domestic final demand. All the information can be extracted from input and output tables in real terms, that is constant prices. The productivities are determined as follows. We maximize the level of domestic consumption subject to material balances and endowment constraints. Now, as is known from the theory of mathematical programming, the Lagrange multipliers associated with the endowment constraints measure the marginal productivities of labor and capital: the consumption increments per units of additional labor or capital. In economics, these Lagrange multipliers are shadow prices that would reign under idealized conditions of perfect competition. We declare these shadow prices to be the factor productivities. For instance, labor productivity is the shadow price of labor in the maximization of domestic final demand subject to endowment and technology constraints.

Services have long ago relegated manufacturing to second rank in the importance of total activity. It is often argued that services suffer from the Baumol disease. An ever larger part of resources are devoted to services, where productivity gains are limited. The whole economy thus drifts to a lower productivity performance. Can the slowdown in total factor productivity that we have experienced since the mid-seventies be ascribed to the increasing importance of services, or do we observe an improvement of productivity performance in the services by way of increased activity, learning-by-doing, specialization? We feel that such questions are best answered within a general equilibirum analysis of the whole economy.

The paper is organized as follows. Factor productivities and TFP are defined by means of a linear program in the next section. In section 3 we present the data of the Canadian economy from 1962 to 1991. In section 4 we present our results. The last section concludes.

2 Productivities

We push the economy to its frontier by maximization of the level of domestic final demand, which excludes trade by definition. Exports and imports are endogenous, controled by the balance of payments. We make no distinction between competitive and non-competitive imports. (The latter are indicated by zeros in the make table.)

Domestic final demand comprises consumption and investment. Investment is merely a means to advance consumption, albeit in the future. We include it in the objective function to account for future consumption. In fact, Weitzman (1976) shows that for competitive economies domestic final demand measures the present discounted value of future consumption.

Productivity growth will be defined as the measure of the shift of the frontier. Instead of comparing observations of the economy in subsequent periods (represented by the dots), we will compare the projections on the respective frontiers (the arrows).

We normalize the level of domestic final demand using base year prices, $e^{\top} forcommoditiesandw^{0}$ for non-business labor. The primal program reads

$$\begin{aligned} &\max_{s,c,g}(e^\top f + w^0 l)c \text{ subject to} \\ (V^\top - U)s &\geq fc + Jg =: F \\ c_j K_j s_j &\leq K_j \\ Ls + lc &\leq N \\ -\pi g &\leq -\pi g^t =: D \\ s &\geq 0. \end{aligned}$$

Here the variables and parameters are the following [with dimensions in brackets].

s	activity vector [# of sectors]
c	level of domestic final demand [scalar]
g	vector of net exports [# of tradeable commodities]
e	unit vector of all components one
$\top$	transposition symbol
f	domestic final demand [# of commodities]
w^0	base year price for non-business labor [scalar]
l	non-business labor employment [scalar]
V	make table [# of sectors by # of commodities]
U	use table [# of commodities by # of sectors]
J	0-1 matrix placing tradeables [# of commodities by # of tradeables]
F	final demand [# of commodities]
c_j	capacity utilization rate of sector j [scalar between 0 and 1]
K_j	capital stock of sector j [scalar]
N	labor force [scalar]
π	U.S. row price vector [# of tradeables]
g^t	vector of net exports observed at time t [# of tradeables]
D	observed trade deficit [scalar].

Productivities are not measured using market prices, but are determined by the dual program, which, as is well known, solves for the Lagrange multipliers of the primal program. These measure the marginal products of the objective value with respect to the constraining entities, unlike observed factor rewards with all their distortions. The dual program reads

$$\begin{aligned} &\min_{p,r,w,\varepsilon\geq 0} rK + wN + \varepsilon D \text{ subject to} \\ p(V^\top - U) &\leq r\hat{c}\hat{K} + wL \\ pf + wl &= \tilde{p}f + \tilde{w}l \\ pJ &= \varepsilon\pi \end{aligned}$$

The variables in the dual program are shadow prices: p of commodities, r of capital (# of sectors), w of labor and ε of foreign debt (the exchange rate). Since the commodity constraint in the primal program has a zero bound, p does not show in the objective function of the dual program. p is normalized by the second dual constraint, essentially about unity. It cannot transform nominal price vector $e^{\top}$ into a real one.In other words, it is no device to measure real output.

We now introduce the concept of productivity growth. Since labor productivity is the Lagrange multiplier or shadow price associated with the labor constraint, w, labor productivity growth is the growth of w, $\dot{w} = dw/dt$. Similarly, r is the vector of marginal productivities for each sectoral capital stock and ε the marginal productivity of the trade deficit.[1] Total factor productivity (TFP)-growth is obtained by summing all factor productivity growth figures over endowments, $\dot{r}K + \dot{w}N + \dot{\varepsilon}D$, and normalizing by the level of productivity, $rK + wN + \varepsilon D$. Formally,

Definition. TFP-growth := $(\dot{r}K + \dot{w}N + \dot{\varepsilon}D)/(rK + wN + \varepsilon D)$.

Remark. Replacement of (f, l) by $(\lambda f, \lambda l)$ with $\lambda > 0$ yields solution $(s, c/\lambda, g)$. The value of the objective function is not affected. By the main theorem of linear programming, $rK + wN + \varepsilon D$ is not either. In fact, the productivities are unaffected, as is, by extension, TFP-growth. The replacement does affect the commodity prices, as to preserve the identity between the national product and the national income, which we present next.

Measures. This straightforward definition of TFP-growth is now related to the commonly used Solow residual. By the main theorem of linear programming, substituting the price normalization equation,

$$pfc + wlc = rK + wN + \varepsilon D.$$

[1] In fact, there is also a non-business capital stock. Its value enters the objective function. In principle, its level constrains the expansion of domestic final demand. In practice, the capital constraint in the non-business sector is never binding at reasonable rates of capacity utilization, and hence its shadow price is zero. For notational simplicity, we have not included the non-business capital stock in the formulation of the program.

There are two consequences. First, by complementary slackness between w and the N-constraint, as well as between ε and the D-constraint using the price equation for tradeables,

$$pF - pJg + wlc = rK + wLs + wlc - pJg.$$

Adding the value of net exports and subtracting non-business labor income,

$$pF = rK + wLs,$$

the macro-economic identity of the national product and national income (excluding non-business labor income from either side). Changes in the units of measurement for the commodities, as involved with the replacement of real by nominal data, affect p and F, but not their product.

The second consequence obtains by total differentiation:

$$\text{TFP - growth} = [(pfc + wlc)^{\cdot} - r\dot{K} - w\dot{N} - \varepsilon\dot{D}]/(pfc + wlc).$$

To establish the link with the Solow residual, focus on the numerator,

$$(pF - pJg + wlc)^{\cdot} - r\dot{K} - w(Ls + lc)^{\cdot} + \varepsilon(\pi g)^{\cdot}.$$

We have assumed that the labor and balance of payment constraints are binding.[2] Differentiating products and rearranging terms,

$$\begin{aligned} & p\dot{F} - r\dot{K} - w(Ls)^{\cdot} \\ & - pJ\dot{g} + \varepsilon(\pi g)^{\cdot} \\ & + \dot{p}(F - Jg) + (wlc)^{\cdot} - w(lc)^{\cdot} \\ & = \\ & p\dot{F} - r\dot{K} - w(Ls)^{\cdot} \\ & + \varepsilon\dot{\pi}g \\ & + \dot{p}fc + \dot{w}lc \end{aligned}$$

[2] If the labor and balance of payment constraints are not binding, an additional term should enter the TFP-growth decomposition, containing the changes in the slacks of those constraints..

The first term is the *technical change effect*, measured by the numerator of the Solow residual evaluated at shadow prices. The second term, $\varepsilon\dot{\pi}g$, is the *terms of trade effect*. Proportional changes in π are offset by a change in ε. Only relative international price changes matter. The last two terms are the *demand effect* (Wolff, 1985). By the remark, $pf + wl$ may be held constant, so that the demand effect reads $-(p\dot{f} + w\dot{l})c$. If demand (f, l) shifts to commodities with low opportunity costs, it is relatively easy to satisfy domestic final demand and TFP gets a boost. The terms of trade and demand effects disappear when there is only one commodity and no non-business labor. Under these circumstances, π is unity and p also by the second dual constraint, hence their derivatives vanish. In other words, in a macro-economic setting TFP-growth reduces to the Solow residual. It should be mentioned, however, that a tiny difference remains in the denominators. We divide by $pfc + wlc = pF - pJg + wlc = pF - \varepsilon\pi g + wlc = pF + \varepsilon D + wlc$. In other words, we account for the deficit and non-business labor income.

Examples. In three examples we will highlight the technical change, terms of trade, and taste components of TFP-growth. The first two examples feature no trade, but ascribe all TFP-growth to either the Solow residual or the taste effect. The third example illustrates the terms of trade effect. The examples differ by end situation. The base situation is always an economy with labor inputs $L = \begin{pmatrix} \frac{4}{3} & \frac{2}{3} \end{pmatrix}$ and commodity outputs $V = I$. There is no trade, capital, intermediate inputs, or unemployed labor.

In the first example, labor employment remains the same, but output shifts from commodity 2 to commodity 1, so that V turns $\begin{pmatrix} 1+\varepsilon & 0 \\ 0 & 1-\varepsilon \end{pmatrix}$. The solution to the primal program was and is $2 * 1 = 2$. By the macro-economic identity w was and is 1. Hence TFP-growth is zero. There is technical change, however, for output has shifted towards the resource intensive commodity, stepping outside the initial production possibility frontier. The Solow residual is $p\dot{F} = \begin{pmatrix} \frac{4}{3} & \frac{2}{3} \end{pmatrix} \begin{pmatrix} +\varepsilon \\ -\varepsilon \end{pmatrix} = \frac{2}{3}\varepsilon$. The new demand is unfavorable. The demand effect is $\dot{p}fc$. The price vector turns $\begin{pmatrix} \frac{4/3}{1+\varepsilon} & \frac{2/3}{1-\varepsilon} \end{pmatrix}$ and has derivative $\begin{pmatrix} -\frac{4}{3}\varepsilon & \frac{2}{3}\varepsilon \end{pmatrix}$ (for ε small), so that the demand effect is $\begin{pmatrix} -\frac{4}{3}\varepsilon & \frac{2}{3}\varepsilon \end{pmatrix} \begin{pmatrix} 1 \\ 1 \end{pmatrix}$ (for ε small) or $-\frac{2}{3}\varepsilon$.

The second example is similar, but now V turns $\begin{pmatrix} 1-\varepsilon & 0 \\ 0 & 1+2\varepsilon \end{pmatrix}$. The solution to the primal program becomes $(1 - \varepsilon + 1 + 2\varepsilon) * 1 = 2 + \varepsilon$ and the wage rate becomes

$1 + \frac{\varepsilon}{2}$. The gain has to be multiplied by the number of worker, yielding TFP-growth of ε. It can be ascribed entirely to the taste effect, for the economy shifts along its frontier, foregoing ε of the doubly labor intensive commodity, nr. 1, for 2ε of commodity nr. 2.

In the third example, world prices $(1 \;\; 1)$ turn $(1+\varepsilon \;\; 1-\varepsilon)$, while L and V remain the same. The linear program expands the domestic consumption vector, $\begin{pmatrix} 1 \\ 1 \end{pmatrix}$, by letting the economy specialize in the resource extensive commodity, nr. 2. Output is the same before and after the international price change, but the terms of trade detiorate, reducing the level of consumption and, therefore, the real wage rate and TFP.

Remarks 1. The TFP measure used in Mohnen, ten Raa and Bourque (1997) is confined to the Solow residual without the terms of trade and taste effects. There is also a slight normalization difference. In this paper, we normalize with respect to $rK + wN + \varepsilon D = pfc + wlc$, whereas Mohnen, ten Raa and Bourque (1997) normalize with respect to $pF = pfc + pJg$.

2. Implicit to our model is the assumption of Leontief preferences over domestic final demand. Retail and banking services are components of the domestic final demand vector. In a way, one might argue that households favor reductions of these components. The smaller the margins, the more efficient the economy. This effect is captured by the demand effect component of TFP-growth. Factor productivity gains within these service sectors are captured by the Solow residual.

3. In discrete time, the differentials are approximated using the identity $x_t y_t - x_{t-1} y_{t-1} = \widehat{x_t}\overline{x_t y_t} + \widehat{y_t}\overline{x_t y_t}$, where $\widehat{x_t} = (x_t - x_{t-1})/\overline{x_t}$ and $\overline{x_t} = (x_t + x_{t-1})/2$, and similarly for $\widehat{y_t}$ and $\overline{y_t}$.

3 Data

We use the input-output tables of the Canadian economy from 1962 to 1991 at the medium level of disaggregation, which has 50 industries and 94 commodities.

The constant price input-output tables have been obtained from Statistics Canada in 1961 prices from 1962 to 1971, in 1971 prices from 1971 to 1981, in 1981 prices from 1981 to 1986, and in 1986 prices from 1986 to 1991. All tables have been converted to 1986 prices using the chain rule. For reasons of confidentiality, the tables contain missing cells, which we have filled using the following procedure. The vertical and horizontal sums in the make and use tables are compared with the reported line and column totals, which do contain the missing values. We select the rows and columns where the two figures differ by more than 5% from the reported totals, or where the difference exceeds $250 million. We then fill holes or adjust cells on a case by case basis filling in priority the intersections of the selected rows and columns, using the information on the input or output structure from other years, and making sure the new computed totals do not exceed the reported ones.

The net capital stock (constructed with a geometric depreciation rate), hours worked and labor earnings data are from the KLEMS dataset of Statistics Canada, and are described in Johnson (1994). In particular, corrections have been made to include in labor the earnings of the self-employed, and to separate business and non-business labor and capital. The total labor force figures are taken from Cansim (D767870) and converted in hours using the number of weekly hours worked in manufacturing (where it is the highest). Out of the 50 industries, no labor nor capital stock data exist for sectors 39, 40, 48, 49, 50, and no capital stock data for industry 46.

The sectoral capacity utilization rates have been provided by the National Wealth and Capital Stock Division of Statistics Canada. They have been constructed using the Hodrick-Preston filter. For agriculture and fishing, we use the utilization rate for food. For all the service sectors, except construction, pipeline transportation, and power and gas distribution, we use the rate for total non-farm goods (excluding energy) producing industries, the most encompassing capacity utilization rate available.

The international commodity prices are approximated by the U.S. prices, given that 70% of Canada's trade is with the United States. We have used the U.S. producer prices from the U.S. Bureau of Labor Statistics, Office of Employment Projection. The 169 commodity classification has been bridged to Statistics Canada's 94 commodity classification. To convert U.S. prices to Canadian equivalents, we have used, whenever available, unit value ratios, (UVRs, which are industry specific) computed and kindly provided to us by Gjalt de Jong (1996). The UVRs are computed using Canadian quantities valued at U.S. prices. For the other commodities, we have used the purchasing power parities computed by the OECD (which are based on final demand categories). The UVRs establish international price linkages for 1987, the PPPs for 1990 in terms of Canadian dollars per U.S. dollar. We hence need two more transformations. First, U.S. dollars are converted to Canadian dollars using the exchange rates taken from Cansim (series 0926/B3400).

Second, since the input-output data are in 1986 prices, we need the linkage for 1986, which is computed by using the respective countries' commodity deflators: the producer price index for the U.S. (see above) and the total commodity deflator from the make table (except for commodities 27, 93 and 94, for which we use the import deflator from the final demand table) for Canada.

Are considered as non-tradeable, commodities 13, 44, 70, 71, 72, 79, 81, 82, 88, 91 and 92, for which no trade shows up in the input-output tables for most of the sample period.

For computational reasons and similar output composition, we have aggregated the non-tradeable commodities 70-72 (residential, non-residential and repair construction). Due to the absence of labor,capital stock and intermediate inputs for industry 39 (government royalties on natural resources), it has been aggregated with industry 5 (crude petroleum and natural gas). In the end, we are thus left with 49 industries and 92 commodities, which are listed in tables 1 and 2. A more detailed documentation of the data and their construction is available from the authors upon request.

4 Results

Perhaps it is most illuminating to discuss the temporally aggregated results first. In table 3 we have productivity growth figures obtained using endogenous weights, i.e. evaluated at the shadow prices and optimal activity levels of the linear program. Table 3 shows a 0.90% annual TFP growth rate over the 1960-75 period.[3] Over the next business cycle (1976-82), TFP growth fell to -4.43%. It recovered to -0.17% per year in the 1980's (1982-91). The demand effect is positive in all three periods. As a matter of fact it explains a large part of TFP-growth. Consumers have consistently changed their patterns of demands to commodity bundles with lower factor contents. The technical change effect plays a minor role: the Solow residual drops below zero after 1975, but recovered in the 80s. The terms of trade effect shows a similar pattern.

Labor productivity reflects the pattern of TFP-growth, declining troughout the period, but nevertheless quite substantial. The productivity of capital declined sharply in

[3]According to Bergeron, Fauvel and Paquet (1995), Canada hit a recession from January 1975 to March 1975, from May 1980 to June 1980, from August 1981 to November 1982, and from April 1990 to March 1991. We therefore chose the slump years 1975, 1982 and 1991 to compare productivity performances over a business cycle. These years also displayed low rates of capacity utilization for non-farm goods producing industries.

the second period and recovered in the 80s but not to the level of the 60s. The productivity of the trade deficit, i.e. the increased consumption permitted by a marginal increase in the allowed deficit, declined in the 60s and in the 80s, but rose in the 70s. With exogenous weights, the shape of the marginal productivity evolutions again differs. The trade deficit has exactly the opposite shape, capital productivity is always declining and labor productivity was higher in the 70s than in the two adjacent periods.

The two culprits of low aggregate TFP-growth performance are the construction and business and personal services. The dramatic downturn in the 1970s is mostly explained by construction. It produces a non-tradeable commodity which acts as a bottleneck in the determination of the production possibility frontier. Hence the shadow price of the capital stock in construction is high, and therefore this sector carries a lot of weight. The analysis suggests that if construction was opened for U.S. activity, the production possibility frontier would be pushed out and, therefore, TFP levels would be increased. The construction sector also explains why the Solow residual evaluated at shadow prices and optimal activity levels remains low in the 1980s. Business and personal services might suffer from the Baumol disease, although it should be noticed, by looking at table 4, that their bad performance in the second period is due to one particular annual growth rate (1977-78).

Transportation, communication and trade have consistently outperformed manufacturing in terms of the Solow residual. FIRE is becoming the success story of the 90s. Its Solow residual is second only to agriculture, which recovers from a disastrous performance in the late 70s. Thus not all service sectors have low TFP growth rates.

Tables 4 and 5 list the annual growth figures giving a more precise timing of the productivity growth up- and downturns. The overall picture is the same. Agriculture suffered in the 70s and early 80s. The performance of construction was deplorable. Manufacturing and B&P services had low Solow residuals. Transportation, and trade have been driving forces, although the productivity in communication is slipping. FIRE and trade are recent success stories.

5 Conclusion

TFP growth rate over the 1960-75 period amounts to 0.90% per annum. Over the next business cycle (1976-82), TFP growth fell to -4.43%. It recovered to -0.17% per year in the 1980's (1982-91). The two culprits of low aggregate TFP-growth are the construction and business and personal services. The dramatic downturn in the 1970s is mostly explained by construction. Business and personal services might suffer from the Baumol disease. Transportation, communication and trade have consistently outperformed manufacturing in terms of the Solow residual. FIRE is becoming the success story of the 90s. Its Solow residual is second only to agriculture, which recovers from a disastrous performance in the late 70s.

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Table 1: List of commodities

1.	Grains
2.	Live animals
3.	Other agricultural products
4.	Forestry Products
5.	Fish landings
6.	Hunting & trapping products
7.	Iron ores & concentrates
8.	Other metal. ores & concentrates
9.	Coal
10.	Crude mineral oils
11.	Natural gas
12.	Non-metallic minerals
13.	Services incidental to mining
14.	Meat products
15.	Dairy products
16.	Fish products
17.	Fruits & vegetables preparations
18.	Feeds
19.	Flour, wheat, meal & other cereals
20.	Breakfast cereal & bakery prod.
21.	Sugar
22.	Misc. Food products
23.	Soft drinks
24.	Alcoholic beverages
25.	Tobacco processed unmanufactured
26.	Cigarettes & tobacco mfg.
27.	Tires & tubes
28.	Other rubber products
29.	Plastic fabricated products
30.	Leather & leather products
31.	Yarns & man made fibres
32.	Fabrics
33.	Other textile products

Table 1: List of commodities (cont'd)

34.	Hosiery & knitted wear
35.	Clothing & accessories
36.	Lumber & timber
37.	Veneer & plywood
38.	Other wood fabricated materials
39.	Furniture & fixtures
40.	Pulp
41.	Newsprint & other paper stock
42.	Paper products
43.	Printing & publishing
44.	Advertising, print media
45.	Iron & steel products
46.	Aluminum products
47.	Copper & copper alloy products
48.	Nickel products
49.	Other non ferrous metal products
50.	Boilers, tanks & plates
51.	Fabricated structural metal products
52.	Other metal fabricated products
53.	Agricultural machinery
54.	Other industrial machinery
55.	Motor vehicles
56.	Motor vehicle parts
57.	Other transport equipment
58.	Appliances & receivers, household
59.	Other electrical products
60.	Cement & concrete products
61.	Other non-metallic mineral products
62.	Gasoline & fuel oil
63.	Other petroleum & coal products
64.	Industrial chemicals
65.	Fertilizers
66.	Pharmaceuticals
67.	Other chemical products

Table 1: List of commodities (cont'd)

68.	Scientific equipment
69.	Other manufactured products
70.	Construction
71.	Pipeline transportation
72.	Transportation & storage
73.	Radio & television broadcasting
74.	Telephone & telegraph
75.	Postal services
76.	Electric power
77.	Other utilities
78.	Wholesale margins
79.	Retail margins
80.	Imputed rent owner ocpd. dwel.
81.	Other finance, ins., real estate
82.	Business services
83.	Education services
84.	Health services
85.	Amusement & recreation services
86.	Accommodation & food services
87.	Other personal & misc. services
88.	Transportation margins
89.	Supplies for office, lab. & cafeteria
90.	Travel, advertising & promotion
91.	Non-competing imports
92.	Unallocated imports & exports

The nine bold indexes indicate the non-tradeable commodities. The commodities correspond to the M-classification of the Canadian input-output tables, except for the aggregation of the original commodities 70-72.

Table 2: List of industries

1. Agricultural & related services ind.
2. Fishing & trapping industries
3. Logging & forestry industries
4. Mining industries
5. Crude petroleum, natural gas, governt's royalties on natural resources
6. Quarry & sand pit industries
7. Service related to mineral extract.
8. Food industries
9. Beverage industries
10. Tobacco products industries
11. Rubber products industries
12. Plastic products industries
13. Leather & allied products ind.
14. Primary textile & textile prod. ind.
15. Clothing industries
16. Wood industries
17. Furniture & fixture industries
18. Paper & allied products industries
19. Printing, publishing & allied ind.
20. Primary metal industries
21. Fabricated metal product industries
22. Machinery industries
23. Transportation equipment industries
24. Electrical & electronic products
25. Non-metallic mineral products ind.
26. Refined petroleum & coal products
27. Chemical & chemical products ind.
28. Other manufacturing industries
29. Construction industries
30. Transportation industries
31. Pipeline transport industries
32. Storage & warehousing industries
33. Communication industries

Table 2: List of Industries (cont'd)

34.	Other utility industries
35.	Wholesale trade industries
36.	Retail trade industries
37.	Finance & real estate industries
38.	Insurance
39.	Owner occupied dwellings
40.	Business service industries
41.	Educational service industries
42.	Health service industry
43.	Accommodation & food service ind.
44.	Amusement & recreational services
45.	Personal & household service ind.
46.	Other service industries
47.	Operating, off., cafet. & lab. Sup.
48.	Travel, advertising & promotion
49.	Transportation margins

The industries correspond to the M-classification of the Canadian input-output tables, except for the aggregation of the original industries 5 and 39. The industries are defined according to the 1980 Standard Industrial Classification.

Table 3: Average annual growth rates and TFP decomposition (in percentages)

	At shadow prices and optimal activity levels		
	1962-75	1976-82	1983-91
Solow residual			
Agriculture	-0.38	-10.55	5.57
Manufacturing	0.58	0.28	0.26
Construction	-0.84	-6.08	-1.61
Transportation	2.92	0.67	0.91
Communication	3.87	0.76	0.41
Trade	2.22	0.44	1.04
FIRE	-0.47	0.26	1.59
B&P services	-0.26	-42.08	-0.31
TFP decomposition			
Solow residual	0.82	-5.73	-0.80
Terms of Trade	0.13	-0.27	-0.01
Demand effect	-0.05	1.57	0.64
TFP-growth	0.90	-4.43	-0.17
Marginal productivity growth rates			
Labor	-0.22	9.36	-1.26
Capital	1.44	-6.99	0.04
Trade deficit	-6.05	-2.93	-3.94

Table 4: Solow residual at shadow prices and optimal activity levels (in percentages)

Period	Agriculture (1-7)	Manufacturing (8-28)	Construction (29)	Transportation (30-32)	Communication (33-34)	Trade (35-36)	FIRE (37-39)	B&P services* (40-49)
62-63	0.80	0.77	4.26	6.90	7.86	1.86	-0.74	0.72
63-64	-5.11	0.63	-3.10	5.00	10.64	2.96	-0.92	-4.22
64-65	3.87	-0.09	-9.52	2.93	3.35	2.07	-0.69	-4.15
65-66	-3.50	-0.24	2.87	4.07	2.88	3.43	0.43	0.62
66-67	0.82	0.36	0.78	0.99	4.93	2.10	-0.18	0.36
67-68	0.58	2.01	1.42	3.11	3.40	1.43	2.51	-0.33
68-69	2.89	1.09	5.65	5.90	0.47	1.89	-0.75	0.09
69-70	0.87	-0.44	0.19	7.33	3.05	3.01	4.09	0.03
70-71	-0.71	1.53	-0.43	0.89	4.20	0.82	-3.46	0.98
71-72	2.33	1.77	-0.99	0.35	5.91	-1.39	-5.05	0.55
72-73	0.28	0.55	-7.81	-0.02	-3.67	0.37	-0.93	1.15
73-74	-2.91	0.02	3.43	0.91	2.48	0.32	-2.65	1.10
74-75	-5.16	-0.43	-7.64	-0.43	4.74	9.92	2.30	-0.32
75-76	-9.54	1.38	-14.68	-1.79	3.56	1.62	1.33	1.16
76-77	-7.42	1.40	-3.81	4.13	1.59	0.24	1.86	0.87
77-78	-0.77	1.11	4.24	1.41	-3.04	2.64	1.50	-327.79
78-79	-2.64	-0.48	-5.96	5.17	-0.20	-2.54	1.06	30.37
79-80	-4.05	-2.67	-9.91	-3.57	2.71	1.38	-0.66	0.20
80-81	-49.23	1.39	-4.93	-2.29	1.06	-0.13	0.20	0.24
81-82	-0.23	-0.13	-7.54	1.66	-0.35	-0.10	-3.45	0.40
82-83	8.98	0.76	-2.67	-3.73	2.72	4.68	1.68	-1.78
83-84	18.59	3.23	5.48	6.33	3.53	2.64	0.53	2.82
84-85	5.61	0.24	-3.12	0.82	-0.81	-0.96	0.53	-2.83
85-86	6.67	-0.63	-5.23	5.84	-0.40	1.16	2.35	3.14
86-87	4.14	-0.39	-0.24	-0.11	4.01	1.42	-4.78	-3.11
87-88	2.92	0.49	-4.67	0.68	-0.56	1.71	-0.22	0.98
88-89	0.06	-0.54	-3.68	-8.20	-0.93	-0.11	3.02	1.10
89-90	-0.60	-0.70	-1.79	1.28	-3.06	0.05	5.19	-1.32
90-91	3.79	-0.08	1.43	5.29	-0.81	-1.21	6.03	-1.79

* In parentheses, industry aggregations from table 2. FIRE = finance, insurance and real estate. B&P services: business and personal services.

Table 5: Shadow prices of capital (in $/1986 $100), shadow wage rates (in $/hour)

Period	Agriculture (1-7)	Manufacturing (8-28)	Construction (29)	Transportation (30-32)	Communication (33-34)	Trade (35-36)	FIRE (37-39)	B&P services* (40-49)	Wage rate
1962	16.21	45.66	9167.33	1.65	52.13	23.97	17.74	17.43	4.33
1963	16.12	51.62	9980.50	2.15	2.08	26.59	57.76	19.64	5.13
1964	45.25	31.60	7725.38	1.58	1.98	13.88	28.77	603.08	3.71
1965	12.50	38.62	9601.74	1.39	1.49	24.63	28.58	15.42	4.19
1966	15.17	47.82	8572.69	8.06	3.16	35.04	47.66	20.52	5.22
1967	41.78	120.82	222.35	46.09	21.60	87.85	183.96	59.46	11.60
1968	8.29	35.13	11140.33	0.59	0.81	27.97	18.23	17.21	3.95
1969	53.46	137.85	0.00	59.09	22.24	102.69	194.02	65.52	11.99
1970	62.67	106.56	0.00	65.19	143.02	107.80	118.81	72.11	10.35
1971	66.72	118.45	0.00	71.34	165.39	113.12	102.67	88.51	9.87
1972	73.26	119.01	0.00	71.26	182.45	104.00	80.44	91.29	9.48
1973	226.11	105.18	0.00	54.73	110.16	102.06	82.27	76.11	8.86
1974	24.95	29.26	0.00	13.36	39.64	4008.11	9.33	150.50	1.72
1975	25.00	41.32	12447.82	1.43	2.99	43.63	1.45	30.17	3.38
1976	20.33	40.00	10570.41	1.05	3.54	41.57	2.14	31.02	3.59
1977	7.75	20.46	5660.43	0.75	1.54	17.98	0.99	15.23	1.85
1978	0.54	1.02	0.00	0.50	2.24	5265.46	0.00	23.76	0.00
1979	23.08	16.53	0.00	9.32	9.85	3979.57	12.42	621.34	1.87
1980	221.11	112.89	0.00	48.40	88.80	82.86	40.66	68.76	9.08
1981	11.59	36.92	8920.50	2.89	11.03	33.52	0.83	25.01	3.99
1982	10.07	27.70	8406.57	3.28	5.37	31.56	1.21	26.26	4.47
1983	12.20	27.16	8365.62	3.16	6.25	29.47	1.35	24.07	4.82
1984	55.93	18.37	0.00	12.58	23.64	3591.06	12.06	360.44	4.62
1985	12.52	31.52	8794.35	3.32	17.03	30.23	2.04	25.94	5.17
1986	8.66	23.13	9057.71	2.85	5.37	15.73	2.24	21.01	4.96
1987	9.75	22.29	8829.48	2.39	5.25	21.33	2.36	20.40	4.62
1988	9.91	20.55	8390.71	1.57	4.54	23.28	2.19	20.13	4.65
1989	7.78	16.19	8288.28	0.00	2.92	18.74	1.64	18.07	4.24
1990	8.97	16.23	7940.02	0.61	3.37	20.69	1.80	22.07	4.59
1991	18.36	15.96	8596.43	0.41	7.59	21.58	2.10	29.99	3.99

* In parentheses, industry aggregations from table 2. FIRE denotes finance, insurance and real estate. B&P services: denotes business and personal services.