Essays in Canadian Productivity and International Trade

by

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Abstract

This thesis is a collection of three empirical papers that made use of recent Canadian trade and production data.

The first chapter "Productivity Performance of Canada" examines Canada's productivity and changes in terms of trade 1961-2007. These changes have been mostly favourable and have had the same effect on real income growth as Total Factor Productivity improvements of the business sector of the economy. The framework applied is developed by Diewert, Kohli and Morrison and is based on production theory. We utilised published and unpublished data from the Statistics Canada Multifactor Productivity program, which develops "bottom up" estimates of business sector productivity from industry estimates. However, we use in this chapter a "top down" approach which utilises (adjusted) final demand data to form a business sector output aggregate and thus leads to much higher estimates of TFP growth for Canada than the corresponding Statistics Canada estimates. Finally, the new export and import time series are used to determine the contributions to real income growth of changes in these disaggregated export and import prices over the 47 year period.

The second chapter "Business Sector Data on Outputs and Inputs for Canada 1961-2007" details the business sector data used in the first chapter and explains the construction of estimates of Canadian final demand expenditures, business sector labour input, business sector capital stock, primary input tax rates, balancing real rates of return and user costs. We also make some recommendations for possible improvements that Statistics Canada could make to its productivity program.

The third chapter "Does Lobbying Affect Antidumping Case Determinations in Canada?" examines whether the mandate of antidumping legislation in Canada was independent of influences other than those allowed. The relation between antidumping case determinations and various determinants is examined, in particular, whether lobbying activities can influence case determinations. Unlike previous studies that constructed political variable with data that have limited information on policy influence targets, this chapter constructs the variable using the Canadian Lobbyists Registration data with detailed information on lobbyists who had indicated they lobbied for administered protection. The current empirical evidence suggests that the antidumping mandate is not apolitical.

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Dedication

To my parents and my family, I dedicate this thesis.

Chapter 1

Productivity Performance of Canada

1.1 Introduction

Gains in productivity are an important factor in leading higher living standards. However, the calculation of productivity is not a straightforward matter. Statistics Canada calculates business sector Multifactor Productivity (MFP) growth or Total Factor Productivity (TFP) growth using a "bottom up" approach; i.e., separate TFP growth estimates are made for each major industrial sector in the Canadian business sector and then these sector estimates are aggregated to provide an estimate of total business sector TFP growth. But aggregate TFP growth can also be calculated using a "top down" approach; i.e., instead of aggregating over business sector industry outputs and intermediate inputs, it is possible to use estimates of deliveries to final demand as the measure of aggregate output growth and this aggregate output information can be combined with information on aggregate primary input usage to give an alternative approach to the measurement of aggregate TFP growth. In this chapter, using the "top down" approach and using new data from Statistics Canada, we show that the productivity performance of the Canadian business sector appears to be much better than the lacklustre official Statistics Canada estimates of TFP growth, which are based on the "bottom up" approach.[1] This indicates the "productivity gap" between the official estimates by Statistics Canada and

[1] However, we will show later that the main source of difference between the two methods for computing TFP growth appears to be in the aggregation of capital services rather than in differences in the aggregation of outputs.

the U.S. may not be as wide as we have come to believe.

Diewert (2006b) (2007c) had shown that if effects of indirect tax can be ignored and that data from the input output tables are consistent then the "top down" approach used in this chapter and the "bottom up" approach used by Statistics Canada should give similar measures of productivity. The "top down" approach can provide a comparison to the official estimates. Furthermore, it also allows us to estimate individual contribution of export and import commodity classes which is not possible using the "bottom up" approach. Thus, the "top down" approach makes it possible to carry out the calculation of terms of trade contribution to real income growth.

In addition to developing new estimates of TFP growth for the Canadian business sector for the years 1962-2007, this chapter will provide new estimates for the growth in real income generated by the Canadian business sector and provide estimates of how various growth factors contributed to this overall real income growth. There are three main factors which explain the growth in real income:

- TFP growth;
- Growth in primary inputs used by the business sector and
- Changes in real output prices.

Included in the last explanatory factor are changes in real export and real import prices. We have developed some new time series for disaggregated components of Canadian exports and imports so that the gains in real income generated by increasing real export prices or decreasing real import prices can be traced back to particular classes of exports and imports. Note that this type of analysis cannot be done using the "bottom up" approach to TFP measurement because the industry input output tables do not have an accurate breakdown of industrial outputs into exports and deliveries to domestic demanders or a breakdown of intermediate inputs into imports and domestically produced intermediates.

When economists measure TFP growth, the output concept is almost always the gross product produced by the sector or economy and a traditional Jorgenson and Griliches (1967) user cost of capital is used to measure the contribution of capital inputs. The traditional user cost of capital has three main components:

- A nominal interest rate component;
- A depreciation component and
- A (negative) price appreciation term.

Sometimes the first and third components listed above are combined into a single real interest rate component. The important points to note are that (i) depreciation appears in the user cost of capital and (ii) a gross output concept is used in the traditional approach to the measurement of TFP growth. However, depreciation is not a source of income; households cannot consume depreciation. Depreciation should be treated as a charge against income instead of a component of income. Thus instead of using a gross output approach to the measurement of output and a user cost of capital that includes depreciation, when attempting to measure the income generated by the private production sector, the depreciation component in the user cost should be removed and treated as an (intertemporal) intermediate input, leading to a net output approach to the measurement of output and a waiting services approach to the user cost of capital. We will implement both the traditional approach to TFP measurement as well as the net output approach and compare the two approaches using Canadian business sector data over the period 1961-2007.

As noted above, it is not easy to measure the exact magnitude of productivity gains or of terms of trade. Diewert (1983), Diewert and Morrison (1986), Diewert, Mizobuchi and Nomura (2005), Diewert and Lawrence (2006), Morrison and Diewert (1990) and Kohli (1990, 1991, 2003, 2004a, 2004b, 2006, 2008) have developed methodologies based on production theory that allow the contribution of each type of gain be represented by an index number estimate. In Section 1.8, we outline the Diewert, Mizobuchi and Nomura (2005) and Diewert and Lawrence (2006) methodology and show how it can be used to measure the determinants of growth of an economy's gross and net real income.

In Sections 1.2-1.4, we apply this same methodology to the business sector of the Canadian economy over the years 1962-2007. The details of how the Canadian business sector data was developed from Statistics Canada sources are described in Chapter 2 "Business Sector Data on Outputs and Inputs for Canada 1961-2007". Section 1.2 aggregates up the data from Chapter 2 and develops conventional measures of Canadian business sector Total Factor Productivity (TFP) for the years 1961-2007. However, productivity growth, while perhaps the most important source of growth in living standards, is not the entire story. If a country's export prices increase more rapidly than its import prices, then it is well known that this has an effect that is similar to a productivity improvement.[2] Thus in Section 1.3, we measure the relative contributions of productivity improvements, changes in real export and import prices and growth of labour and capital inputs to the growth of (gross) real income generated by the business sector in Canada using the methodology explained in Subsections 1.8.2-1.8.5. This is still not the end of the story; GDP is an imperfect measure of productive potential, not welfare.[3] For welfare measurement purposes, it is generally conceded that Net Domestic Product (NDP) is a better measure of output, since investment that just equals depreciation means that society is not made any better off from the viewpoint of sustainable final consumption possibilities. Hence in Section 1.4, we subtract depreciation off from gross investment and use consumption plus sales to the non-business sector plus *net investment* plus the trade balance as our business sector output concept. Thus depreciation will be treated as an intermediate input in this production model.

[2] See for example Diewert and Morrison (1986).

[3] For a more extensive discussion of the merits of GDP versus net income, see Diewert (2006a).

Subsection 1.8.6 explains this real net output approach and adapts a translog model of production based on the work of Diewert and Morrison (1986) and Kohli (1990) to this new model of market sector real net income generation.[4] This approach is implemented for the Canadian business sector in Section 1.4. The main determinants of growth in real net income generated by the business or market sector of the economy are:

- Technical progress or improvements in Total Factor Productivity;
- Growth in domestic output prices or the prices of internationally traded goods and services relative to the price of consumption and
- Growth in primary inputs.

It turns out that productivity growth becomes a more important factor for explaining real *net* income growth compared to explaining real *gross* income growth. Also the importance of capital deepening is greatly reduced in the net output framework compared to the gross output framework. Somewhat surprisingly, for the years 2000-2007, improvements in the terms of trade made almost the same contribution to real income growth as capital deepening in the gross output framework and in the net output framework, the effects of falling real import prices contributed substantially more to real income growth than capital deepening over the period 2000-2007. Section 1.5 discusses how our estimates compare to the productivity estimates of other countries. We compare our Canadian real income growth estimates using the "top down" approach with the estimations that were done for Australia and Japan. It can be seen that the overall average income growth of the three countries are similar, but the productivity performances are very different. Canada had benefited from terms of trade improvement and thus even without a stellar productivity performance, the real income growth was as much as the two other countries that have relatively higher productivity growths. Then in Section 1.6, we look at changes in real export and import

[4] For previous implementations of this model of real net income to Japan and Australia, see Diewert, Mizobuchi and Nomura (2005) and Diewert and Lawrence (2006).

prices by commodity class and their effects on real income growth in both the gross output and the net output frameworks. These new results are somewhat surprising. Finally Section 1.7 concludes.[5]

1.2 Output and Input Aggregates and Conventional Productivity Growth in Canada

In Chapter 2, we constructed price and quantity series for 23 net outputs and 9 primary inputs for the business sector of the Canadian economy for the years 1961-2007. The 23 net outputs are,

- Q_1, Domestic consumption (excluding market residential rents and the services of owner occupied housing);
- Q_2, Real sales of goods and services by the business sector to the non-market sector less real sales of goods and services from the non-market sector to the business sector;
- Q_3, Government investment;
- Q_4, Business sector investment in residential structures;
- Q_5, Business sector investment in information and communication technology (ICT) machinery and equipment;
- Q_6, Business sector investment in non-ICT machinery and equipment;
- Q_7, Business sector investment in non-residential structures;
- Q_8, Inventory change;
- Q_9, Exports of agricultural and fish products;
- Q_{10}, Exports of energy products;

[5]The final part of Section 1.8 has some new material on how the real net output model used in the present paper can be extended from a single production sector to the case of many industries.

- Q_{11}, Exports of forest products;
- Q_{12}, Exports of industrial goods and materials (excluding energy and forest product exports);
- Q_{13}, Exports of machinery and equipment (excluding automotive products);
- Q_{14}, Exports of automotive products;
- Q_{15}, Exports of other consumer goods (excluding automotive products);
- Q_{16}, Exports of services;
- Q_{17}, Imports of agricultural and fish products;
- Q_{18}, Imports of energy products;
- Q_{19}, Imports of industrial goods and materials (including imports of forest products but excluding imports of energy products);
- Q_{20}, Imports of machinery and equipment (excluding automotive products);
- Q_{21}, Imports of automotive products;
- Q_{22}, Imports of other consumer goods and
- Q_{23}, Import of services.

The nine primary inputs into the business sector are,

- Q_{24}, The labour services of workers with primary or secondary education;
- Q_{25}, The labour services of workers with some or completed secondary certificate or diploma;

- Q_{26}, The labour services of workers with a university degree or above;[6]
- Q_{27}, The stock of ICT machinery and equipment available to the business sector at the start of each year;
- Q_{28}, The stock of non-ICT machinery and equipment available to the business sector at the start of each year;
- Q_{29}, The starting stock of business sector non-residential structures;
- Q_{30},The starting stocks of inventories used by the business sector;
- Q_{31}, The stock of agricultural land use by the business sector and
- Q_{32}, The stock of non-agricultural, non-residential land used by the business sector.

As explained in Chapter 2, user cost prices for the last six primary inputs were constructed using balancing or endogenous real rates of return that made the value of net output produced by the business sector equal to the value of primary inputs used by the business sector. Details of the construction are given in Chapter 2 where the price and quantity series constructed from the 23 net outputs and 9 primary inputs are also shown.

In this section, we will aggregate the above net outputs and primary inputs into D, domestic output, equal to an aggregate of the first eight net outputs; X, exports equal to an aggregate of the eight types of exports of goods and services; M, imports equal to an aggregate of the seven types of imports of goods and services; L, labour services equal to an aggregate of the three types of labour services; K, capital services equal to an aggregate of the six types of capital services. Once these aggregates have been constructed, we further aggregate the three net outputs $D + X - M$ into real gross domestic product Y and aggregate the two inputs K and L into domestic input Z and finally construct a conventional measure of productivity Y/Z.

[6] These three types of labour services input data are taken directly from Statistics Canada KLEMS program; see Baldwin, Gu and Yan (2007) for description.

The aggregations were done using chained Törnqvist price indexes,[7] and the resulting prices and quantities are shown in Tables 1.1 and 1.2.

Table 1.1: Prices of Canadian Business Sector Output and Input Aggregates

Year	P_C^t	P_D^t	P_X^t	P_M^t	P_L^t	P_K^t	P_Y^t	P_Z^t
1961	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
1962	1.00538	1.00538	1.02992	1.05787	1.03625	1.01691	0.99683	1.03034
1963	1.02055	1.02264	1.04054	1.09648	1.06604	1.15494	1.00691	1.09305
1964	1.02437	1.02959	1.05692	1.10526	1.11049	1.23317	1.01577	1.14776
1965	1.03690	1.05092	1.07980	1.10214	1.18272	1.25857	1.04400	1.20580
1966	1.07553	1.08861	1.12451	1.11930	1.25929	1.34193	1.08930	1.28444
1967	1.11050	1.12289	1.15421	1.14426	1.33342	1.23578	1.12505	1.30269
1968	1.15168	1.15976	1.20119	1.16726	1.41620	1.30595	1.16924	1.38147
1969	1.18980	1.19995	1.23088	1.19648	1.52197	1.34691	1.20982	1.46616
1970	1.22208	1.23858	1.26710	1.21965	1.61278	1.40223	1.25289	1.54532
1971	1.24828	1.28233	1.28552	1.24798	1.72528	1.39719	1.29339	1.61828
1972	1.29847	1.34008	1.33325	1.27498	1.86392	1.49709	1.35869	1.74411
1973	1.38744	1.44587	1.51489	1.35954	2.03837	2.06511	1.49788	2.05198
1974	1.58382	1.65206	1.91283	1.64641	2.35044	2.47332	1.73334	2.39718
1975	1.82198	1.87090	2.16694	1.89029	2.70332	2.21008	1.95274	2.53719
1976	1.90726	1.97372	2.29702	1.92853	3.10646	2.39955	2.09001	2.86510
1977	2.03175	2.09967	2.50231	2.17241	3.38889	2.74058	2.19373	3.17107
1978	2.19264	2.26119	2.73837	2.41667	3.53495	3.09969	2.34654	3.39783
1979	2.40645	2.48060	3.20786	2.73027	3.78520	3.80986	2.60728	3.82051
1980	2.69497	2.75772	3.73464	2.97957	4.11781	3.97428	2.97313	4.09308
1981	2.95335	3.03059	3.99821	3.26618	4.59295	4.05499	3.23724	4.42379
1982	3.22860	3.28484	4.08926	3.43918	5.02021	3.61928	3.46983	4.51822

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[7] More specifically, the chained Divisia option in Shazam was used to do the aggregations.

Table 1.1 – Continued

Year	P_C^t	P_D^t	P_X^t	P_M^t	P_L^t	P_K^t	P_Y^t	P_Z^t
1983	3.46323	3.46344	4.15051	3.42324	5.22085	4.44415	3.68247	4.97537
1984	3.61506	3.60128	4.29656	3.58225	5.48101	4.94318	3.81283	5.33580
1985	3.72257	3.71138	4.38071	3.67711	5.75670	5.17976	3.91833	5.59935
1986	3.80422	3.80294	4.37060	3.74437	5.90250	5.08340	3.98140	5.65108
1987	3.89726	3.90844	4.45792	3.69150	6.11054	5.74526	4.14995	6.03889
1988	4.00205	4.01307	4.47080	3.60108	6.51242	5.76285	4.30933	6.29679
1989	4.11690	4.12618	4.56005	3.59364	6.78864	5.58998	4.47092	6.40227
1990	4.35206	4.28654	4.52868	3.64367	7.04667	5.31935	4.60964	6.45499
1991	4.59099	4.42296	4.37107	3.57992	7.34245	4.50786	4.72731	6.30363
1992	4.65258	4.47108	4.49573	3.72567	7.48023	4.98747	4.75269	6.58795
1993	4.74252	4.55596	4.69389	3.92460	7.45961	5.15125	4.82121	6.64462
1994	4.77089	4.62372	4.97322	4.16089	7.41314	6.03823	4.89058	6.98418
1995	4.79147	4.65787	5.29132	4.27688	7.53622	6.56286	5.02353	7.27300
1996	4.88952	4.71581	5.32097	4.22185	7.63205	6.99768	5.13502	7.50733
1997	4.96547	4.77523	5.32718	4.23677	7.91076	7.00934	5.19090	7.68381
1998	5.03224	4.84195	5.31558	4.37960	8.13918	6.93415	5.15347	7.79482
1999	5.12045	4.91274	5.37870	4.36044	8.33890	7.36196	5.27960	8.08916
2000	5.25425	5.02564	5.71039	4.44227	8.74780	8.33839	5.54730	8.73198
2001	5.40970	5.14618	5.80311	4.58416	8.97770	8.04237	5.62691	8.75403
2002	5.47743	5.22044	5.68895	4.61494	9.09489	8.53655	5.61217	9.02599
2003	5.61543	5.29558	5.64768	4.31493	9.26253	8.32732	5.87497	9.04388
2004	5.69551	5.37836	5.78629	4.20643	9.48779	9.25929	6.12630	9.55745
2005	5.81654	5.49862	5.95274	4.15511	9.84265	9.80219	6.39760	9.99376
2006	5.92386	5.63197	5.97000	4.12736	10.29074	9.81133	6.58063	10.27222
2007	6.02712	5.75706	6.02590	4.02177	10.66121	10.14050 5	6.84476	10.63228

Table 1.2: Quantities of Canadian Business Sector Output and Input Aggregates, TFP Levels and TFP Growth Rates

Year t	Q_D^t	Q_X^t	Q_M^t	Q_L^t	Q_K^t	Q_Y^t	Q_Z^t	T^t	τ^t
1961	28752	6867	−7897	19202	8520	27722	27722	1.00000	–
1962	30578	7195	−8033	20042	8739	29750	28782	1.03361	1.03361
1963	32261	7832	−8031	20574	9007	32113	29582	1.08555	1.05024
1964	34602	9105	−8989	21446	9324	34766	30768	1.12995	1.04090
1965	37904	9418	−10180	22416	9751	37149	32164	1.15499	1.02216
1966	40831	10696	−11579	23550	10328	39949	33880	1.17914	1.02091
1967	41117	11827	−12306	24056	11057	40656	35112	1.15790	0.98198
1968	42835	12910	−13527	24158	11627	42246	35756	1.18152	1.02040
1969	46062	13802	−15377	24718	12059	44521	36737	1.21189	1.02571
1970	46017	15211	−15293	24798	12569	45988	37285	1.23341	1.01776
1971	48326	15929	−16480	25333	13007	47844	38238	1.25120	1.01442
1972	52098	17257	−18892	26101	13416	50590	39410	1.28367	1.02595
1973	59241	19008	−21754	27591	13866	56663	41362	1.36992	1.06719
1974	65163	18347	−23977	28558	14615	59579	43080	1.38298	1.00953
1975	63453	16951	−23228	28530	15571	57119	43961	1.29930	0.93949
1976	67488	18390	−24774	28499	16309	61084	44559	1.37086	1.05508
1977	70950	19678	−24836	28805	17018	65759	45492	1.44552	1.05446
1978	73085	21544	−26197	30018	17690	68588	47367	1.44801	1.00173
1979	78467	22467	−28092	31737	18344	72879	49736	1.46532	1.01195
1980	77309	22548	−28715	32833	19285	71254	51757	1.37669	0.93951
1981	80810	23012	−30716	33723	20148	73083	53480	1.36653	0.99262
1982	70930	22882	−25710	32059	21330	68632	52707	1.30214	0.95288
1983	75524	24326	−28444	32283	21742	72008	53296	1.35109	1.03759
1984	80477	28444	−33270	33497	22102	76807	54884	1.39943	1.03578
1985	85491	29938	−35548	34871	22585	81087	56743	1.42902	1.02114
1986	88667	31456	−37965	36384	23167	83519	58843	1.41937	0.99325
1987	94688	32933	−39889	38166	23747	89072	61210	1.45517	1.02522

Continued on Next Page...

Table 1.2 – Continued

Year t	Q_D^t	Q_X^t	Q_M^t	Q_L^t	Q_K^t	Q_Y^t	Q_Z^t	T^t	τ^t
1988	101144	35371	−45163	39912	24550	93146	63746	1.46120	1.00414
1989	104645	35434	−47820	40981	25638	94280	65839	1.43198	0.98000
1990	102201	37556	−48551	41030	26721	93557	66811	1.40032	0.97789
1991	96067	38167	−49281	39707	27455	87853	65884	1.33345	0.95224
1992	98558	40921	−51473	39311	27831	91077	65705	1.38615	1.03952
1993	98528	45382	−55461	40184	28050	92144	66858	1.37821	0.99427
1994	103227	51076	−60606	41745	28099	97970	68602	1.42809	1.03619
1995	105681	55452	−64385	42958	28426	101581	70163	1.44779	1.01380
1996	108585	58646	−67340	44212	28923	105126	71906	1.46199	1.00981
1997	116675	63457	−77378	45636	29440	109300	73839	1.48025	1.01249
1998	120947	69086	−81755	47078	30519	115417	76307	1.51254	1.02182
1999	124963	76337	−88261	48781	31631	121154	79074	1.53216	1.01297
2000	132088	83350	−95661	50512	32736	128862	81864	1.57409	1.02737
2001	132099	80654	−90649	51183	33919	130142	83653	1.55574	0.98834
2002	140327	81599	−92347	52290	34561	137310	85376	1.60829	1.03377
2003	142198	79268	−96341	53129	35172	133617	86799	1.53939	0.95716
2004	150705	83281	−104558	55049	35675	139173	89210	1.56007	1.01343
2005	158450	84730	−112492	55875	36549	141962	90878	1.56211	1.00131
2006	165871	85022	−117772	56905	37720	145225	93035	1.56098	0.99928
2007	173734	86002	−124556	58347	38998	148654	95699	1.55335	0.99511

Note that we have also listed the price of our household consumption aggregate, P_C^t, in Table 1.1, which will play a role in the subsequent sections. The *productivity level* in year t of the Canadian business sector, T^t, can be defined as the aggregate year t output, Q_Y^t divided by the aggregate year t input, Q_Z^t,[8]

$$T^t \equiv \frac{Q_Y^t}{Q_Z^t} \qquad t = 1961, \ldots, 2007 \tag{1.1}$$

Productivity growth for year t, τ^t, is defined as the productivity level in year t, T^t, divided by the productivity level from the previous year,

$$\tau^t \equiv \frac{T^t}{T^{t-1}} \qquad t = 1962, \ldots, 2007 \tag{1.2}$$

Table 1.2 lists the quantities that match up to the prices in Table 1.1 and it also lists productivity levels and growth rates. The average rate of total factor productivity (TFP) growth over the 46 years (1962-2007) is 1.01% per year,[9] which is much higher than the 0.5 to 0.7% per year range that Diewert and Lawrence (2000) found over the period 1962-1996. The present 1.01% average rate of TFP growth can also be compared with Statistics Canada's recent KLEMS program average Multifactor Productivity Growth over the same years of 0.38% per year,[10] which is a rather substantial difference.[11]

[8]This is known as Multifactor Productivity or Total Factor Productivity.

[9]This rate of TFP growth is reasonably close to the average rate of productivity growth of Australia obtained by Diewert and Lawrence (2006) using a similar methodology and over a similar period. The Diewert and Lawrence market sector average rate of TFP growth for Australia over the period of 1961-2004 was 1.49% per year. However, there is an upward bias in the Diewert and Lawrence results due to the fact that they essentially used hours worked as their measure of labour input instead of a quality adjusted measure of labour input for Australia (which was not available).

[10]See CANSIM II series V41712881, Canada, Multifactor Productivity, Business Sector, Table 3830021, Multifactor Productivity, Value Added, Capital Input and Labour Input in the Aggregate Business Sector and Major Sub-Sectors. Comparing levels of TFP with the starting level being 1 in 1961, our TFP ended up at 1.553 in 2007 whereas KLEMS Multifactor Productivity ended up at 1.184 in 2007. This is a very substantial difference.

[11]Our measures of business sector output and capital input were different from the KLEMS measures because we excluded rental housing from our measure of capital services, whereas the KLEMS measures included rental housing in their output and capital input measures. Our measures of labour input were identical and it turned out that the

During the golden years of 1962-1973, Canada's TFP growth averaged about 2.68% per year; over the dismal years of 1974-1991, the average TFP growth was essentially 0 (-0.086 per year); TFP growth nicely recovered during 1992-1999 to an average of 1.76% per year. Finally, from 2000-2007, the average TFP growth fell to only 0.20% per year. There were two years of poor productivity growth, 2001 and 2003, where drops of 1.17% and 4.28% occurred. After some increases in productivity growth in 2004 and 2005, slight drops in productivity growth again occurred in 2006 and 2007. If the two poor-performing years are excluded, the productivity growth during this period is on average 1.4% per year.

Productivity growth does not necessarily represent the whole story behind the growth in living standards. If the prices of Canadian exports increases more rapidly than the prices of Canadian imports, then the real income generated by the business sector increases. This terms of trade effect is not taken into account in the conventional productivity growth computation. Thus in the following section, we implement the translog real income methodology explained in Subsections 1.8.2-1.8.5 and this approach will enable us to assess the contribution to Canadian living standards of improvements in Canada's terms of trade.

1.3 Explaining Real Income Growth Generated by the Canadian Business Sector: the Gross Output Approach

The basic methodology used in this section can easily be explained in non-technical terms. The business sector faces exogenous domestic and international prices for the net outputs it produces: domestic outputs, exports and (minus) imports. It also utilises inputs of labour and capital in order to produce its outputs. The value of outputs produced by the business sector

average rate of growth of our business sector value added measure was very close to the corresponding KLEMS average growth rate. The capital services growth rates differed substantially.

less the value of imports used (value added) must eventually flow back to the labour and capital primary inputs that were used to produce the value added. This is the gross income generated by the business sector. In order to turn this into *real income* ρ^t, we divide the gross income in year t by the price of consumption in year t, P_C^t. This real income is the number of consumption bundles that *could* be purchased by the owners of the labour and capital inputs that were used in year t by the Canadian business sector. We also divide each of the prices of domestic output, export, import, labour and capital services (P_D^t, P_X^t, P_M^t, P_L^t and P_K^t) by the price of consumption, P_C^t, to form the corresponding real output and input prices facing the Canadian business sector in each year. Our measures of gross real income generated by the business sector, ρ^t and the corresponding real output and input prices are shown in Table 1.3.

Table 1.3: Gross Real Income Generated by the Canadian Business Sector and Real Output and Input Prices

Year t	ρ^t	$\frac{P_D^t}{P_C^t}$	$\frac{P_X^t}{P_C^t}$	$\frac{P_M^t}{P_C^t}$	$\frac{P_L^t}{P_C^t}$	$\frac{P_K^t}{P_C^t}$
1961	27722	1.00000	1.00000	1.00000	1.00000	1.00000
1962	29497	1.00000	1.02441	1.05221	1.03070	1.01147
1963	31684	1.00205	1.01959	1.07440	1.04457	1.13169
1964	34474	1.00509	1.03178	1.07897	1.08407	1.20383
1965	37404	1.01352	1.04137	1.06292	1.14063	1.21379
1966	40460	1.01216	1.04554	1.04070	1.17085	1.24769
1967	41188	1.01115	1.03936	1.03040	1.20074	1.11281
1968	42890	1.00701	1.04299	1.01353	1.22968	1.13395
1969	45270	1.00853	1.03453	1.00561	1.27918	1.13205
1970	47147	1.01350	1.03684	0.99801	1.31970	1.14742
1971	49573	1.02727	1.02983	0.99976	1.38213	1.11929
1972	52936	1.03205	1.02679	0.98191	1.43547	1.15296
1973	61173	1.04211	1.09186	0.97989	1.46916	1.48843
1974	65204	1.04308	1.20773	1.03952	1.48403	1.56162
1975	61218	1.02685	1.18933	1.03749	1.48373	1.21301
1976	66937	1.03485	1.20436	1.01115	1.62875	1.25811
1977	71002	1.03343	1.23160	1.06923	1.66796	1.34888
1978	73403	1.03126	1.24889	1.10217	1.61219	1.41368
1979	78961	1.03081	1.33303	1.13456	1.57294	1.58319
1980	78608	1.02328	1.38578	1.10560	1.52796	1.47470
1981	80108	1.02615	1.35379	1.10592	1.55517	1.37301
1982	73760	1.01742	1.26657	1.06522	1.55492	1.12101
1983	76566	1.00006	1.19845	0.98845	1.50751	1.28324
1984	81009	0.99619	1.18852	0.99092	1.51616	1.36739
1985	85351	0.99699	1.17680	0.98779	1.54643	1.39145
1986	87409	0.99966	1.14888	0.98427	1.55157	1.33625
1987	94847	1.00287	1.14386	0.94720	1.56791	1.47418

Continued on Next Page...

Table 1.3 – Continued

Year t	ρ^t	$\frac{P_D^t}{P_C^t}$	$\frac{P_X^t}{P_C^t}$	$\frac{P_M^t}{P_C^t}$	$\frac{P_L^t}{P_C^t}$	$\frac{P_K^t}{P_C^t}$
1988	100298	1.00275	1.11713	0.89981	1.62727	1.43997
1989	102387	1.00225	1.10764	0.87290	1.64897	1.35781
1990	99095	0.98495	1.04058	0.83723	1.61916	1.22226
1991	90462	0.96340	0.95210	0.77977	1.59932	0.98189
1992	93036	0.96099	0.96629	0.80078	1.60776	1.07198
1993	93673	0.96066	0.98975	0.82753	1.57292	1.08618
1994	100428	0.96915	1.04241	0.87214	1.55383	1.26564
1995	106501	0.97212	1.10432	0.89260	1.57284	1.36970
1996	110404	0.96447	1.08824	0.86345	1.56090	1.43116
1997	114262	0.96169	1.07285	0.85325	1.59315	1.41162
1998	118198	0.96219	1.05630	0.87031	1.61741	1.37794
1999	124920	0.95943	1.05044	0.85157	1.62855	1.43776
2000	136049	0.95649	1.08681	0.84546	1.66490	1.58698
2001	135368	0.95129	1.07272	0.84740	1.65956	1.48666
2002	140688	0.95308	1.03862	0.84254	1.66043	1.55850
2003	139793	0.94304	1.00574	0.76841	1.64948	1.48294
2004	149700	0.94432	1.01594	0.73855	1.66584	1.62572
2005	156144	0.94534	1.02342	0.71436	1.69218	1.68523
2006	161326	0.95073	1.00779	0.69673	1.73717	1.65624
2007	168821	0.95519	0.99980	0.66728	1.76887	1.68249

The results show that the gross real income generated by the Canadian business sector has grown from $27,722 million dollars worth of 1961 consumption bundles in 1961 to $168,821 in 2007, a 6.09 fold increase. The real price of domestic output has fallen to 0.9552 times the starting level (due to the fact that machinery and equipment prices have risen less rapidly than the prices of consumption) and the real price of exports has fallen slightly to 0.9998 times of the starting level while the real price of imports has fallen substantially to 0.6673 times the starting level. The quality adjusted real wage of business sector workers have risen to 1.77 times their initial 1961 levels. The real price of capital services has risen 1.68 fold, this reflects rapidly rising prices of agricultural land and non-agricultural business land as well as upward trends in machinery and equipment depreciation rates and in real rates of return. The details are discussed in Chapter 2.[12]

There are six quantitative factors that can be used to explain the real income ρ^t generated by the business sector in year t:

1. The price of domestic production (an aggregate of $C+I+G$) relative to the price of consumption in year t, $\frac{P_D^t}{P_C^t}$;
2. The price of exports relative to the price of consumption in year t, $\frac{P_X^t}{P_C^t}$;
3. The price of imports relative to the price of consumption in year t, $\frac{P_M^t}{P_C^t}$;
4. The quantity of labour used by the business sector in year t, Q_L^t;
5. The quantity of capital used by the business sector in year t, Q_K^t and
6. The level of technology of the business sector in year t.

[12] The volatility of the real price of capital services reflects the fact that we have used balancing real rates of return in our user costs and these real rates are subject to a considerable amount of measurement error. One would expect the aggregate real price of capital services to decline, reflecting the decline in the real price of machinery and equipment, but this decline is offset by a large increase in the real price of land services.

The formal model outlined in Section 1.8, based on the work of Diewert and Morrison (1986) and Kohli (1990), allows us to decompose the growth of real income from year $t-1$ to t, $\frac{\rho^t}{\rho^{t-1}}$, into multiplicative year to year contribution factors α_D^t, α_X^t, α_M^t, β_L^t, β_K^t and τ^t that describe the effects of changes in the six quantitative factors listed above going from year $t-1$ to t. The following equation which decomposes the year to year growth in real income generated by the business sector, $\frac{\rho^t}{\rho^{t-1}}$, into a product of six year to year explanatory contribution factors:[13]

$$\frac{\rho^t}{\rho^{t-1}} = \tau^t \alpha_D^t \alpha_X^t \alpha_M^t \beta_L^t \beta_K^t \qquad t = 1962, 1963, \ldots, 2007. \tag{1.3}$$

Thus if α_D^t is greater than one, this means that the domestic price of output grew faster than the price of consumption going from year $t-1$ to t and α_D^t measures the contribution of rising real domestic output prices to the growth in real income. Similarly, if α_X^t is greater than one, this means Canadian export prices grew faster than the price of consumption going from year $t-1$ to t and α_X^t measures the contribution of rising real export prices to the growth in real income generated by the Canadian business sector. However, if α_M^t is larger than one, this means the Canadian import prices did not increase as quickly as the price of consumption going from year $t-1$ to t and α_M^t measures the contribution of falling real import prices to the growth in real income generated by the Canadian business sector. If β_L^t is larger than one, then the labour input in the business sector increased going from year $t-1$ to t and β_L^t measures the contribution of the increase in labour input to the growth in real income generated by the Canadian business sector. Similarly for β_K^t, if it is greater than one, then the business sector capital service input increased going from year $t-1$ to t and β_K^t measures the contribution of the increase in capital input to the growth in real income generated by the business sector. Finally, if τ^t is larger than one, then the efficiency of the Canadian business sector increased from year $t-1$

[13] See Equations (1.50), (1.59) and (1.64) in Section 1.8 in order to derive this equation. All of the variables in Equation (1.3) can be identified using data in Chapter 2.

to t and τ^t measures the contribution of the efficiency increase to the growth in real income generated by the Canadian business sector.[14] The year to year contribution factors and the averages of them are listed in Table 1.4.

The periodic averages of the year to year growth in real income show that the gross real income generated by the Canadian business sector over the entire sample period grew at 4.10 percent per year over the 47 years (1961-2007). The biggest contributor to this growth was the growth of quality adjusted labour input at 1.60 percentage points per year. Next was capital services input, which contributed on average 1.13 percentage points per year, followed by TFP growth (1.01 percentage points per year) and declines in real import prices (0.43 percentage points per year). Declines in real domestic output prices and real export prices give rise to negative average contribution factors, −0.09 and −0.03 percentage points per year respectively. The last column in Table 1.4 gives the product of the real export and real import price contribution factors, α^t_{XM}, which is defined as,

$$\alpha^t_{XM} \equiv \alpha^t_X \alpha^t_M \tag{1.4}$$

Roughly speaking, α^t_{XM} is the *terms of trade contribution factor*, it gives the contribution to real income growth of the combined effects of real changes in the international prices faced by the Canadian business sector.[15] It can be seen that the effects of changing real international prices are not negligible for Canada: on average, changing real export and import prices contributed 0.38 percentage points per year to real income growth over the entire sam-

[14] The productivity growth rates, τ^t, computed here do not completely agree with the ones computed in the last section. The discrepancy arises because the input aggregates in calculating τ^t here is a direct Törnqvist quantity index whereas an implicit quantity index is used in the earlier computation.

[15] Ulrich Kohli has pointed out that this is a slight abuse of terminology. Strictly speaking, the terms of trade is the price of exports over the price of imports and hence involves only two prices. Our definition of α^t_{XM} involves three prices: the price of exports, the price of imports and the price of domestic consumption. Our terms of trade contribution factor is the rate of change counterpart to Kohli's(2006; 50) *trading gains factor*.

ple period.[16] However, for shorter periods, the effects of changing real international prices can be far more important in explaining changes in the real income generated by the market sector of the economy. If the attention is restricted to the recent years (2000-2007), it can be seen that the improvements in Canadian terms of trade become larger than the average contribution of capital deepening. During this period, the average annual growth in the real income generated by the Canadian business sector was 3.88% per year, which can be explained by the following factors: decreases in the real price of imports (1.63 percentage points), increases in quality adjusted labour input (1.40 percentage points), increases in capital services input (1.01 percentage points) and improvements in TFP (0.20 percentage points). There were also small negative contributors to market sector real income growth during the naughts: decreases in the real price of domestically produced goods and services (−0.05 percentage points) and decreases in real prices of exports (−0.34 percentage points). Thus decreases in the real price of imports proved to be the most important factor in explaining the growth in real income generated by the market sector during this period. Overall, the joint effects of changes in real export and import prices contributed about 1.28 percentage points per year on average to the growth of market sector real income during this period, which was larger than the capital deepening contribution of 1.01 percentage points per year.[17]

[16]Thus the contribution of falling real import prices outweighs the effects of the falling export prices.

[17]These results are very similar to the results obtained for Australia using a similar framework by Diewert and Lawrence (2006); i.e. both Australia and Canada have had very favourable changes in their terms of trade in recent years which contributed greatly to real income growth during the naughts.

Table 1.4: Business Sector Year to Year Growth in Real Income and Year to Year Contribution Factors

Year t	$\frac{\rho^t}{\rho^{t-1}}$	τ^t	α_D^t	α_X^t	α_M^t	β_L^t	β_K^t	α_{XM}^t
1962	1.06402	1.03361	1.00000	1.00602	0.98556	1.03028	1.00773	0.99150
1963	1.07414	1.05024	1.00210	0.99882	0.99418	1.01820	1.00943	0.99301
1964	1.08806	1.04090	1.00308	1.00312	0.99883	1.02848	1.01127	1.00194
1965	1.08499	1.02216	1.00854	1.00248	1.00428	1.03048	1.01448	1.00677
1966	1.08172	1.02091	0.99862	1.00108	1.00622	1.03428	1.01841	1.00730
1967	1.01799	0.98199	0.99899	0.99830	1.00302	1.01478	1.02126	1.00131
1968	1.04133	1.02040	0.99587	1.00107	1.00519	1.00296	1.01535	1.00627
1969	1.05548	1.02571	1.00153	0.99744	1.00259	1.01608	1.01117	1.00003
1970	1.04146	1.01776	1.00497	1.00073	1.00253	1.00223	1.01266	1.00326
1971	1.05145	1.01443	1.01352	0.99775	0.99943	1.01508	1.01033	0.99717
1972	1.06785	1.02595	1.00468	0.99901	1.00617	1.02134	1.00911	1.00518
1973	1.15561	1.06713	1.00988	1.02092	1.00072	1.03876	1.01043	1.02166
1974	1.06589	1.00953	1.00096	1.03484	0.97865	1.02287	1.01826	1.01275
1975	0.93887	0.93953	0.98361	0.99488	1.00076	0.99933	1.02109	0.99563
1976	1.09342	1.05508	1.00821	1.00415	1.00992	0.99926	1.01435	1.01412
1977	1.06072	1.05446	0.99858	1.00755	0.97932	1.00735	1.01349	0.98671
1978	1.03382	1.00172	0.99784	1.00495	0.98842	1.02793	1.01294	0.99331
1979	1.07573	1.01194	0.99955	1.02461	0.98852	1.03661	1.01293	1.01285
1980	0.99553	0.93951	0.99259	1.01519	1.01049	1.02181	1.01843	1.02584
1981	1.01907	0.99262	1.00286	0.99086	0.99988	1.01743	1.01559	0.99074
1982	0.92076	0.95289	0.99143	0.97430	1.01502	0.96690	1.01927	0.98894
1983	1.03805	1.03756	0.98324	0.97884	1.02800	1.00458	1.00660	1.00625
1984	1.05802	1.03578	0.99618	0.99668	0.99903	1.02358	1.00609	0.99572
1985	1.05360	1.02114	1.00080	0.99590	1.00130	1.02563	1.00803	0.99719
1986	1.02411	0.99325	1.00270	0.99013	1.00150	1.02750	1.00923	0.99162
1987	1.08509	1.02522	1.00323	0.99823	1.01598	1.03099	1.00898	1.01417
1988	1.05747	1.00414	0.99988	0.99069	1.02084	1.02900	1.01207	1.01133

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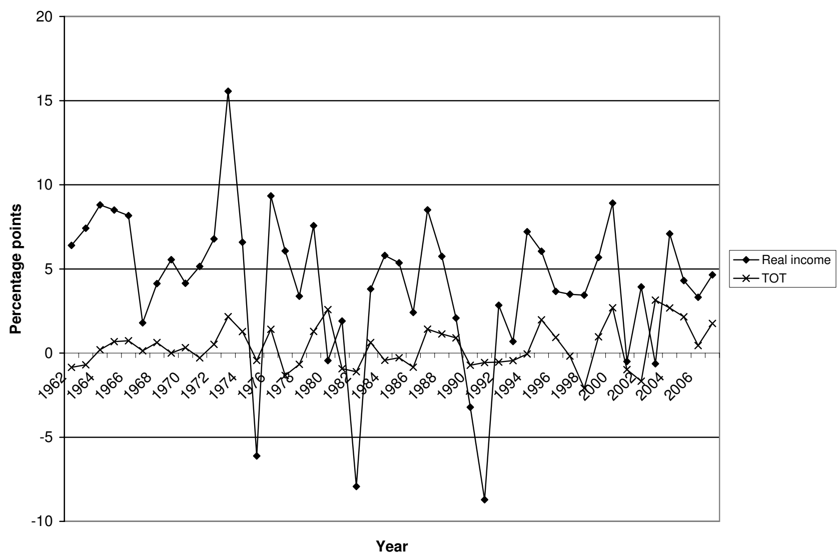
Table 1.4 – Continued

Year t	$\frac{\rho^t}{\rho^{t-1}}$	τ^t	α_D^t	α_X^t	α_M^t	β_L^t	β_K^t	α_{XM}^t
1989	1.02083	0.98000	0.99949	0.99669	1.01242	1.01743	1.01513	1.00907
1990	0.96784	0.97789	0.98239	0.97601	1.01721	1.00080	1.01395	0.99280
1991	0.91289	0.95226	0.97770	0.96525	1.03013	0.97776	1.00854	0.99433
1992	1.02845	1.03952	0.99745	1.00613	0.98853	0.99310	1.00421	0.99460
1993	1.00684	0.99427	0.99965	1.01091	0.98478	1.01498	1.00253	0.99552
1994	1.07211	1.03618	1.00887	1.02652	0.97368	1.02550	1.00059	0.99949
1995	1.06047	1.01379	1.00300	1.03239	0.98772	1.01850	1.00418	1.01971
1996	1.03665	1.00981	0.99248	0.99158	1.01786	1.01829	1.00644	1.00929
1997	1.03495	1.01249	0.99721	0.99167	1.00659	1.02019	1.00656	0.99820
1998	1.03444	1.02182	1.00051	0.99062	0.98839	1.02012	1.01304	0.97912
1999	1.05687	1.01297	0.99722	0.99650	1.01318	1.02301	1.01296	1.00963
2000	1.08909	1.02737	0.99710	1.02251	1.00432	1.02211	1.01289	1.02693
2001	0.99499	0.98834	0.99495	0.99152	0.99867	1.00825	1.01348	0.99021
2002	1.03930	1.03377	1.00177	0.98014	1.00323	1.01340	1.00711	0.98331
2003	0.99364	0.95716	0.98994	0.98132	1.05112	1.00995	1.00664	1.03148
2004	1.07087	1.01343	1.00129	1.00574	1.02093	1.02224	1.00542	1.02679
2005	1.04305	1.00131	1.00104	1.00412	1.01731	1.00912	1.00950	1.02150
2006	1.03319	0.99928	1.00552	0.99168	1.01286	1.01119	1.01240	1.00443
2007	1.04646	0.99511	1.00461	0.99587	1.02185	1.01543	1.01301	1.01763
Averages								
1962-2007	1.04100	1.01010	0.99904	0.99969	1.00430	1.01600	1.01130	1.00380
1962-1973	1.06870	1.02680	1.00350	1.00220	1.00070	1.02110	1.01260	1.00290
1974-1991	1.02340	0.99914	0.99562	0.99665	1.00540	1.01320	1.01310	1.00190
1992-1999	1.04130	1.01760	0.99955	1.00580	0.99509	1.01670	1.00630	1.00070
2000-2007	1.03880	1.00200	0.99953	0.99661	1.01630	1.01400	1.01010	1.01280

Figure 1.1 shows the contribution of the combined effects of real changes in export and import prices ($\alpha_{XM}^t - 1$) and the changes in real income ($[\rho^t/\rho^{t-1}] - 1$) in 1962-2007. As shown in the figure, the movements of the two series start out quite differently, but are very similar from 1994 onward. In fact, as we mention earlier, during the years 2000-2007, much of the changes in real income can be explained by the combined changes in the international prices, largely coming from the decreases in import prices.

Figure 1.1: Real Income Change and Terms of Trade Contribution 1962-2007 (Gross Output Approach)



The various growth factors for the four subperiods, as listed in Table 1.4 are:

- The 12 golden years for the Canadian economy, 1962-1973, when the real income generated by the business grew by 6.87% per year and TFP growth was a stellar 2.68% per year;
- The 18 dismal years for the Canadian economy, 1974-1991, characterised by stagflation, oil shocks and rapidly increasing tax rates when the real income generated by the business sector grew by 2.34% per year and TFP growth was essentially zero;
- The 8 years after the recession of 1991, 1992-1999, when real income growth recovered to 4.13% per year and TFP growth recovered to 1.76% per year and
- The 8 years in this century, 2000-2007, when TFP growth dropped to 0.20% per year but real income growth was strong at 3.88% due to the very strong contribution made by falling real import prices during this period, which contributed on average 1.63% per year to real income growth.

The annual changes presented in Table 1.4 can be converted into levels using Equations (1.54) with extensions to multiple inputs and outputs. Let T^t, A_D^t, A_X^t, A_M^t, B_L^t, B_K^t and A_{XM}^t be the cumulated products of the annual link factors τ^t, α_D^t, α_X^t, α_M^t, β_L^t, β_K^t and α_{XM}^t respectively. Using these definitions and cumulating Equation (1.3) leads to the following equation, which explains the cumulative growth in real gross income generated by the Canadian business sector relative to the base year 1961:

$$\frac{\rho^t}{\rho^{1961}} = T^t A_D^t A_X^t A_M^t B_L^t B_K^t; \qquad t = 1962, 1963, \ldots, 2007. \qquad (1.5)$$

The cumulated variables that appear in Equation (1.5) are presented in Table 1.5 along with the cumulated terms of trade contribution factor, A_{XM}^t

defined to be the product of the two cumulated international price factors, A_X^t and A_M^t.

Table 1.5 shows that the gross real income generated by the business sector grew 6.09 fold over the years 1961-2007. The main factors explaining this growth are growth of quality adjusted labour input (with cumulative growth factor 2.06), productivity increases (with cumulative growth factor 1.55), growth of capital services (with cumulative growth factor 1.67) and lower import prices (with cumulative growth factor 1.21). There were negative contributions from declining real domestic output prices (with cumulative growth factor 0.96) and declining real export prices (with cumulative growth factor 0.98). The real prices of Canadian raw material exports have increased dramatically in recent years, but these increases do not show up in the A_X^t column of Table 1.5, i.e. the overall real price of Canadian exports have remained relatively constant in the recent years. This apparent contradiction can be explained by the falling real prices for Canadian exports of manufactured goods. As already noted above, in the same period, the effects of the falling real import prices have been substantial.

Table 1.5: Business Sector Cumulated Growth in Real Income and Cumulated Contribution Factors

Year t	$\frac{\rho^t}{\rho^{1961}}$	T^t	A_D^t	A_X^t	A_M^t	B_L^t	B_K^t	A_{XM}^t
1961	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
1962	1.06402	1.03361	1.00000	1.00602	0.98556	1.03028	1.00773	0.99150
1963	1.14291	1.08554	1.00210	1.00483	0.97983	1.04903	1.01723	0.98456
1964	1.24355	1.12994	1.00519	1.00796	0.97868	1.07891	1.02869	0.98648
1965	1.34925	1.15498	1.01378	1.01046	0.98288	1.11179	1.04359	0.99316
1966	1.45950	1.17913	1.01238	1.01155	0.98899	1.14991	1.06280	1.00042
1967	1.48576	1.15790	1.01136	1.00983	0.99197	1.16691	1.08540	1.00172
1968	1.54716	1.18151	1.00719	1.01091	0.99713	1.17037	1.10206	1.00800
1969	1.63300	1.21189	1.00873	1.00832	0.99971	1.18918	1.11437	1.00803
1970	1.70070	1.23340	1.01374	1.00905	1.00224	1.19184	1.12848	1.01131
1971	1.78820	1.25120	1.02745	1.00678	1.00167	1.20981	1.14014	1.00845
1972	1.90953	1.28367	1.03226	1.00578	1.00785	1.23563	1.15052	1.01367
1973	2.20668	1.36984	1.04246	1.02683	1.00857	1.28352	1.16252	1.03563
1974	2.35207	1.38289	1.04346	1.06260	0.98704	1.31287	1.18375	1.04883
1975	2.20829	1.29927	1.02636	1.05716	0.98778	1.31200	1.20871	1.04425
1976	2.41459	1.37083	1.03478	1.06155	0.99759	1.31103	1.22605	1.05899
1977	2.56120	1.44548	1.03331	1.06956	0.97696	1.32066	1.24259	1.04492
1978	2.64781	1.44798	1.03108	1.07485	0.96565	1.35754	1.25867	1.03793
1979	2.84833	1.46527	1.03062	1.10130	0.95457	1.40724	1.27495	1.05127
1980	2.83559	1.37664	1.02298	1.11803	0.96458	1.43794	1.29844	1.07844
1981	2.88968	1.36648	1.02590	1.10781	0.96447	1.46300	1.31869	1.06845
1982	2.66070	1.30211	1.01711	1.07935	0.97896	1.41457	1.34410	1.05663
1983	2.76193	1.35101	1.00006	1.05651	1.00637	1.42105	1.35297	1.06324
1984	2.92218	1.39934	0.99624	1.05300	1.00540	1.45455	1.36120	1.05869
1985	3.07883	1.42893	0.99704	1.04868	1.00671	1.49183	1.37214	1.05571
1986	3.15306	1.41928	0.99972	1.03833	1.00822	1.53286	1.38481	1.04686
1987	3.42136	1.45508	1.00295	1.03649	1.02432	1.58036	1.39724	1.06170

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Table 1.5 – Continued

Year t	$\frac{\rho^t}{\rho^{1961}}$	T^t	A_D^t	A_X^t	A_M^t	B_L^t	B_K^t	A_{XM}^t
1988	3.61799	1.46111	1.00284	1.02684	1.04567	1.62620	1.41411	1.07373
1989	3.69336	1.43190	1.00233	1.02344	1.05865	1.65455	1.43550	1.08347
1990	3.57459	1.40024	0.98467	0.99889	1.07687	1.65588	1.45553	1.07567
1991	3.26319	1.33340	0.96272	0.96417	1.10931	1.61905	1.46796	1.06957
1992	3.35604	1.38609	0.96026	0.97009	1.09659	1.60787	1.47414	1.06379
1993	3.37900	1.37814	0.95993	0.98067	1.07990	1.63196	1.47788	1.05903
1994	3.62268	1.42800	0.96844	1.00667	1.05148	1.67357	1.47875	1.05849
1995	3.84175	1.44770	0.97135	1.03928	1.03856	1.70452	1.48493	1.07936
1996	3.98254	1.46190	0.96404	1.03053	1.05711	1.73569	1.49449	1.08938
1997	4.12172	1.48016	0.96135	1.02195	1.06407	1.77074	1.50430	1.08743
1998	4.26368	1.51245	0.96184	1.01236	1.05172	1.80636	1.52391	1.06472
1999	4.50616	1.53206	0.95917	1.00882	1.06558	1.84792	1.54366	1.07497
2000	4.90761	1.57400	0.95639	1.03152	1.07018	1.88878	1.56356	1.10392
2001	4.88304	1.55565	0.95156	1.02278	1.06876	1.90437	1.58464	1.09311
2002	5.07494	1.60819	0.95324	1.00247	1.07221	1.92989	1.59591	1.07486
2003	5.04267	1.53930	0.94365	0.98374	1.12702	1.94909	1.60651	1.10869
2004	5.40004	1.55997	0.94487	0.98939	1.15061	1.99244	1.61521	1.13840
2005	5.63249	1.56201	0.94585	0.99346	1.17052	2.01060	1.63056	1.16287
2006	5.81943	1.56088	0.95107	0.98519	1.18558	2.03310	1.65078	1.16802
2007	6.08978	1.55325	0.95545	0.98112	1.21149	2.06447	1.67226	1.18862

As discussed in Subsection 1.8.6, the concept of income used in this section is biased upwards. The problem is that depreciation payments are part of the user cost of capital for each asset but depreciation does not provide households with any sustainable purchasing power. Hence, the measure of real income, ρ^t that is used in this section is overstated. In the following section, we implement the *net real income model* that is described in more detail in Subsection 1.8.6.

1.4 Explaining Real Income Growth Generated by the Canadian Business Sector: the Net Output Approach

The overstatement of income problem that is implicit in the gross output approach used in the previous section can readily be remedied: all we need to do is take the user cost formula for an asset that has investment price P_I^t in year t and decompose it into two parts:

- One part that represents depreciation and foreseen obsolescence, $\delta P_I^t K^t$, and
- The remaining part that is the reward for postponing consumption, $r^t P_I^t K^t$.

The depreciation part $\delta P_I^t K^t$ will be removed from the user cost and treated as an intermediate input as an offset to gross investment.

The user costs in the previous section took the form of:

$$U^t = (r^t + \delta^t + \tau_B^t) P_I^t \tag{1.6}$$

where r^t is the period t balancing real rate of interest, δ^t is a geometric depreciation rate for period t, τ_B^t is an appropriate business taxation rate on the asset (including property taxes if applicable) and P_I^t is the period t investment price for the asset. However, in the net output approach to the measurement of income,[18] we split up each (gross product) user cost times the beginning of the period stock K^t into the depreciation component $\delta P_I^t K^t$ and the remaining term $(r^t + \tau_B^t) P_I^t K^t$ and we regard the second term as a genuine income component but we treat the first term as an intermediate input cost for the business sector and as an offset to gross investment made by the business sector during the year under consideration. Thus in this section, the new aggregate for domestic output will aggregate $C + I + G$ like before, but the depreciation series for business structures, ICT and non-ICT machinery and equipment as negative outputs of the business sector. The ICT and non-ICT machinery and equipment and non-residential structures user costs are also changed because now the depreciation terms are omitted. The new investment aggregate I is a *net investment aggregate* (gross investment components were indexed with a positive sign in the aggregate and depreciation components were indexed with a negative sign in the aggregate) and the new capital services aggregate is now a "reward for waiting" capital services aggregate.[19]

By including these changes, the aggregate data series would have changed. The new net product prices, quantities and real income series (counterparts to Tables 1.1 to 1.3) are shown in Tables 1.6 to 1.8.[20]

[18] See Diewert (2006a) for a more detailed discussion of the net output approach to income measurement.

[19] This approach seems to be broadly consistent with an approach advocated by Rymes (1968, 1983), who stressed the role of waiting services: "Second, one can consider the 'waiting' or 'abstinence' associated with the net returns to capital as the non-labour primary input." T.K. Rymes (1968, p.362). Denison (1974) also advocated a net output approach to productivity measurement.

[20] The TFP growth rate τ^t in Tables 1.7 and 1.9 differ slightly because when calculating τ^t in Table 1.9, the input aggregate is a direct Törnqvist quantity index whereas in Table 1.7, the input aggregate is an implicit quantity index; i.e. the value of inputs was deflated by the Törnqvist input price index. Both the direct and implicit Törnqvist indexes are superlative and hence will generally approximate each other very closely; see Diewert (1978).

Table 1.6: Prices of Canadian Business Sector Net Output and Input Aggregates

Year	P_C^t	P_D^t	P_X^t	P_M^t	P_L^t	P_K^t	P_Y^t	P_Z^t
1961	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
1962	1.00538	1.00477	1.02992	1.05787	1.03625	1.01517	0.99506	1.03177
1963	1.02055	1.01951	1.04054	1.09648	1.06604	1.21066	1.00167	1.09654
1964	1.02437	1.02570	1.05692	1.10526	1.11049	1.32368	1.01000	1.15544
1965	1.03690	1.04437	1.07980	1.10214	1.18272	1.32976	1.03635	1.21382
1966	1.07553	1.08188	1.12451	1.11930	1.25929	1.43384	1.08239	1.29617
1967	1.11050	1.11723	1.15421	1.14426	1.33342	1.23143	1.11942	1.31158
1968	1.15168	1.15726	1.20119	1.16726	1.41620	1.33236	1.16779	1.39834
1969	1.18980	1.19642	1.23088	1.19648	1.52197	1.35774	1.20736	1.48633
1970	1.22208	1.23208	1.26710	1.21965	1.61278	1.39712	1.24801	1.56563
1971	1.24828	1.27432	1.28552	1.24798	1.72528	1.33648	1.28652	1.63857
1972	1.29847	1.33283	1.33325	1.27498	1.86392	1.45722	1.35367	1.77330
1973	1.38744	1.44088	1.51489	1.35954	2.03837	2.36282	1.49982	2.11395
1974	1.58382	1.64631	1.91283	1.64641	2.35044	2.88611	1.73846	2.47391
1975	1.82198	1.86583	2.16694	1.89029	2.70332	2.22381	1.95864	2.59155
1976	1.90726	1.96938	2.29702	1.92853	3.10646	2.45812	2.10208	2.95469
1977	2.03175	2.09474	2.50231	2.17241	3.38889	2.93446	2.20157	3.28528
1978	2.19264	2.25525	2.73837	2.41667	3.53495	3.40699	2.35179	3.51206
1979	2.40645	2.47513	3.20786	2.73027	3.78520	4.47127	2.61939	3.96092
1980	2.69497	2.75871	3.73464	2.97957	4.11781	4.51719	3.00661	4.22499
1981	2.95335	3.03348	3.99821	3.26618	4.59295	4.37549	3.27072	4.55078
1982	3.22860	3.29615	4.08926	3.43918	5.02021	3.31517	3.50723	4.60204
1983	3.46323	3.51354	4.15051	3.42324	5.22085	4.86150	3.76691	5.15888
1984	3.61506	3.65788	4.29656	3.58225	5.48101	5.66773	3.90201	5.56258
1985	3.72257	3.76949	4.38071	3.67711	5.75670	5.97348	4.00777	5.84765
1986	3.80422	3.86708	4.37060	3.74437	5.90250	5.68664	4.07122	5.88540
1987	3.89726	3.98569	4.45792	3.69150	6.11054	6.89128	4.26595	6.34107

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Table 1.6 – Continued

Year	P_C^t	P_D^t	P_X^t	P_M^t	P_L^t	P_K^t	P_Y^t	P_Z^t
1988	4.00205	4.09782	4.47080	3.60108	6.51242	6.81320	4.44386	6.62912
1989	4.11690	4.21841	4.56005	3.59364	6.78864	6.34569	4.62309	6.72753
1990	4.35206	4.39764	4.52868	3.64367	7.04667	5.68557	4.77719	6.76258
1991	4.59099	4.59362	4.37107	3.57992	7.34245	4.19549	4.95539	6.60905
1992	4.65258	4.64682	4.49573	3.72567	7.48023	5.09947	4.98029	6.94680
1993	4.74252	4.73209	4.69389	3.92460	7.45961	5.28267	5.04452	6.97845
1994	4.77089	4.78795	4.97322	4.16089	7.41314	6.90899	5.10110	7.35256
1995	4.79147	4.81456	5.29132	4.27688	7.53622	7.86053	5.24941	7.68006
1996	4.88952	4.87348	5.32097	4.22185	7.63205	8.64495	5.37425	7.94364
1997	4.96547	4.93146	5.32718	4.23677	7.91076	8.52931	5.42748	8.13030
1998	5.03224	4.99337	5.31558	4.37960	8.13918	8.19333	5.36027	8.22664
1999	5.12045	5.08140	5.37870	4.36044	8.33890	9.06262	5.51701	8.58639
2000	5.25425	5.20795	5.71039	4.44227	8.74780	11.02286	5.83458	9.36276
2001	5.40970	5.34378	5.80311	4.58416	8.97770	10.23916	5.91943	9.35715
2002	5.47743	5.42904	5.68895	4.61494	9.09489	11.21972	5.89394	9.67799
2003	5.61543	5.56047	5.64768	4.31493	9.26253	10.98273	6.26151	9.75266
2004	5.69551	5.66394	5.78629	4.20643	9.48779	12.99255	6.57696	10.39319
2005	5.81654	5.80418	5.95274	4.15511	9.84265	14.07954	6.90744	10.91980
2006	5.92386	5.95701	5.97000	4.12736	10.29074	13.95161	7.12388	11.23987
2007	6.02712	6.10280	6.02590	4.02177	10.66121	14.56298	7.44707	11.66971

Table 1.7: Quantities of Canadian Business Sector Net Output and Input Aggregates, TFP Levels and TFP Growth Rates

Year t	Q_D^t	Q_X^t	Q_M^t	Q_L^t	Q_K^t	Q_Y^t	Q_Z^t	T^t	τ^t
1961	25452	6867	−7897	19202	5220	24422	24422	1.00000	0.00000
1962	27156	7195	−8033	20042	5348	26328	25391	1.03690	1.03690
1963	28698	7832	−8031	20574	5509	28554	26083	1.09471	1.05576
1964	30880	9105	−8989	21446	5701	31052	27143	1.14400	1.04503
1965	33935	9418	−10180	22416	5925	33184	28332	1.17124	1.02381
1966	36532	10696	−11579	23550	6230	35653	29773	1.19750	1.02242
1967	36362	11827	−12306	24056	6592	35906	30646	1.17166	0.97842
1968	37696	12910	−13527	24158	6852	37114	30995	1.19743	1.02199
1969	40646	13802	−15377	24718	7070	39110	31769	1.23106	1.02808
1970	40280	15211	−15293	24798	7342	40264	32096	1.25450	1.01904
1971	42286	15929	−16480	25333	7549	41816	32831	1.27365	1.01526
1972	45763	17257	−18892	26101	7730	44262	33788	1.30999	1.02854
1973	52582	19008	−21754	27591	7933	49995	35471	1.40947	1.07594
1974	58017	18347	−23977	28558	8319	52422	36838	1.42305	1.00963
1975	55709	16951	−23228	28530	8833	49405	37340	1.32313	0.92979
1976	59148	18390	−24774	28499	9121	52781	37551	1.40561	1.06233
1977	62034	19678	−24836	28805	9410	56883	38119	1.49224	1.06164
1978	63659	21544	−26197	30018	9728	59212	39650	1.49336	1.00075
1979	68536	22467	−28092	31737	10037	62995	41659	1.51215	1.01259
1980	66718	22548	−28715	32833	10516	60768	43244	1.40523	0.92929
1981	69487	23012	−30716	33723	10875	61904	44491	1.39137	0.99013
1982	58666	22882	−25710	32059	11336	56604	43138	1.31216	0.94307
1983	62713	24326	−28444	32283	11395	59449	43409	1.36953	1.04372
1984	67214	28444	−33270	33497	11520	63785	44743	1.42557	1.04092
1985	71770	29938	−35548	34871	11757	67611	46338	1.45908	1.02351
1986	74416	31456	−37965	36384	12018	69537	48102	1.44561	0.99077

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Table 1.7 – Continued

Year t	Q_D^t	Q_X^t	Q_M^t	Q_L^t	Q_K^t	Q_Y^t	Q_Z^t	T^t	τ^t
1987	79795	32933	−39889	38166	12246	74450	50086	1.48644	1.02824
1988	85403	35371	−45163	39912	12556	77740	52113	1.49175	1.00357
1989	87899	35434	−47820	40981	12974	77984	53590	1.45520	0.97550
1990	84568	37556	−48551	41030	13358	76421	53985	1.41560	0.97278
1991	77953	38167	−49281	39707	13573	70326	52730	1.33371	0.94215
1992	79864	40921	−51473	39311	13581	72949	52299	1.39486	1.04585
1993	79507	45382	−55461	40184	13599	73662	53248	1.38337	0.99177
1994	83827	51076	−60606	41745	13567	79042	54838	1.44137	1.04192
1995	85817	55452	−64385	42958	13673	82146	56148	1.46303	1.01503
1996	88197	58646	−67340	44212	13898	85143	57603	1.47809	1.01029
1997	95522	63457	−77378	45636	14100	88674	59196	1.49799	1.01346
1998	98627	69086	−81755	47078	14461	93588	60980	1.53474	1.02454
1999	101444	76337	−88261	48781	14834	98099	63031	1.55635	1.01408
2000	107179	83350	−95661	50512	15180	104411	65066	1.60470	1.03107
2001	106033	80654	−90649	51183	15588	104590	66165	1.58075	0.98507
2002	113127	81599	−92347	52290	15743	110657	67391	1.64202	1.03876
2003	114374	79268	−96341	53129	16011	106675	68489	1.55756	0.94856
2004	121796	83281	−104558	55049	16135	111286	70423	1.58024	1.01457
2005	128251	84730	−112492	55875	16435	113118	71554	1.58088	1.00040
2006	134178	85022	−117772	56905	16858	115217	73025	1.57777	0.99804
2007	140386	86002	−124556	58347	17304	117368	74899	1.56702	0.99318

Comparing Table 1.6 with Table 1.1, we see that the 2007 price of domestic absorption, P_D has increased to 6.10 from the gross approach level of 5.76. This is because net investment is considerably smaller than gross investment and so the relatively low inflation prices of ICT and non-ICT machinery and equipment get much smaller weights in net domestic absorption compared to their weights in gross domestic absorption. The other striking difference between the results of the two approaches is that the price of waiting services, P_K^t, in Table 1.6 grew 14.56 fold over the sample period whereas the price of traditional capital services, P_K^t, in Table 1.1 grew only 10.14 fold. The difference in growth rate can be explained by the fact that the prices of ICT, machinery and equipment services get much lower weights in the calculation of capital services aggregate for Table 1.6 than in the calculation for Table 1.1 because the corresponding user cost for the net concept of capital services now excludes the very large depreciation terms in the net user cost. Thus the prices of agricultural land and business non-agricultural land get much higher weights in the net user cost compared to the gross concept user cost.[21] However, even though the land components now get a much higher weight in waiting services compared to machinery and equipment, the overall price increase in input prices has only increased to 11.67 fold (compared to the gross output model 10.63 fold increase in input prices) over the sample period due to the fact that the importance of capital services dramatically shrinks relative to labour services in the net output framework.

Thus the level of business sector TFP using the net approach increased 1.57 fold over the period 1961-2007 and the average rate of net TFP growth was 1.04 percent per year. Recall that using the gross approach, the level of business sector TFP increased 1.55 fold over the period 1961-2007 and the average rate of gross product TFP growth was 1.01 percent per year. Therefore switching to the more appropriate net approach does not substantially increase Canadian business sector TFP growth on average. Table 1.9 shows

[21] From Table 2.13, we estimate the price of agricultural land increased 19.26 fold and the price of business non-agricultural land increased 52.46 fold over the period 1961-2007. For comparison purposes, the price of residential land increased 88.93 fold over this period.

the breakdown of the net TFP growth and the averages over subperiods.

Figures 1.2 and 1.3 show the levels of productivity and the rates of productivity growth using the two approaches. Throughout the sample period, the level of productivity calculated using the net output approach is constantly higher than the one using the gross output approach. However, the difference between the rates of productivity growth is not as clear.

Figure 1.2: Level of Total Factor Productivity in Canada 1961-2007

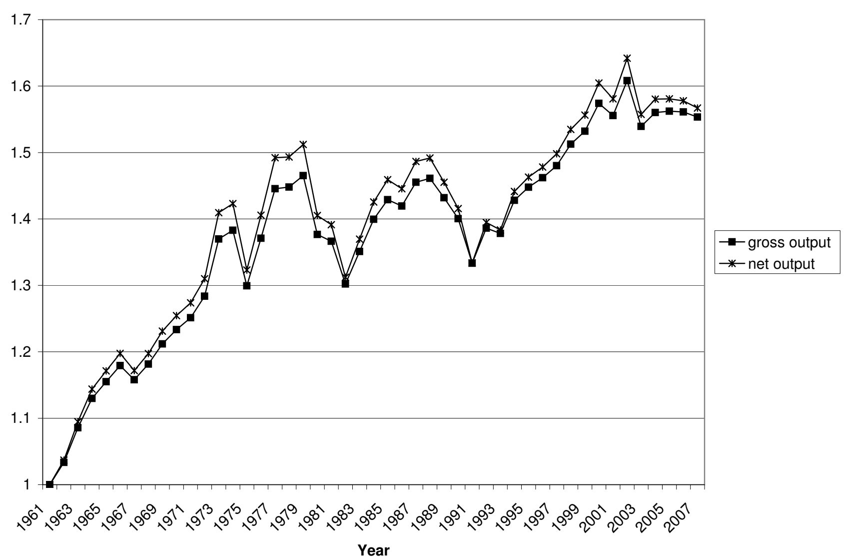
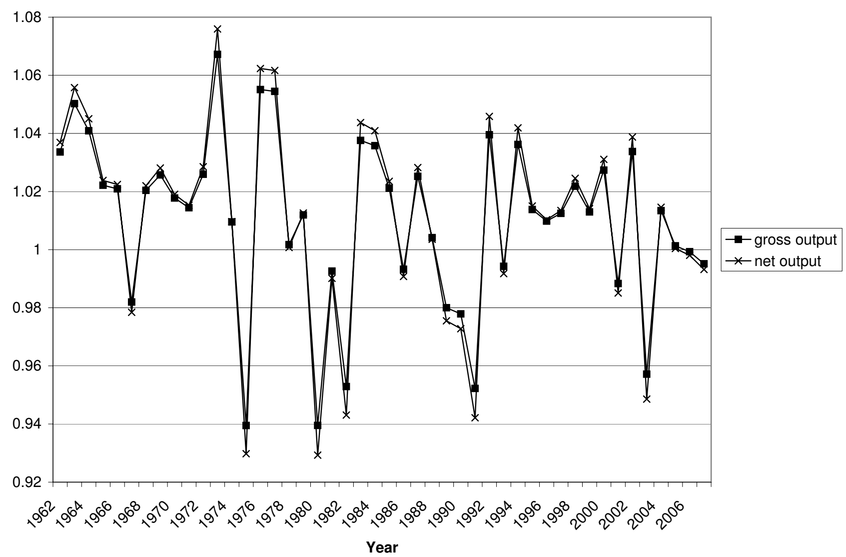


Figure 1.3: Rate of Productivity Growth in Canada 1962-2007



The net counterpart to Table 1.3 is Table 1.8; ρ^t now represents the *net real income* generated by the Canadian business sector in year t.

Table 1.8: Net Real Income Generated by the Canadian Business Sector and Real Output and Input Prices

Year t	ρ^t	$\frac{P_D^t}{P_C^t}$	$\frac{P_X^t}{P_C^t}$	$\frac{P_M^t}{P_C^t}$	$\frac{P_L^t}{P_C^t}$	$\frac{P_K^t}{P_C^t}$
1961	24422	1.00000	1.00000	1.00000	1.00000	1.00000
1962	26058	0.99939	1.02441	1.05221	1.03070	1.00974
1963	28025	0.99899	1.01959	1.07440	1.04457	1.18628
1964	30616	1.00130	1.03178	1.07897	1.08407	1.29219
1965	33166	1.00720	1.04137	1.06292	1.14063	1.28244
1966	35880	1.00591	1.04554	1.04070	1.17085	1.33315
1967	36195	1.00606	1.03936	1.03040	1.20074	1.10890
1968	37633	1.00484	1.04299	1.01353	1.22968	1.15688
1969	39687	1.00556	1.03453	1.00561	1.27918	1.14115
1970	41119	1.00818	1.03684	0.99801	1.31970	1.14323
1971	43096	1.02086	1.02983	0.99976	1.38213	1.07066
1972	46143	1.02647	1.02679	0.98191	1.43547	1.12226
1973	54045	1.03851	1.09186	0.97989	1.46916	1.70300
1974	57540	1.03945	1.20773	1.03952	1.48403	1.82225
1975	53111	1.02407	1.18933	1.03749	1.48373	1.22055
1981	58173	1.03257	1.20436	1.01115	1.62875	1.28882
1977	61637	1.03101	1.23160	1.06923	1.66796	1.44430
1978	63509	1.02855	1.24889	1.10217	1.61219	1.55383
1979	68569	1.02854	1.33303	1.13456	1.57294	1.85804
1980	67795	1.02365	1.38578	1.10560	1.52796	1.67616
1981	68556	1.02713	1.35379	1.10592	1.55517	1.48153
1982	61489	1.02092	1.26657	1.06522	1.55492	1.02681
1983	64662	1.01453	1.19845	0.98845	1.50751	1.40375
1984	68848	1.01184	1.18852	0.99092	1.51616	1.56781

Continued on Next Page...

Table 1.8 – Continued

Year t	ρ^t	$\frac{P_D^t}{P_C^t}$	$\frac{P_X^t}{P_C^t}$	$\frac{P_M^t}{P_C^t}$	$\frac{P_L^t}{P_C^t}$	$\frac{P_K^t}{P_C^t}$
1985	72791	1.01260	1.17680	0.98779	1.54643	1.60467
1986	74417	1.01652	1.14888	0.98427	1.55157	1.49482
1987	81494	1.02269	1.14386	0.94720	1.56791	1.76824
1988	86322	1.02393	1.11713	0.89981	1.62727	1.70243
1989	87573	1.02466	1.10764	0.87290	1.64897	1.54138
1990	83886	1.01047	1.04058	0.83723	1.61916	1.30641
1991	75908	1.00057	0.95210	0.77977	1.59932	0.91385
1992	78088	0.99876	0.96629	0.80078	1.60776	1.09605
1993	78353	0.99780	0.98975	0.82753	1.57292	1.11390
1994	84512	1.00358	1.04241	0.87214	1.55383	1.44816
1995	89997	1.00482	1.10432	0.89260	1.57284	1.64053
1996	93584	0.99672	1.08824	0.86345	1.56090	1.76806
1997	96925	0.99315	1.07285	0.85325	1.59315	1.71772
1998	99689	0.99228	1.05630	0.87031	1.61741	1.62817
1999	105696	0.99237	1.05044	0.85157	1.62855	1.76989
2000	115943	0.99119	1.08681	0.84546	1.66490	2.09789
2001	114445	0.98781	1.07272	0.84740	1.65956	1.89274
2002	119071	0.99117	1.03862	0.84254	1.66043	2.04835
2003	118949	0.99021	1.00574	0.76841	1.64948	1.95581
2004	128508	0.99446	1.01594	0.73855	1.66584	2.28119
2005	134333	0.99788	1.02342	0.71436	1.69218	2.42060
2006	138557	1.00560	1.00779	0.69673	1.73717	2.35515
2007	145019	1.01256	0.99980	0.66728	1.76887	2.41624

Table 1.9: Business Sector Year to Year Growth in Net Real Income and Net Year to Year Contribution Factors

Year t	$\frac{\rho^t}{\rho^{t-1}}$	τ^t	α_D^t	α_X^t	α_M^t	β_L^t	β_K^t	α_{XM}^t
1962	1.06695	1.03690	0.99936	1.00682	0.98365	1.03439	1.00509	0.99037
1963	1.07552	1.05573	0.99958	0.99866	0.99342	1.02062	1.00654	0.99209
1964	1.09244	1.04503	1.00235	1.00352	0.99868	1.03219	1.00817	1.00219
1965	1.08330	1.02381	1.00602	1.00279	1.00483	1.03441	1.00908	1.00764
1966	1.08183	1.02242	0.99868	1.00121	1.00702	1.03875	1.01165	1.00824
1967	1.00877	0.97846	1.00016	0.99807	1.00342	1.01676	1.01232	1.00148
1968	1.03974	1.02199	0.99878	1.00122	1.00592	1.00337	1.00799	1.00714
1969	1.05457	1.02808	1.00073	0.99708	1.00296	1.01835	1.00651	1.00003
1970	1.03608	1.01904	1.00263	1.00083	1.00289	1.00256	1.00771	1.00372
1971	1.04810	1.01527	1.01250	0.99741	0.99934	1.01734	1.00547	0.99676
1972	1.07070	1.02854	1.00555	0.99887	1.00709	1.02456	1.00446	1.00595
1973	1.17124	1.07552	1.01191	1.02388	1.00082	1.04429	1.00568	1.02472
1974	1.06467	1.00963	1.00093	1.03955	0.97585	1.02594	1.01228	1.01445
1975	0.92302	0.93008	0.98430	0.99415	1.00087	0.99924	1.01408	0.99501
1981	1.09531	1.06233	1.00882	1.00478	1.01144	0.99915	1.00651	1.01627
1977	1.05956	1.06162	0.99842	1.00869	0.97623	1.00846	1.00663	0.98472
1978	1.03037	1.00074	0.99754	1.00571	0.98666	1.03229	1.00764	0.99229
1979	1.07966	1.01254	0.99999	1.02844	0.98677	1.04236	1.00801	1.01484
1980	0.98872	0.92929	0.99516	1.01757	1.01214	1.02525	1.01249	1.02992
1981	1.01123	0.99015	1.00348	0.98937	0.99986	1.02031	1.00834	0.98923
1982	0.89691	0.94322	0.99391	0.96965	1.01780	0.96092	1.00885	0.98690
1983	1.05161	1.04339	0.99387	0.97483	1.03347	1.00546	1.00113	1.00745
1984	1.06473	1.04092	0.99739	0.99609	0.99886	1.02789	1.00279	0.99495
1985	1.05728	1.02351	1.00075	0.99518	1.00152	1.03017	1.00531	0.99670
1986	1.02234	0.99078	1.00390	0.98843	1.00176	1.03236	1.00552	0.99017
1987	1.09509	1.02822	1.00612	0.99793	1.01871	1.03633	1.00477	1.01659
1988	1.05925	1.00358	1.00122	0.98918	1.02427	1.03381	1.00644	1.01319

Continued on Next Page. . .

Table 1.9 – Continued

Year t	$\frac{\rho^t}{\rho^{t-1}}$	τ^t	α_D^t	α_X^t	α_M^t	β_L^t	β_K^t	α_{XM}^t
1989	1.01449	0.97551	1.00072	0.99614	1.01449	1.02035	1.00782	1.01058
1990	0.95790	0.97280	0.98583	0.97186	1.02025	1.00094	1.00640	0.99155
1991	0.90490	0.94235	0.98998	0.95890	1.03585	0.97366	1.00297	0.99327
1992	1.02871	1.04579	0.99815	1.00731	0.98635	0.99178	1.00010	0.99356
1993	1.00340	0.99177	0.99902	1.01303	0.98186	1.01790	1.00025	0.99466
1994	1.07861	1.04182	1.00581	1.03168	0.96871	1.03047	0.99950	0.99940
1995	1.06490	1.01503	1.00121	1.03853	0.98545	1.02197	1.00188	1.02342
1996	1.03985	1.01029	0.99235	0.99006	1.02114	1.02164	1.00419	1.01099
1997	1.03570	1.01346	0.99657	0.99019	1.00777	1.02386	1.00370	0.99788
1998	1.02852	1.02454	0.99914	0.98892	0.98629	1.02383	1.00616	0.97536
1999	1.06026	1.01408	1.00009	0.99586	1.01562	1.02730	1.00618	1.01141
2000	1.09695	1.03105	0.99888	1.02656	1.00509	1.02609	1.00605	1.03178
2001	0.98708	0.98508	0.99688	0.99002	0.99844	1.00973	1.00708	0.98847
2002	1.04043	1.03876	1.00315	0.97657	1.00382	1.01586	1.00263	0.98029
2003	0.99897	0.94856	0.99909	0.97802	1.06051	1.01173	1.00451	1.03720
2004	1.08037	1.01455	1.00406	1.00672	1.02453	1.02607	1.00212	1.03142
2005	1.04532	1.00040	1.00326	1.00479	1.02017	1.01062	1.00538	1.02506
2006	1.03145	0.99804	1.00745	0.99032	1.01498	1.01303	1.00744	1.00516
2007	1.04664	0.99318	1.00676	0.99519	1.02549	1.01799	1.00754	1.02056
Averages								
1962-2007	1.04070	1.01040	1.00030	0.99958	1.00510	1.01850	1.00620	1.00450
1962-1973	1.06910	1.02920	1.00320	1.00250	1.00080	1.02400	1.00760	1.00340
1974-1991	1.02090	0.99781	0.99791	0.99591	1.00650	1.01530	1.00710	1.00210
1992-1999	1.04250	1.01960	0.99904	1.00690	0.99415	1.01980	1.00270	1.00080
2000-2007	1.04090	1.00120	1.00240	0.99602	1.01910	1.01640	1.00530	1.01500

Note that from Tables 1.8, the starting level of net real income in 1961, \$24,422 million, is less than the corresponding starting value of gross real income in 1961 from Tables 1.3, which was \$27,722 million (see Figure 1.4). This makes sense since we now subtract depreciation from the previous estimates of gross income. Net real income generated by the Canadian business sector grew 5.94 fold over the period 1961-2007 which is 2.5 percent less than the 6.09 fold growth of gross real income. The real price of waiting capital services grew 2.42 fold, which is more rapid than the previous 1.68 fold increase in the real price of gross capital services. This difference is due to the fact that depreciation gave the prices of ICT and other machinery and equipment (which decreases in real terms) a larger role in the price of gross capital services but when depreciation is regarded as an intermediate input, the price of land (which increases in real terms) gets a much larger weight in the price of waiting capital services.

The same translog contributions methodology explained in Section 1.8 can be applied to the net output model used in this section. Thus Equation (1.3) in the last section is applicable to our new measure of real income generated by the Canadian business sector and Table 1.9 shows the net income generated (counterpart to Table 1.4). The contribution of the combined effects of real changes in international prices ($\alpha_{XM}^{t} - 1$) and the changes in real income ($[\rho^{t}/\rho^{t-1}] - 1$) in 1962-2007 using the net approach are also depicted in Figure 1.5.

Figure 1.4: Real Income Generated by the Business Sector in Canada 1961-2007

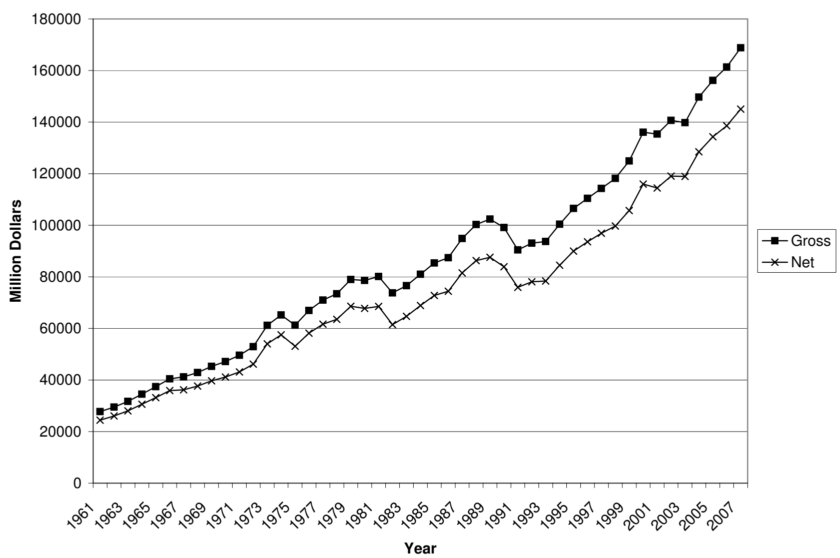
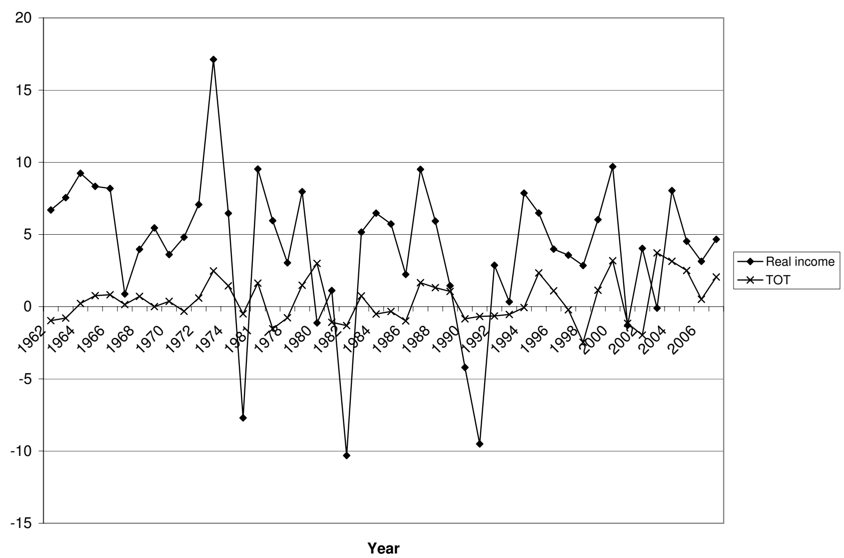


Figure 1.5: Real Income Change and Terms of Trade Contribution 1962-2007 (Net Output Approach)



The net real income generated by the Canadian business sector grew at an annual rate of 4.07 percent on average over the 47 year period (1961-2007), which is slightly less than the gross real income growth rate of 4.10 percent. Real domestic output prices averaged a tiny positive contribution to the growth in real net income of 0.03 per year and falling real export prices made a tiny negative contribution of −0.04 per year. Positive average contributions to the growth of real net income were due to productivity improvements (1.04 per year compared to 1.01 in the gross output framework), growth of labour input (1.85 per year compared to the previous gross income 1.60), growth of capital input (0.62 per year compared to the previous 1.13) and falls in real import prices (0.51 per year compared to the previous 0.43). Comparing these average contribution growth rates in the gross and net real income frameworks leads to the following observations:

- The role of productivity improvements is *magnified* in the net output framework compared to the gross output framework;[22]
- The role of increases in labour input is also *magnified* in the net output framework;
- The role of increases in capital input (capital deepening) is greatly *diminished* in the net income framework and
- The role of falling real import prices is also *magnified* in the net output framework.

During the naughts, the average contribution factor for changes in real export and import prices together was 1.28 percentage points per year in

[22]This phenomenon is reasonably well known and is explained in Schreyer (2001): as the input denominator in a total factor productivity measure shrinks (by treating inputs as negative outputs and placing them in the net output numerator), the resulting measure of TFP will increase. This magnification effect shows up most clearly during periods of large productivity growth; i.e. during the period 1962-1973, the average net TFP growth was 2.92% per year compared to the average gross rate of 2.68% and during the period 1992-1999, the average net TFP growth rate was 1.96% per year compared to the average gross rate of 1.76%.

the gross framework and 1.50 percentage points per year in the net framework. The corresponding contribution factor for capital growth during the naughts was 1.01 percentage points in the gross framework and 0.53 percentage points in the net framework. Looking at the contribution of falling import prices alone in the net output framework, during the entire sample period, falling import prices contributed about 0.51 percentage points per year to real income growth whereas the effects of net capital accumulation contributed about 0.62 percentage points per year. During the years of the present decade, falling import prices contributed a very large 1.91 percentage points per year to real income growth whereas the effects of net capital accumulation contributed only 0.53 percentage points per year and TFP improvements contributed only 0.12 percentage points per year. Thus for short periods, changes in the real export or import prices that a country faces can have substantially larger effects on living standards than the effects of net capital accumulation or improvements in TFP.

The average annual rate of TFP growth in the net output framework was a satisfactory 1.04 percentage points per year. As usual, there are considerable variations in the average over different periods. During the golden years, 1962-1973, TFP growth averaged a spectacular 2.92 percentage points per year. During the dismal years, 1974-1991, TFP growth actually averaged −0.22 percentage points per year. The TFP growth recovered during 1992-1999 to average a respectable 1.96 percentage points per year. However, during the years 2000-2007, net TFP growth fell to 0.12 percentage points per year, and the decline can be explained all by two poor performance years (2001 and 2003). When these two years are excluded, the TFP growth averaged 1.27 percentage points.

The year to year growth presented in Table 1.9 can be cumulated and the decomposition given by Equation (1.5) in the last section is applied to the new net data. The cumulated variables are shown in Table 1.10.

The net real income generated by the business sector grew 5.94 fold over the years 1961-2007. The main factors explaining this growth are growth of labour input (cumulative growth factor factor 2.31), productivity increases (cumulative growth factor 1.57), growth of waiting capital services (cumulative growth factor 1.33), lower real import prices (cumulative factor 1.25)[23] and higher real domestic output prices (cumulative growth factor 1.01). There was a small negative contribution from declining real export prices (cumulative growth factor 0.97).

[23] Note that most of this growth took place over the years 2001-2007.

Table 1.10: Business Sector Cumulated Growth in Net Real Income and Cumulated Contribution Factors

Year t	$\frac{\rho^t}{\rho^{1961}}$	T^t	A_D^t	A_X^t	A_M^t	B_L^t	B_K^t	A_{XM}^t
1961	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
1962	1.06695	1.03690	0.99936	1.00682	0.98365	1.03439	1.00509	0.99037
1963	1.14753	1.09468	0.99895	1.00548	0.97718	1.05572	1.01166	0.98254
1964	1.25360	1.14397	1.00130	1.00902	0.97589	1.08970	1.01993	0.98469
1965	1.35802	1.17121	1.00732	1.01184	0.98060	1.12720	1.02920	0.99221
1966	1.46915	1.19747	1.00599	1.01306	0.98749	1.17088	1.04118	1.00039
1967	1.48203	1.17168	1.00615	1.01111	0.99086	1.19050	1.05401	1.00187
1968	1.54093	1.19745	1.00492	1.01234	0.99672	1.19452	1.06243	1.00902
1969	1.62502	1.23108	1.00565	1.00939	0.99967	1.21644	1.06935	1.00906
1970	1.68365	1.25452	1.00830	1.01022	1.00256	1.21955	1.07760	1.01281
1971	1.76462	1.27368	1.02091	1.00761	1.00190	1.24070	1.08349	1.00953
1972	1.88938	1.31002	1.02657	1.00647	1.00901	1.27116	1.08832	1.01553
1973	2.21292	1.40896	1.03879	1.03050	1.00983	1.32747	1.09450	1.04063
1974	2.35603	1.42253	1.03975	1.07126	0.98545	1.36190	1.10794	1.05567
1975	2.17468	1.32306	1.02343	1.06499	0.98630	1.36086	1.12354	1.05040
1976	2.38194	1.40553	1.03246	1.07008	0.99758	1.35971	1.13085	1.06749
1977	2.52380	1.49215	1.03083	1.07939	0.97387	1.37121	1.13835	1.05118
1978	2.60045	1.49325	1.02829	1.08555	0.96087	1.41549	1.14704	1.04308
1979	2.80761	1.51198	1.02828	1.11643	0.94816	1.47544	1.15623	1.05856
1980	2.77594	1.40507	1.02330	1.13605	0.95967	1.51269	1.17067	1.09023
1981	2.80710	1.39124	1.02686	1.12397	0.95954	1.54342	1.18044	1.07849
1982	2.51771	1.31225	1.02061	1.08985	0.97661	1.48310	1.19088	1.06436
1983	2.64765	1.36919	1.01435	1.06242	1.00930	1.49120	1.19222	1.07230
1984	2.81903	1.42521	1.01171	1.05826	1.00815	1.53279	1.19555	1.06689
1985	2.98050	1.45871	1.01246	1.05316	1.00969	1.57904	1.20190	1.06336
1986	3.04707	1.44526	1.01641	1.04097	1.01146	1.63013	1.20853	1.05291
1987	3.33683	1.48605	1.02263	1.03882	1.03038	1.68935	1.21430	1.07038

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Table 1.10 – Continued

Year t	$\frac{\rho^t}{\rho^{1961}}$	T^t	A_D^t	A_X^t	A_M^t	B_L^t	B_K^t	A_{XM}^t
1988	3.53455	1.49137	1.02388	1.02758	1.05539	1.74646	1.22212	1.08450
1989	3.58575	1.45484	1.02462	1.02362	1.07068	1.78199	1.23167	1.09597
1990	3.43478	1.41527	1.01011	0.99481	1.09237	1.78368	1.23956	1.08670
1991	3.10813	1.33368	0.99998	0.95392	1.13153	1.73670	1.24324	1.07939
1992	3.19738	1.39475	0.99813	0.96090	1.11609	1.72243	1.24336	1.07244
1993	3.20824	1.38326	0.99715	0.97342	1.09584	1.75326	1.24367	1.06672
1994	3.46043	1.44111	1.00295	1.00426	1.06155	1.80668	1.24305	1.06607
1995	3.68503	1.46276	1.00416	1.04295	1.04611	1.84638	1.24539	1.09104
1996	3.83187	1.47781	0.99648	1.03258	1.06822	1.88633	1.25061	1.10302
1997	3.96868	1.49771	0.99306	1.02245	1.07652	1.93133	1.25523	1.10069
1998	4.08186	1.53446	0.99220	1.01112	1.06176	1.97735	1.26297	1.07356
1999	4.32783	1.55606	0.99229	1.00693	1.07835	2.03132	1.27078	1.08582
2000	4.74740	1.60437	0.99119	1.03367	1.08383	2.08432	1.27846	1.12032
2001	4.68605	1.58043	0.98809	1.02335	1.08214	2.10460	1.28752	1.10741
2002	4.87549	1.64169	0.99121	0.99937	1.08627	2.13798	1.29090	1.08559
2003	4.87047	1.55724	0.99030	0.97741	1.15200	2.16307	1.29673	1.12597
2004	5.26189	1.57990	0.99433	0.98398	1.18026	2.21947	1.29948	1.16135
2005	5.50038	1.58054	0.99756	0.98870	1.20406	2.24303	1.30647	1.19045
2006	5.67335	1.57743	1.00500	0.97913	1.22210	2.27225	1.31619	1.19659
2007	5.93796	1.56668	1.01179	0.97442	1.25325	2.31313	1.32611	1.22119

1.5 Productivity Performance Comparison with Other Countries

Canada's official productivity growth rate of 0.70 percent per year (1962-2008) had led to worries of low productivity performance comparing to fellow industrial countries and stimulated many discussions on how to close the wide "productivity gap" between Canada and the U.S. According to Statistics Canada official estimates, between 1961 and 2008 (shown in Table 1.11), productivity in Canada rose 2.0% a year on average, while productivity grew 2.3% on average in the United States. This comparison shows that the average labour productivity growth in Canada has been satisfactory as compared to the United States in the last four decades. However, when the focus is restricted to the present decade, the productivity growth rate is estimated to be only 0.7% per year in Canada while the United States grew 2.6% per year. Statistics Canada decomposed the labour productivity growth into three components: capital deepening, labour composition change and multifactor productivity growth. The results of their decomposition shows that contributions of the first two components are similar in the two countries, and the slow growth in productivity in Canada post-2000 was entirely contributed by the slow growth in multifactor productivity.

In the previous section, we had shown that it is possible to estimate well using the "top down" approach and our estimates seem reasonable. Our TFP (multifactor) growth by the net approach is 1.04% (1961-2007) while the official estimate is 0.38% (1961-2007). The large difference between our estimate and the official estimate suggests that there may be possibility of miscalculation in the official estimates. Now if this is truly the case, then the so called "productivity gap" between Canada and the U.S. should in fact be narrower than we had initially thought.

How does Canada compare with other developed countries? Base on the same net output approach used in this chapter, Diewert, Mizobuchi and Nomura (2005) had estimated the productivity performances in Japan (1956-

Table 1.11: Average Productivity Growth in Canada and the United States, 1961-2008

		1961-2008	2000-2008
		percent per year[a]	
Canada	**Output per hour worked**	2.0	0.7
	Contribution of capital deepening	1.3	1.1
	Contribution of labour compensation	0.4	0.3
	Multifactor productivity growth	0.3	−0.6
United States	**Output per hour worked**	2.3	2.6
	Contribution of capital deepening	0.8	1.0
	Contribution of labour compensation	0.2	0.2
	Multifactor productivity growth	1.2	1.4

[a] Source: The Canadian Productivity Review, 15-206-X no.025, Statistics Canada

2003) and Diewert and Lawrence (2006) for Australia (1961-2004). Table 1.12 summarises the estimated results of Canada, Japan and Australia in the same subperiods.

Overall, the average real income growth rates of all three countries are very close, all of which had an estimated rate of approximately 4.00 percent. In all subperiods, Canada had been similar to Australia in terms of real income growth rate. Japan, on the other hand, had a substantial decline in real income growth since 1992. However, Canada is the lowest in the three countries for TFP growth. In the subperiod 1962-1973, Canada had a higher TFP growth rate than Australia. But the situation had reversed since; Australia had outperformed Canada in all the remaining subperiods. Japan had experienced low growth in TFP in 1992-1999 but had somewhat recovered in 2000 onward. Thus, the three countries have similar average real income growth but very different TFP growth. The average TFP growth in Canada had been reasonable compared to other countries, and certainly not as poor as official estimates had shown.

Table 1.12: Real Income and TFP Growth of Canada, Japan and Australia

		Average Growth Rate (%)				
		1962-	**1962-1973**	**1974-1991**	**1992-1999**	**2000-**
$\frac{\rho^t}{\rho^{t-1}}$	**Canada**	4.07	6.91	2.09	4.25	4.09
	Japan	3.94	8.79	3.21	0.02	0.47
	Australia	3.78	5.66	2.52	3.52	4.26
τ^t	**Canada**	1.04	2.92	0.00	1.96	0.12
	Japan	2.86	6.08	2.33	0.13	1.03
	Australia	1.86	2.62	1.12	2.80	1.16

Recall that we had shown earlier that Canada had benefited most from increases in labour and capital inputs, and productivity improvement. The contribution of terms of trade improvements was also significant and positive for all subperiods. However, this is not the case in Australia and Japan. Diewert and Lawrence (2006) showed that terms of trade improvement was transitory in Australia: in 1974-1991 and 1992-1999, the contributions of terms of trade were negative. Similar results were found in Japan by Diewert, Mizobuchi and Nomura (2005). This transitory property of terms of trade contributions had caused the overall effect of international prices changes to be much smaller as compared to what was found in Canada. The comparison between these countries shows that Canada had generated similar real income growth rates as other developed countries through the additional benefit of terms of trade improvement over short period of time. However, it is still lagging behind in the TFP improvements. Higher TFP growth is important for income growth to be sustainable. Thus, the worries of the Canadian government are not totally unfounded, policies to encourage technology advancement are needed in the long term.

In the following section, we will use our disaggregated data on exports and imports and our net output methodology to determine the effects of changing disaggregated real export and import prices on the growth of real income generated by the production sector.

1.6 The Effects of Changing Real Export and Import Prices on Real Income Growth

We generate real price series for eight export sectors and seven import sectors using value and quantity series from disaggregated trade data. Details describing the actual construction of these price indexes are shown in Chapter 2. The export commodity classes are as follows,

- X_1, Exports of agricultural and fish products;
- X_2, Exports of energy products;
- X_3, Exports of forest products;
- X_4, Exports of industrial goods and materials (excluding energy and forest product exports);
- X_5, Exports of machinery and equipment (excluding automotive products);
- X_6, Exports of automotive products;
- X_7, Exports of other consumer goods (excluding automotive products);
- X_8, Exports of services;

and the import commodity classes are,

- M_1, Imports of agricultural and fish products;
- M_2, Imports of energy products;
- M_3, Imports of industrial goods and materials (including imports of forest products but excluding imports of energy products);

- M_4, Imports of machinery and equipment (excluding automotive products);
- M_5, Imports of automotive products;
- M_6, Imports of other consumer goods and
- M_7, Imports of services.

The values, prices and quantities of Canadian export that we constructed are depicted in Figures 1.6-1.8; and the values, prices and quantities of Canadian imports are shown in Figures 1.9-1.11. As can be seen in Figure 1.6, the export values of forest products, agricultural products and other consumer goods remained rather steady over the sample period. The services sector had grown a lot during 1980s and 1990s in its value of export but the growth seemed to have stopped since. On the other hand, industrial goods and materials (excluding energy and forest products), machinery and equipments, energy products and automotive products all had increased quite a great deal. For the export prices, most of the sectors had steady growth throughout the sample period as shown in Figure 1.7. The only exception is the energy sector which experienced huge price increase in the recent years. The export quantities depicted in Figure 1.8 show that machinery and equipment had been the fastest growing in export quantity component. Automotive products and industrial goods were also impressive in terms of growth. The other sectors had been rather slow in growth or stagnant through out the sample period.

As can be seen in Figure 1.9, the most rapid growing value of imports was machinery and equipment but the growth leveled off during the last ten years. Imports of industrial goods and materials, services imports and automotive imports all grew at similarly moderate rate, while imports of other consumer goods, energy products and agricultural products all experienced little growth only. As energy prices are determined internationally, the price of energy imports grew most as in the case of exports. Prices of other imports as shown in Figure 1.10 show they grew much slower and at similar rate. For import quantities (shown in Figure 1.11), machinery and equipment grew the fastest, this reflects Statistics Canada had quality adjusted the prices of information and computer technological devices. The rest of the import sectors seemed to be growing only moderately and at similar rate in quantity. Comparing Figures 1.7 and 1.10, it can be seen that the export prices increase more rapidly than the import prices, and this leads to the improvement in Canadian terms of trade and in living standards.

Figure 1.6: Canadian Export Values 1961-2007

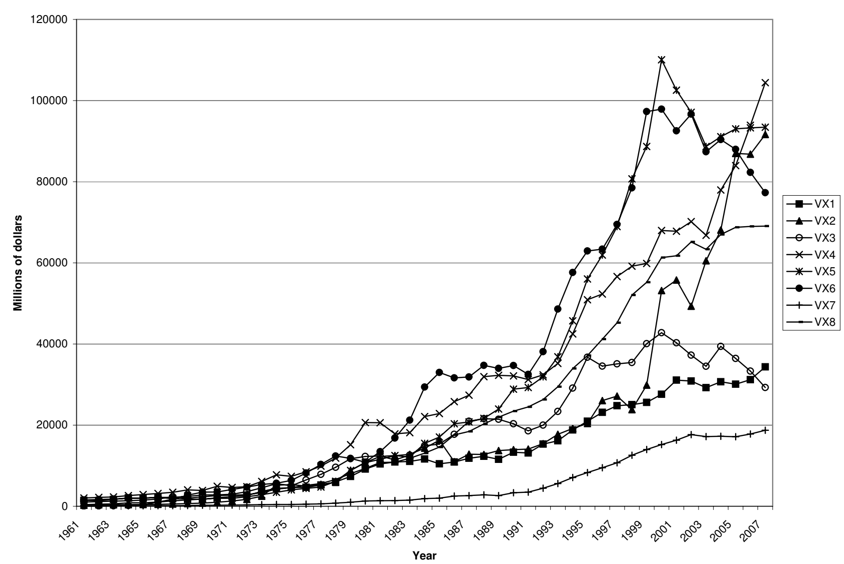


Figure 1.7: Canadian Export Prices 1961-2007

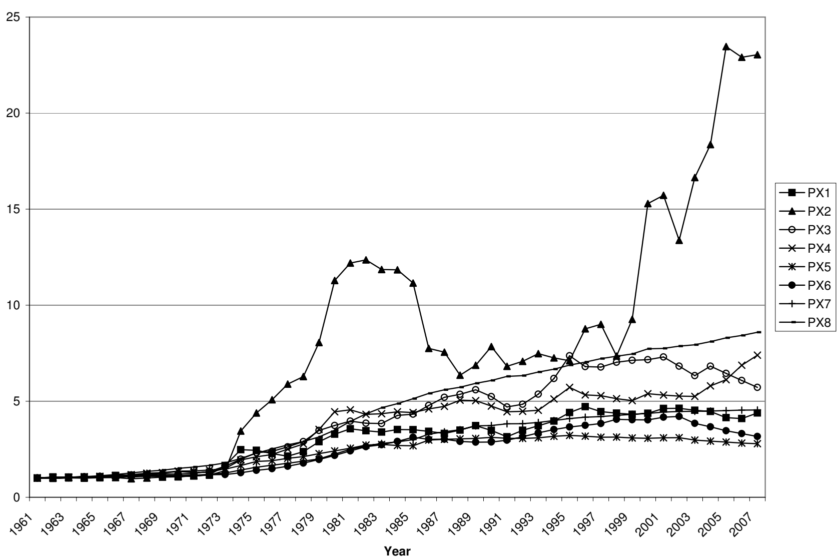


Figure 1.8: Canadian Export Quantities 1961-2007

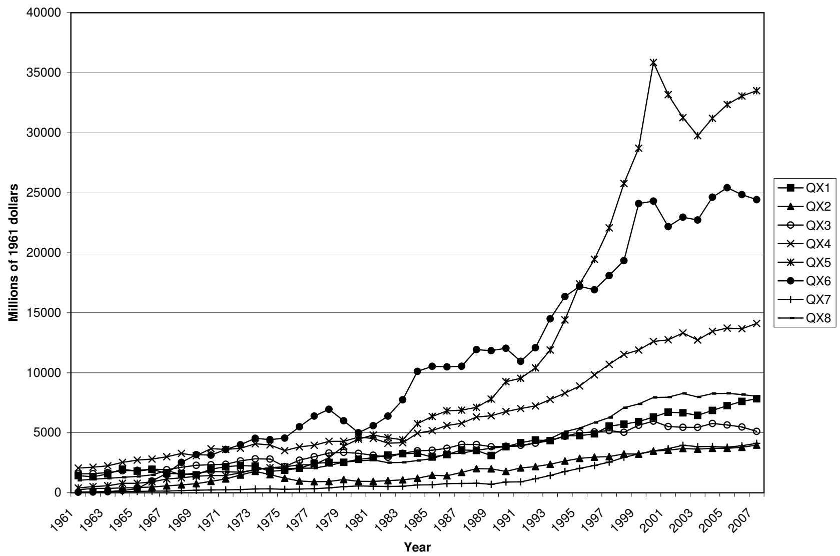


Figure 1.9: Canadian Import Values 1961-2007

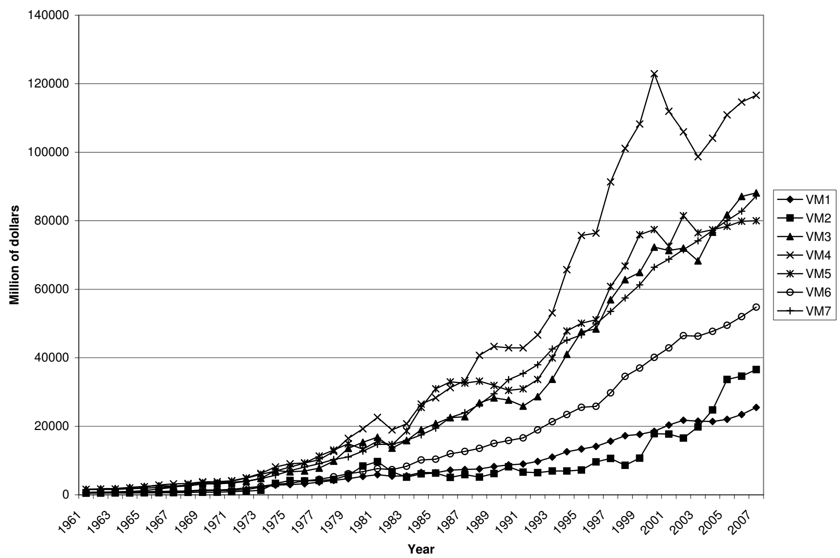


Figure 1.10: Canadian Import Prices 1961-2007

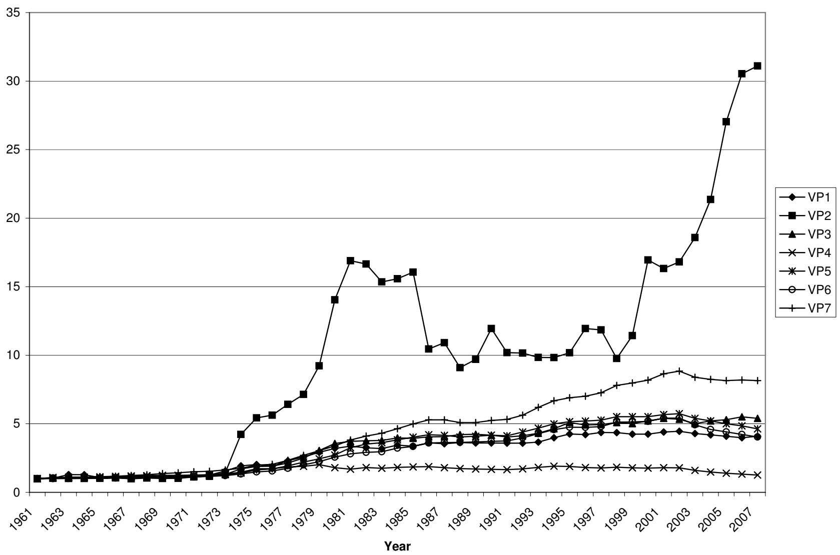
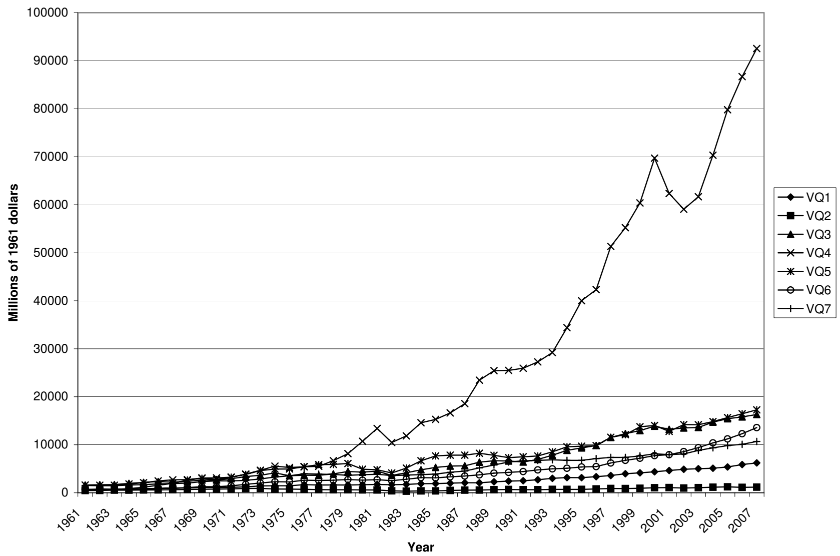


Figure 1.11: Canadian Import Quantities 1961-2007



The methodology explained in Section 1.8 can be used to work out the contribution of each change in the real export price for our eight classes of exports to the business sector real income growth. Table 1.13 can be viewed as a decomposition of the aggregate export contribution factor α_X^t which appeared in Table 1.4 of the previous section into eight commodity specific factors, α_{X1}^t to α_{X8}^t, which multiply together to yield the overall export contribution factor α_X^t.

$$\alpha_X^t = \alpha_{X1}^t \alpha_{X2}^t \alpha_{X3}^t \alpha_{X4}^t \alpha_{X5}^t \alpha_{X6}^t \alpha_{X7}^t \alpha_{X8}^t \tag{1.7}$$

The arithmetic averages of the contribution factors for the years 1962-2007 are listed in the last row of Table 1.13. The average contribution factors for the eight classes of exports are as follows. The increases in real energy products export prices had contributed an average of 0.16 percentage points to real income growth. Real export price increases in materials, services and forest products had contributed on average 0.04, 0.03 and 0.01 percentage points respectively. The big negative contributors were machinery and equipment and autos which by their increases in export prices contributed −0.14 and −0.11 percentage points on average. Both agricultural products and other consumer goods had minor negative contributions (−0.02 and −0.006 percentage points). Overall the cumulative effects of real export price changes were not large.

Table 1.13: Year to Year Export Contribution Factors Using the Gross Output Approach

Year t	α^t_{X1}	α^t_{X2}	α^t_{X3}	α^t_{X4}	α^t_{X5}	α^t_{X6}	α^t_{X7}	α^t_{X8}
1961	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
1962	1.00246	0.99979	1.00175	1.00105	1.00047	1.00001	0.99998	1.00050
1963	0.99909	1.00013	0.99984	0.99946	0.99993	1.00000	0.99999	1.00038
1964	1.00024	0.99981	1.00077	1.00085	1.00029	1.00003	1.00005	1.00108
1965	1.00005	1.00009	1.00025	1.00082	1.00027	0.99990	0.99999	1.00110
1966	1.00105	0.99965	0.99910	1.00106	0.99995	0.99962	0.99995	1.00069
1967	0.99912	0.99892	0.99937	0.99955	1.00024	0.99947	0.99995	1.00169
1968	0.99842	1.00004	0.99947	1.00204	1.00080	0.99926	0.99996	1.00108
1969	0.99775	1.00020	1.00063	0.99980	0.99970	0.99862	1.00003	1.00070
1970	0.99799	0.99978	0.99837	1.00243	1.00121	0.99960	0.99985	1.00150
1971	1.00017	1.00058	1.00064	0.99524	0.99947	1.00035	0.99997	1.00133
1972	1.00062	0.99975	1.00186	0.99786	0.99977	0.99863	0.99993	1.00059
1973	1.01170	1.00227	1.00621	1.00512	0.99895	0.99633	0.99997	1.00025
1974	1.01167	1.01381	1.00379	1.00950	0.99948	0.99661	0.99995	0.99960
1975	0.99357	1.00875	1.00085	0.99584	0.99932	0.99734	0.99982	0.99942
1976	0.99550	1.00655	0.99938	1.00068	0.99921	1.00080	1.00007	1.00193
1977	0.99542	1.00491	1.00152	1.00382	0.99996	1.00128	0.99998	1.00067
1978	1.00112	1.00101	1.00138	1.00165	0.99880	1.00162	0.99994	0.99942
1979	1.00390	1.00475	1.00535	1.01165	0.99911	1.00036	0.99984	0.99948
1980	1.00059	1.01020	0.99756	1.01039	0.99739	0.99936	1.00002	0.99968
1981	0.99965	0.99911	0.99821	0.99362	0.99822	1.00063	1.00008	1.00132
1982	0.99470	0.99797	0.99410	0.98862	0.99867	0.99986	0.99987	1.00027
1983	0.99600	0.99596	0.99645	0.99553	0.99710	0.99767	0.99988	1.00007
1984	0.99986	0.99692	1.00309	0.99859	0.99680	1.00148	0.99992	1.00005
1985	0.99878	0.99680	0.99926	0.99713	0.99824	1.00461	1.00007	1.00103
1986	0.99854	0.98521	1.00399	1.00146	1.00474	0.99414	1.00048	1.00147
1987	0.99813	0.99830	1.00334	1.00036	0.99942	0.99806	1.00009	1.00053

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Table 1.13 – Continued

Year t	α^t_{X1}	α^t_{X2}	α^t_{X3}	α^t_{X4}	α^t_{X5}	α^t_{X6}	α^t_{X7}	α^t_{X8}
1988	1.00074	0.99338	1.00021	1.00308	0.99894	0.99445	1.00004	0.99985
1989	1.00108	1.00160	1.00074	0.99741	0.99889	0.99644	1.00017	1.00036
1990	0.99633	1.00251	0.99411	0.99146	0.99753	0.99582	0.99965	0.99836
1991	0.99523	0.99360	0.99252	0.99124	0.99535	0.99815	0.99975	0.99890
1992	1.00301	1.00080	1.00079	0.99933	0.99883	1.00391	0.99988	0.99959
1993	1.00162	1.00137	1.00417	0.99950	0.99939	1.00426	0.99997	1.00061
1994	1.00218	0.99856	1.00769	1.00981	1.00161	1.00497	1.00029	1.00116
1995	1.00412	0.99903	1.01136	1.01013	1.00106	1.00404	1.00031	1.00199
1996	1.00197	1.00840	0.99328	0.99105	0.99645	1.00045	0.99995	1.00012
1997	0.99693	1.00055	0.99879	0.99775	0.99595	1.00104	0.99984	1.00081
1998	0.99868	0.99053	1.00139	0.99571	0.99862	1.00535	1.00003	1.00032
1999	0.99868	1.00929	0.99979	0.99644	0.99571	0.99687	0.99991	0.99985
2000	0.99949	1.02921	0.99874	1.00405	0.99534	0.99595	0.99967	1.00076
2001	1.00108	0.99990	0.99941	0.99601	0.99679	1.00079	0.99974	0.99778
2002	0.99956	0.98790	0.99586	0.99798	0.99896	0.99959	0.99985	1.00029
2003	0.99818	1.01374	0.99544	0.99746	0.99209	0.98638	0.99949	0.99862
2004	0.99897	1.00663	1.00271	1.00759	0.99623	0.99343	0.99976	1.00050
2005	0.99670	1.01989	0.99665	1.00302	0.99619	0.99198	0.99970	1.00026
2006	0.99901	0.99604	0.99714	1.00937	0.99629	0.99433	0.99978	0.99976
2007	1.00169	0.99898	0.99747	1.00571	0.99727	0.99492	0.99971	1.00013
Average	0.99981	1.00160	1.00010	1.00040	0.99859	0.99889	0.99994	1.00030

As in the case of export prices, the import price cumulative contribution factor, α_M^t from Table 1.4 can be decomposed as a multiplicative contribution factors of the seven sectors as follows,

$$\alpha_M^t = \alpha_{M1}^t \alpha_{M2}^t \alpha_{M3}^t \alpha_{M4}^t \alpha_{M5}^t \alpha_{M6}^t \alpha_{M7}^t \tag{1.8}$$

Table 1.14 lists the decomposition of the aggregate import contribution factor from 1961 to 2007 constructed using the gross output approach. We calculate the arithmetic averages of these series to find the individual contribution factor of each import sector over the sample period. The biggest contribution was by the lower machinery and equipment real import prices which contributed 0.42 percentage points to the real income growth in the business sector. The lower real import prices in autos, other consumer goods, material and forest products and agricultural products also provided small contributions to the real income growth (0.05, 0.05, 0.04 and 0.02 percentage points respectively). However, the higher real energy products import prices had a negative contribution of −0.11 percentage points. Real services import prices also had −0.05 percentage points contribution. Overall, the cumulative effects of real import price changes using the gross output approach were rather large but most of the effects can be explained by the large contribution of lower machinery and equipment real import prices.

Table 1.14: Year to Year Import Contribution Factors Using the Gross Output Approach

Year t	α^t_{M1}	α^t_{M2}	α^t_{M3}	α^t_{M4}	α^t_{M5}	α^t_{M6}	α^t_{M7}
1961	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
1962	0.99874	0.99961	0.99670	0.99415	0.99894	0.99981	0.99754
1963	0.99376	1.00056	0.99909	1.00100	0.99996	1.00035	0.99948
1964	1.00066	1.00014	0.99901	1.00027	0.99953	0.99988	0.99934
1965	1.00535	0.99987	0.99962	0.99936	1.00083	1.00036	0.99889
1966	1.00137	1.00013	1.00229	1.00074	1.00077	1.00055	1.00035
1967	1.00143	1.00134	1.00032	1.00008	1.00020	1.00037	0.99926
1968	1.00014	0.99971	1.00310	1.00207	1.00021	1.00061	0.99935
1969	1.00060	1.00103	1.00046	1.00118	1.00054	1.00038	0.99839
1970	0.99914	1.00024	1.00083	1.00175	1.00102	1.00052	0.99903
1971	0.99983	0.99895	1.00293	0.99961	0.99933	1.00039	0.99839
1972	0.99925	0.99947	1.00294	1.00253	1.00108	1.00014	1.00075
1973	0.99638	0.99828	0.99795	1.00345	1.00322	1.00104	1.00042
1974	0.99773	0.97757	0.99099	1.00353	1.00350	1.00143	1.00348
1975	1.00262	0.99610	1.00285	0.99800	0.99926	1.00095	1.00098
1976	1.00315	1.00033	1.00209	1.00360	0.99988	0.99990	1.00093
1977	0.99634	0.99794	0.99672	0.99895	0.99575	0.99803	0.99541
1978	0.99914	0.99912	0.99549	1.00532	0.99538	0.99812	0.99583
1979	0.99941	0.99529	0.99284	1.00335	0.99939	0.99986	0.99835
1980	1.00068	0.98932	0.99713	1.02330	1.00048	0.99939	1.00024
1981	1.00000	0.99625	1.00065	1.01201	0.99413	0.99851	0.99842
1982	1.00303	1.00359	1.00474	1.00039	1.00076	1.00142	1.00102
1983	1.00245	1.00362	1.00491	1.01029	1.00281	1.00233	1.00131
1984	0.99957	1.00058	1.00070	1.00194	0.99914	0.99895	0.99815
1985	1.00136	0.99998	1.00327	1.00153	0.99795	0.99986	0.99737
1986	0.99894	1.00798	0.99979	1.00109	0.99793	0.99820	0.99758
1987	1.00113	0.99970	1.00175	1.00762	1.00328	1.00074	1.00166

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Table 1.14 – Continued

Year t	α^t_{M1}	α^t_{M2}	α^t_{M3}	α^t_{M4}	α^t_{M5}	α^t_{M6}	α^t_{M7}
1988	1.00021	1.00303	0.99992	1.00726	1.00483	1.00124	1.00421
1989	1.00090	0.99950	1.00203	1.00592	1.00120	1.00092	1.00190
1990	1.00120	0.99742	1.00494	1.00733	1.00273	1.00159	1.00189
1991	1.00138	1.00371	1.00632	1.00840	1.00454	1.00210	1.00332
1992	1.00034	1.00025	0.99958	0.99776	0.99624	0.99815	0.99616
1993	1.00038	1.00079	0.99927	0.99694	0.99632	0.99799	0.99302
1994	0.99816	1.00010	0.99494	0.99505	0.99449	0.99722	0.99344
1995	0.99853	0.99957	0.99249	1.00373	0.99720	0.99875	0.99740
1996	1.00087	0.99777	1.00560	1.01056	1.00119	1.00137	1.00040
1997	0.99962	1.00043	1.00162	1.00582	1.00034	1.00057	0.99819
1998	1.00056	1.00344	0.99860	0.99798	0.99625	0.99712	0.99442
1999	1.00139	0.99781	1.00394	1.00745	1.00194	1.00104	0.99956
2000	1.00077	0.99235	0.99897	1.00809	1.00286	1.00123	0.99998
2001	0.99976	1.00165	0.99912	1.00127	1.00032	0.99895	0.99762
2002	0.99993	0.99961	1.00220	1.00182	1.00012	1.00052	0.99902
2003	1.00174	0.99824	1.00786	1.01891	1.00875	1.00741	1.00725
2004	1.00109	0.99661	0.99805	1.01224	1.00458	1.00520	1.00304
2005	1.00114	0.99293	1.00044	1.01076	1.00552	1.00355	1.00289
2006	1.00116	0.99622	0.99800	1.00870	1.00420	1.00347	1.00111
2007	0.99972	0.99996	1.00341	1.00795	1.00516	1.00359	1.00190
Average	1.00020	0.99887	1.00040	1.00420	1.00050	1.00050	0.99954

The decomposition of the aggregate export contribution factor α_X^t in Table 1.9 (net output approach) is listed in Table 1.15. The increases in real energy products export prices had contributed an average of 0.18 percentage points to real income growth. Real export price increases in materials, services and forest products had contributed 0.04, 0.04 and 0.01 percentage points respectively to the growth. Machinery and equipment and autos both contributed negatively, −0.17 and −0.13 percentage points, to the real income growth. Agricultural products and other consumer goods had minor negative contributions (−0.02 and −0.007 percentage points). Again, overall the cumulative effects of real export price changes, α_X^t, were not large, but it can be seen that the net output approach has magnified the results obtained from the gross output approach.

Table 1.15: Year to Year Export Contribution Factors Using the Net Output Approach

Year t	α^t_{X1}	α^t_{X2}	α^t_{X3}	α^t_{X4}	α^t_{X5}	α^t_{X6}	α^t_{X7}	α^t_{X8}
1961	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
1962	1.00279	0.99976	1.00198	1.00119	1.00053	1.00001	0.99998	1.00056
1963	0.99897	1.00014	0.99982	0.99939	0.99992	1.00000	0.99998	1.00043
1964	1.00027	0.99979	1.00087	1.00096	1.00032	1.00003	1.00005	1.00122
1965	1.00006	1.00010	1.00028	1.00093	1.00031	0.99989	0.99998	1.00124
1966	1.00119	0.99960	0.99899	1.00120	0.99994	0.99957	0.99994	1.00078
1967	0.99900	0.99878	0.99929	0.99949	1.00028	0.99940	0.99994	1.00191
1968	0.99820	1.00005	0.99939	1.00233	1.00091	0.99916	0.99995	1.00123
1969	0.99744	1.00023	1.00072	0.99977	0.99966	0.99843	1.00003	1.00080
1970	0.99770	0.99975	0.99814	1.00278	1.00139	0.99954	0.99983	1.00172
1971	1.00020	1.00067	1.00074	0.99453	0.99939	1.00040	0.99996	1.00153
1972	1.00072	0.99971	1.00214	0.99755	0.99974	0.99842	0.99993	1.00068
1973	1.01333	1.00258	1.00708	1.00584	0.99881	0.99581	0.99997	1.00029
1974	1.01322	1.01566	1.00429	1.01077	0.99941	0.99617	0.99994	0.99954
1975	0.99265	1.01001	1.00097	0.99525	0.99922	0.99696	0.99979	0.99934
1976	0.99481	1.00755	0.99928	1.00078	0.99909	1.00093	1.00008	1.00222
1977	0.99473	1.00566	1.00175	1.00440	0.99995	1.00148	0.99998	1.00077
1978	1.00129	1.00116	1.00160	1.00190	0.99862	1.00187	0.99993	0.99933
1979	1.00450	1.00548	1.00617	1.01346	0.99898	1.00042	0.99981	0.99940
1980	1.00069	1.01179	0.99718	1.01202	0.99699	0.99926	1.00003	0.99963
1981	0.99959	0.99896	0.99792	0.99258	0.99793	1.00073	1.00009	1.00154
1982	0.99373	0.99760	0.99302	0.98655	0.99842	0.99984	0.99985	1.00032
1983	0.99523	0.99518	0.99578	0.99467	0.99654	0.99722	0.99985	1.00008
1984	0.99984	0.99636	1.00365	0.99833	0.99623	1.00174	0.99990	1.00005
1985	0.99857	0.99624	0.99913	0.99663	0.99793	1.00542	1.00008	1.00121
1986	0.99829	0.98267	1.00468	1.00171	1.00557	0.99313	1.00056	1.00172
1987	0.99782	0.99802	1.00391	1.00042	0.99932	0.99774	1.00010	1.00062

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Table 1.15 – Continued

Year t	α_{X1}^t	α_{X2}^t	α_{X3}^t	α_{X4}^t	α_{X5}^t	α_{X6}^t	α_{X7}^t	α_{X8}^t
1988	1.00086	0.99231	1.00024	1.00358	0.99877	0.99355	1.00005	0.99983
1989	1.00126	1.00187	1.00086	0.99698	0.99871	0.99586	1.00020	1.00041
1990	0.99568	1.00295	0.99309	0.98997	0.99710	0.99509	0.99959	0.99808
1991	0.99434	0.99241	0.99113	0.98961	0.99449	0.99781	0.99971	0.99869
1992	1.00359	1.00095	1.00094	0.99920	0.99860	1.00466	0.99986	0.99951
1993	1.00193	1.00163	1.00497	0.99940	0.99927	1.00509	0.99996	1.00073
1994	1.00260	0.99828	1.00917	1.01170	1.00192	1.00593	1.00035	1.00138
1995	1.00489	0.99885	1.01349	1.01202	1.00125	1.00479	1.00037	1.00236
1996	1.00232	1.00993	0.99206	0.98943	0.99581	1.00054	0.99994	1.00015
1997	0.99638	1.00064	0.99857	0.99735	0.99522	1.00123	0.99981	1.00095
1998	0.99844	0.98881	1.00164	0.99493	0.99837	1.00633	1.00003	1.00038
1999	0.99843	1.01101	0.99976	0.99579	0.99493	0.99629	0.99989	0.99983
2000	0.99940	1.03446	0.99851	1.00477	0.99451	0.99523	0.99961	1.00090
2001	1.00128	0.99988	0.99931	0.99531	0.99622	1.00093	0.99970	0.99738
2002	0.99948	0.98571	0.99511	0.99761	0.99878	0.99952	0.99982	1.00034
2003	0.99785	1.01620	0.99463	0.99701	0.99068	0.98397	0.99940	0.99837
2004	0.99880	1.00776	1.00317	1.00888	0.99559	0.99231	0.99972	1.00058
2005	0.99616	1.02318	0.99610	1.00351	0.99557	0.99067	0.99965	1.00030
2006	0.99885	0.99539	0.99668	1.01090	0.99568	0.99340	0.99974	0.99972
2007	1.00197	0.99881	0.99706	1.00665	0.99682	0.99409	0.99967	1.00015
Average	0.99977	1.00180	1.00010	1.00040	0.99834	0.99871	0.99993	1.00040

The decomposition of the aggregate import contribution factor α_M^t in Table 1.9 is shown in Table 1.16. The lower machinery and equipment real import prices contributed 0.49 percentage points to the real income growth. The lower real import prices in autos, other consumer goods, material and forest products and agricultural products contributed minor to the real income growth (0.06, 0.06, 0.05 and 0.03 percentage points respectively). The higher real energy products import prices had a −0.13 percentage points contribution whereas the higher real services import prices had a −0.06 percentage points contribution. Overall, the cumulative effects of real import price changes, α_M^t using the net output approach were quite large (0.51 percentage points) but again mostly can be explained by the large contribution of lower machinery and equipment prices. As in the case of export prices, the net output approach has magnified the results of the gross output approach.

Table 1.16: Year to Year Import Contribution Factors Using the Net Output Approach

Year t	α^t_{M1}	α^t_{M2}	α^t_{M3}	α^t_{M4}	α^t_{M5}	α^t_{M6}	α^t_{M7}
1961	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
1962	0.99858	0.99956	0.99626	0.99337	0.99879	0.99978	0.99722
1963	0.99295	1.00063	0.99897	1.00113	0.99996	1.00040	0.99941
1964	1.00075	1.00016	0.99888	1.00030	0.99947	0.99986	0.99925
1965	1.00604	0.99986	0.99958	0.99928	1.00094	1.00040	0.99875
1966	1.00154	1.00014	1.00259	1.00083	1.00087	1.00062	1.00039
1967	1.00162	1.00152	1.00036	1.00009	1.00023	1.00042	0.99916
1968	1.00016	0.99967	1.00353	1.00236	1.00024	1.00069	0.99926
1969	1.00068	1.00118	1.00053	1.00135	1.00061	1.00043	0.99817
1970	0.99902	1.00027	1.00095	1.00200	1.00116	1.00060	0.99889
1971	0.99980	0.99880	1.00337	0.99956	0.99923	1.00045	0.99815
1972	0.99913	0.99939	1.00338	1.00291	1.00124	1.00016	1.00086
1973	0.99587	0.99804	0.99767	1.00393	1.00367	1.00119	1.00048
1974	0.99743	0.97463	0.98980	1.00400	1.00397	1.00162	1.00394
1975	1.00300	0.99554	1.00325	0.99771	0.99916	1.00109	1.00112
1976	1.00363	1.00038	1.00241	1.00414	0.99987	0.99988	1.00108
1977	0.99578	0.99763	0.99622	0.99880	0.99511	0.99773	0.99472
1978	0.99900	0.99898	0.99479	1.00614	0.99467	0.99783	0.99519
1979	0.99932	0.99457	0.99174	1.00386	0.99929	0.99983	0.99810
1980	1.00078	0.98766	0.99669	1.02697	1.00055	0.99930	1.00028
1981	1.00000	0.99563	1.00075	1.01400	0.99317	0.99826	0.99816
1982	1.00359	1.00424	1.00560	1.00046	1.00090	1.00169	1.00121
1983	1.00292	1.00432	1.00586	1.01228	1.00334	1.00278	1.00156
1984	0.99950	1.00068	1.00083	1.00230	0.99899	0.99876	0.99782
1985	1.00159	0.99997	1.00384	1.00180	0.99760	0.99984	0.99691
1986	0.99876	1.00937	0.99975	1.00128	0.99757	0.99789	0.99716
1987	1.00132	0.99965	1.00205	1.00892	1.00383	1.00087	1.00194

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Table 1.16 – Continued

Year t	α^t_{M1}	α^t_{M2}	α^t_{M3}	α^t_{M4}	α^t_{M5}	α^t_{M6}	α^t_{M7}
1988	1.00024	1.00353	0.99990	1.00844	1.00562	1.00144	1.00490
1989	1.00104	0.99942	1.00236	1.00690	1.00140	1.00107	1.00222
1990	1.00141	0.99697	1.00581	1.00862	1.00320	1.00187	1.00222
1991	1.00163	1.00441	1.00750	1.00998	1.00539	1.00249	1.00394
1992	1.00041	1.00030	0.99949	0.99733	0.99553	0.99780	0.99542
1993	1.00045	1.00094	0.99913	0.99635	0.99561	0.99761	0.99168
1994	0.99780	1.00012	0.99398	0.99410	0.99343	0.99668	0.99219
1995	0.99826	0.99949	0.99110	1.00443	0.99668	0.99852	0.99691
1996	1.00103	0.99736	1.00662	1.01249	1.00140	1.00162	1.00048
1997	0.99955	1.00051	1.00191	1.00686	1.00040	1.00068	0.99787
1998	1.00067	1.00407	0.99834	0.99761	0.99557	0.99660	0.99341
1999	1.00165	0.99741	1.00466	1.00883	1.00229	1.00124	0.99948
2000	1.00091	0.99101	0.99879	1.00954	1.00338	1.00145	0.99997
2001	0.99972	1.00195	0.99896	1.00149	1.00038	0.99876	0.99719
2002	0.99992	0.99954	1.00260	1.00215	1.00014	1.00062	0.99884
2003	1.00205	0.99792	1.00927	1.02232	1.01032	1.00874	1.00854
2004	1.00128	0.99604	0.99772	1.01434	1.00536	1.00609	1.00356
2005	1.00133	0.99177	1.00051	1.01253	1.00643	1.00413	1.00336
2006	1.00135	0.99560	0.99768	1.01012	1.00489	1.00403	1.00129
2007	0.99968	0.99995	1.00397	1.00927	1.00600	1.00418	1.00221
Average	1.00030	0.99871	1.00040	1.00490	1.00060	1.00060	0.99945

The detailed breakdown of the average contributions by changes in export and import sectoral prices shows that the real income growth generated by the business sector has benefited from lower machinery and equipment import prices. The negative effects of higher real import prices in energy and services on real income growth were offset by the large positive contribution by machinery and equipment. Other real import prices had only minor contributions. Although the cumulative effects of the real export price changes had been quite small, the cumulative effects of the real import price changes had been large and so the overall improvement in terms of trade 1961-2007 was relatively large. Note that the results obtained using the net output approach were slightly bigger than the results obtained using the gross output approach.

1.7 Conclusion

Statistics Canada has substantially revised their published KLEMS database and we use these revised data in our analysis. We have included data from 2007 and revised our estimations for other years. Furthermore, Statistics Canada made available to the authors some unpublished data from their KLEMS database on land, inventories and ICT capital which improved our earlier estimates and narrowed the differences of our estimates of TFP growth in Canada and the official Statistics Canada estimates. By incorporating these data, the precision of our analytical results was highly enhanced. We also provide a more detailed breakdown of exports and imports in the present paper so that the effects of changes in real export and import prices by commodity category on real income can be determined.

There are six major conclusions that we can draw from the results.

First, using new detailed data, we have shown that the productivity performance of the business sector of the Canadian economy has been reasonably satisfactory over the past 47 years. In particular, traditional gross income TFP growth averaged 1.01 percent per year over the period 1962-

2007[24] and when the net output framework was used, TFP growth averaged 1.04 percent per year. However, there was a long period (1974-1991) where the productivity performance of the Canadian business sector was decidedly unsatisfactory. We also compared Canada's productivity performance with those of Australia and Japan. The three countries had very similar overall average real income growth. However, the estimated Canadian TFP growth rate is relatively lower than Australia and much lower than Japan. Thus the overall welfare in Canada is comparatively good on an international level, but there is still need to encourage productivity improvement.

Second, we have shown that the role of explanatory factors for growth in the real income generated by the business sector of the Canadian economy changes substantially when we shift from the standard gross product growth accounting framework to a theoretically more appropriate net product growth accounting framework. In general, the main positive drivers of real income growth (growth in labour input, TFP growth and declining real import prices) are *magnified* but the effects of capital services input growth are greatly *diminished* when we switch to the net output framework as compared to the gross output framework.[25] An important implication of this result is that improvements in TFP probably become the most important factor for explaining improvements in per capita living standards in the long run and the favourable effects of capital deepening are not as big as they appear to be in the traditional gross income growth accounting methodology.

Third, we have shown that the "top down" approach performs well when estimating the productivity functions using the final demand deliveries. Thus, the large difference between the estimates from this approach and the official KLEMS estimates using the "bottom up" approach indicates there is a need to review the calculation of the official estimates. More

[24]The corresponding Statistics Canada average Multifactor Productivity growth rate over 1962-2006 was only 0.43 percent per year.

[25]Diewert, Mizobuchi and Nomura (2005) and Diewert and Lawrence (2006) found similar results for Japan and Australia using a similar net output framework.

importantly, this unveils the possibility that the wide "productivity gap" between Canada and the U.S. may not have been as severe as portrayed.

Fourth, the results presented here show that over short periods of time, changes in the external price environment facing an economy can have substantial effects on living standards. Thus during the years of the present decade, the real net income generated by the Canadian business sector grew at an average rate of 4.07 percent per year and declines in real import prices (the China effect) contributed 1.91 percentage points to this increase, which was greater than the effects of quality adjusted labour input growth (1.64 percentage points per year), increases in waiting services (0.53 percentage points per year).[26]

Fifth, in the decomposition of year to year real income growth, we found that changes in export and import prices can have substantial effects on real income growth. By applying detailed trade statistics, we constructed export and import price indexes for the 15 commodity classes to calculate their individual contribution to the real income growth. We found that the increases in real energy products export prices and the lower real import prices of machinery and equipment (except auto) had contributed most to real income growth. The lower export prices in machinery and equipment and autos, and higher real energy products import prices contributed negatively to the real income growth. Overall, the cumulative effects of real import price changes were much larger than the cumulative effects of real export price changes.

Finally, the study uncovered many data problems which should be addressed in future work on Canadian productivity performance. A discussion of the data problems is presented in Chapter 2. More generally, it is evident that statistical agencies are able to provide reasonably accurate data on the prices and quantities of the outputs produced and intermediate inputs used

[26]The Canadian experience with improvement in the terms of trade during the past decade is similar to the Australian experience; see Diewert and Lawrence (2006).

by the various industries in the economy. This is in large part due to the fact that the *System of National Accounts 1993* used by most statistical agencies has developed an adequate methodology for the treatment of gross outputs and intermediate inputs. However, the corresponding methodology for the treatment of primary inputs was not well developed.[27] In particular, the treatment of capital services was absent the *System of National Accounts 1993* and will only be introduced in the next international version of the System of National Accounts. This absence of a standard methodology for the treatment of capital services means that national statistical agencies have not been able to deliver a generally accepted treatment of capital services in their productivity accounts. Thus detailed data on capital stocks and flows by industry is either not available from national statistical agencies or is not provided due to the lack of information on capital inputs. Given the importance of accurate information on productivity growth, it is important that international agencies provide guidance on acceptable methods for measuring primary input prices and volumes and that national statistical agencies provide more details on how they construct their estimates of primary inputs in their productivity accounts. National departments that have an interest in better productivity measurement (e.g., central banks, department of finance and industry departments) should support initiatives that will improve the measurement of primary input growth.

1.8 Explaining Real Income Growth with The Translog Approach

1.8.1 Introduction

This section will present in details the theoretical frameworks that are used in the main text. Subsection 1.8.2 looks at the production theory framework that is mainly drawn from Diewert and Morrison (1986). Sub-

[27]The *System of National Accounts 1993* (SNA) has a good chapter on wage indexes but does not provide a standard methodology for the treatment of self-employment labour input. The recent preliminary manual on the measurement of capital by Schreyer (2007) fills in an important methodological gap in the existing SNA.

section 1.8.3 explains the Translog GDP function approach. Subsection 1.8.4 shows how to decompose aggregate contribution factor due to changes in all market sector primary inputs into separate effects. Then in Subsection 1.8.5, we explain the deflated NDP Translog approach. Finally, Subsection 1.8.6 introduces how sectoral contributions to real income growth are calculated.

1.8.2 The Production Theory Framework

In this subsection, we present the production theory framework which will be used in the main text of the paper.[28] The main reference is Diewert and Morrison (1986)[29] but we also draw on the theory of the output price index, which was developed by Fisher and Shell (1972) and Archibald (1977). This theory is the producer theory counterpart to the theory of the cost of living index for a single consumer (or household) that was first developed by the Russian economist, A.A. Konüs (1924). These economic approaches to price indexes rely on the assumption of (competitive) *optimizing behaviour* on the part of economic agents (consumers or producers). Thus we consider only the market sector of the economy in what follows; i.e., that part of the economy that is motivated by profit maximizing behaviour. In our empirical work, we define the market sector to be the Canadian business sector of the economy less the rental and owner occupied housing sectors.[30]

[28]With the exception of the last subsection of this section, the material is drawn from Diewert (2005b), Diewert, Mizobuchi and Nomura (2005) and Diewert and Lawrence (2006).

[29]The theory also draws on Samuelson (1953), Diewert (1974; 133-141)(1980)(1983;1077-1100), Fox and Kohli (1998), Kohli (1978)(1990)(1991)(2003)(2004a)(2004b)(2006)(2008), Morrison and Diewert (1990), Samuelson (1953) and Sato (1976).

[30]The Canadian business sector excludes all of the general government sectors such as schools, hospitals, universities, defence and public administration where no independent measures of output can be obtained. For owner occupied housing, output is equal to input and hence no productivity improvements can be generated by this sector according to SNA conventions. Due to the difficulties involved in splitting up the residential housing stock into the rental and owner occupied portions, we omit the entire residential housing stock and the consumption of residential housing services in our data. However, we do include investment in residential housing, since that investment is part of the output of the market production sector.

Initially, we assume that the market sector of the economy produces quantities of M (net) outputs[31], $y \equiv [y_1, \ldots, y_M]$, which are sold at the positive producer prices $P \equiv [P_1, \ldots, P_M]$. We further assume that the market sector of the economy uses positive quantities of N primary inputs, $x \equiv [x_1, \ldots, x_N]$ which are purchased at the positive primary input prices $W \equiv [W_1, \ldots, W_N]$. In period t, we assume that there is a feasible set of output vectors y that can be produced by the market sector if the vector of primary inputs x is utilised by the market sector of the economy; denote this period t production possibilities set by S^t. We assume that S^t is a closed convex cone that exhibits a free disposal property.[32]

Given a vector of output prices P and a vector of available primary inputs x, we define the *period* t market sector *GDP function*, $g^t(P, x)$, as follows,[33]

$$g^t(P, x) \equiv \max_y \{P \cdot y : (y, x) \text{ belongs to } S^t\}; \qquad t = 0, 1, 2 \ldots \quad (1.9)$$

Thus market sector GDP depends on t (which represents the period t technology set S^t), on the vector of output prices P that the market sector faces

[31]If the mth commodity is an import (or other produced input) into the market sector of the economy, then the corresponding quantity y_m is indexed with a negative sign. We will follow Kohli (1978)(1991) and Woodland (1982) in assuming that imports flow through the domestic production sector and are "transformed" (perhaps only by adding transportation, wholesaling and retailing margins) by the domestic production sector. The recent textbook by Feenstra (2004; 76) also uses this approach.

[32]For more explanation for the meaning of these properties, see Diewert (1973)(1974; 134) or Woodland(1982) or Kohli (1978)(1991). The assumption that S^t is a cone means that the technology is subject to constant returns to scale. This is an important assumption since it implies that the value of outputs should equal the value of inputs in equilibrium. In our empirical work, we use an *ex post* rate of return in our user costs of capital, which forces the value of inputs to equal the value of outputs for each period. The function g^t is known as the *GDP function or the national product function* in the international trade literature (see Kohli (1978)(1991), Woodland (1982) and Feenstra (2004; 76)). It was introduced into the economics literature by Samuelson (1953). Alternative terms for this function include: (i) the *gross profit function*; see Gorman (1968); (ii) the *restricted profit function*; see Lau (1976) and McFadden(1978); and (iii) the *variable profit function*; see Diewert (1973)(1974).

[33]The function $g^t(P, x)$ will be linearly homogeneous and convex in the components of P and linearly homogeneous and concave in the components of x; see Diewert (1973)(1974; 136). Notation: $P \cdot y \equiv \sum_{m=1}^{M} P_m y_m$.

and on x, the vector of primary inputs that is available to the market sector.

If P^t is the period t output price vector and x^t is the vector of inputs used by the market sector during period t and if the GDP function is differentiable with respect to the components of P at the point (P^t, x^t), then the period t vector of market sector outputs y^t will be equal to the vector of first order partial derivatives of $g^t(P^t, x^t)$ with respect to the components of P; i.e., we will have the following equations for each period t:[34]

$$y^t = \nabla_P g^t(P^t, x^t); \qquad t = 0, 1, 2, \ldots \tag{1.10}$$

Thus the period t market sector supply vector y^t can be obtained by differentiating the period t market sector GDP function with respect to the components of the period t output price vector P^t.

If the GDP function is differentiable with respect to the components of x at the point (P^t, x^t), then the period t vector of input prices W^t will be equal to the vector of first order partial derivatives of $g^t(P^t, x^t)$ with respect to the components of x; i.e., we will have the following equations for each period t:[35]

$$W^t = \nabla_x g^t(P^t, x^t); \qquad t = 0, 1, 2, \ldots \tag{1.11}$$

Thus the period t market sector input prices W^t paid to primary inputs can be obtained by differentiating the period t market sector GDP function with respect to the components of the period t input quantity vector x^t.

The constant returns to scale assumption on the technology sets S^t implies that the value of outputs will equal the value of inputs in period t; i.e., we have the following relationships:

[34]These relationships are due to Hotelling (1932; 594). Note that $\nabla_P g^t(P^t, x^t) \equiv \left[\frac{\partial g^t(P^t,x^t)}{\partial P_1}, \ldots, \frac{\partial g^t(P^t,x^t)}{\partial P_M}\right]$.

[35]These relationships are due to Samuelson (1953) and Diewert (1974; 140). Note that $\nabla_x g^t(P^t, x^t) \equiv \left[\frac{\partial g^t(P^t,x^t)}{\partial x_1}, \ldots, \frac{\partial g^t(P^t,x^t)}{\partial x_N}\right]$.

$$g^t(P^t, x^t) = P^t \cdot y^t = W^t \cdot x^t; \qquad t = 0, 1, 2, \ldots \qquad (1.12)$$

The above material will be useful in what follows but of course, our focus is not on GDP; instead our focus is on the income generated by the market sector or more precisely, on *the real income generated by the market sector.* However, since market sector GDP (the value of market sector production) is distributed to the factors of production used by the market sector, nominal market sector GDP will be equal to nominal market sector income; i.e., from Equation (1.12), we have $g^t(P^t, x^t) = P^t \cdot y^t = W^t \cdot x^t$. As an approximate welfare measure that can be associated with market sector production,[36] we will choose to measure the *real income generated by the market sector in period* t, r^t, in terms of the number of consumption bundles that the nominal income could purchase in period t; i.e., define ρ^t as follows,

$$\begin{aligned} \rho^t &\equiv \frac{W^t \cdot x^t}{P_C^t} \qquad t = 0, 1, 2, \ldots \\ &= w^t \cdot x^t \\ &= p^t \cdot y^t \\ &= g^t(p^t, x^t) \end{aligned} \qquad (1.13)$$

where $P_C^t > 0$ is the *period* t *consumption expenditures deflator* and the market sector period t *real output price* p^t and *real input price* w^t vectors are defined as the corresponding nominal price vectors deflated by the consumption expenditures price index; i.e., we have the following definitions:[37]

[36] Since some of the primary inputs used by the market sector can be owned by foreigners, our measure of *domestic* welfare generated by the market production sector is only an approximate one. Moreover, our suggested welfare measure is not sensitive to the distribution of the income that is generated by the market sector.

[37] Our approach is similar to the approach advocated by Kohli (2004b; 92), except he essentially deflates nominal GDP by the domestic expenditures deflator rather than just the domestic (household) expenditures deflator; i.e., he deflates by the deflator for $C + G + I$, whereas we suggest deflating by the deflator for C. Another difference in his approach compared to the present approach is that we restrict our analysis to the market

$$p^t \equiv \frac{P^t}{P_C^t}; \qquad w^t \equiv \frac{W^t}{P_C^t}; \qquad t = 0, 1, 2, \ldots \tag{1.14}$$

The first and last equality in (1.13) imply that period t real income, ρ^t, is equal to the period t GDP function, evaluated at the period t real output price vector p^t and the period t input vector x^t, $g^t(P^t, x^t)$. Thus the *growth in real income over time can be explained by three main factors*: τ (*Technical Progress or TFP growth), growth in real output prices and the growth of primary inputs*. We will shortly give formal definitions for these three growth factors.

Using the linear homogeneity properties of the GDP functions $g^t(P, x)$ in P and x separately, we can show that the following counterparts to the relations (1.10) and (1.11) hold using the deflated prices p and w:[38]

$$y^t = \nabla_p g^t(p^t, x^t); \qquad t = 0, 1, 2, \ldots \tag{1.15}$$

$$w^t = \nabla_x g^t(p^t, x^t); \qquad t = 0, 1, 2, \ldots \tag{1.16}$$

Now we are ready to define a family of *period t productivity growth factors or technical progress shift factors* $\tau(p, x, t)$:[39]

$$\tau(p, x, t) \equiv \frac{g^t(p, x)}{g^{t-1}(p, x)}; \qquad t = 1, 2, \ldots \tag{1.17}$$

Thus $\tau(p, x, t)$ measures the proportional change in the real income produced by the market sector at the reference real output prices p and reference

sector GDP, whereas Kohli deflates all of GDP (probably due to data limitations). Our treatment of the balance of trade surplus or deficit is also different.

[38] If producers in the market sector of the economy are solving the profit maximization problem that is associated with $g^t(P, x)$, which uses the original output prices P, then they will also solve the profit maximization problem that uses the normalized output prices $p \equiv \frac{P}{P_C}$; i.e., they will also solve the problem defined by $g^t(p, x)$.

[39] This measure of technical progress is due to Diewert and Morrison(1986; 662). A special case of it was defined earlier by Diewert (1983; 1063).

input quantities used by the market sector x where the numerator in Equation (1.17) uses the period t technology and the denominator uses the period $t-1$ technology. Thus each choice of reference vectors p and x will generate a possibly different measure of the shift in technology going from period $t-1$ to period t. Note that we are using the chain system to measure the shift in technology.

It is natural to choose special reference vectors for the measure of technical progress defined by Equation (1.17): a *Laspeyres type measure* τ_L^t that chooses the period $t-1$ reference vectors p^{t-1} and x^{t-1} and a *Paasche type measure* τ_P^t that chooses the period t reference vectors p^t and x^t:

$$\tau_L^t \equiv \tau(p^{t-1}, x^{t-1}, t) = \frac{g^t(p^{t-1}, x^{t-1})}{g^{t-1}(p^{t-1}, x^{t-1})}; \qquad t = 1, 2, \ldots \qquad (1.18)$$

$$\tau_P^t \equiv \tau(p^t, x^t, t) = \frac{g^t(p^t, x^t)}{g^{t-1}(p^t, x^t)}; \qquad t = 1, 2, \ldots \qquad (1.19)$$

Since both measures of technical progress are equally valid, it is natural to average them to obtain an overall measure of technical change. If we want to treat the two measures in a symmetric manner and we want the measure to satisfy the time reversal property from index number theory[40] (so that the estimate going backwards is equal to the reciprocal of the estimate going forwards), then the geometric mean will be the best simple average to take.[41] Thus we define the geometric mean of (1.18) and (1.19) as follows,[42]

$$\tau^t \equiv \left[\tau_L^t \tau_P^t\right]^{\frac{1}{2}} \qquad t = 1, 2, \ldots \qquad (1.20)$$

[40]See Fisher (1922; 64).

[41]See the discussion in Diewert (1997) on choosing the "best" symmetric average of Laspeyres and Paasche indexes that will lead to the satisfaction of the time reversal test by the resulting average index.

[42]The theoretical productivity change indexes defined by (1.19)-(1.20) were first defined by Diewert and Morrison (1986; 662-663) in the nominal GDP context. See Diewert (1993) for properties of symmetric means.

At this point, it is not clear how we will obtain empirical estimates for the theoretical productivity growth indexes defined by (1.18)-(1.20). One obvious way would be to assume a functional form for the GDP function $g^t(p,x)$, collect data on output and input prices and quantities for the market sector for a number of years (and for the consumption expenditures deflator), add error terms to Equations (1.15) and (1.16) and use econometric techniques to estimate the unknown parameters in the assumed functional form. However, econometric techniques are generally not completely straightforward: different econometricians will make different stochastic specifications and will choose different functional forms.[43] Moreover, as the number of outputs and inputs grows, it will be impossible to estimate a flexible functional form. Thus we will suggest methods for implementing measures like (1.20) in this section that are based on exact index number techniques.

We turn now to the problem of defining theoretical indexes for the effects on real income due to changes in real output prices. Define a family of *period t real output price growth factors* $\alpha(p^{t-1},p^t,x,s)$:[44]

$$\alpha(p^{t-1},p^t,x,s) \equiv \frac{g^s(p^t,x)}{g^s(p^{t-1},x)}; \qquad s=1,2,\ldots \tag{1.21}$$

Thus $\alpha(p^{t-1},p^t,x,s)$ measures the proportional change in the real income produced by the market sector that is induced by the change in real output prices going from period $t-1$ to t, using the technology that is available during period s and using the reference input quantities x. Thus each choice

[43] "The estimation of GDP functions such as (19) can be controversial, however, since it raises issues such as estimation technique and stochastic specification. ... We therefore prefer to opt for a more straightforward index number approach." Kohli (2004a; 344).

[44] This measure of real output price change was essentially defined by Fisher and Shell(1972; 56-58), Samuelson and Swamy (1974; 588-592), Archibald (1977; 60-61), Diewert (1980; 460-461)(1983; 1055) and Balk (1998; 83-89). Readers who are familiar with the theory of the true cost of living index will note that the real output price index defined by (1.21) is analogous to the Konüs (1924) true cost of living index which is a ratio of cost functions, say $\frac{C(u,p^t)}{C(u,p^{t-1})}$ where u is a reference utility level: g^s replaces C and the reference utility level u is replaced by the vector of reference variables x.

of the reference technology s and the reference input vector x will generate a possibly different measure of the effect on real income of a change in real output prices going from period $t-1$ to period t.

Again, it is natural to choose special reference vectors for the measures defined by (1.21): a *Laspeyres type measure* α_L^t that chooses the period $t-1$ reference technology and reference input vector x^{t-1} and a *Paasche type measure* α_P^t that chooses the period t reference technology and reference input vector x^t:

$$\alpha_L^t \equiv \alpha(p^{t-1}, p^t, x^{t-1}, t-1) = \frac{g^{t-1}(p^t, x^{t-1})}{g^{t-1}(p^{t-1}, x^{t-1})}; \qquad t = 1, 2, \ldots \quad (1.22)$$

$$\alpha_P^t \equiv \alpha(p^{t-1}, p^t, x^t, t) = \frac{g^t(p^t, x^t)}{g^t(p^{t-1}, x^t)}; \qquad t = 1, 2, \ldots \quad (1.23)$$

Since both measures of real output price change are equally valid, it is natural to average them to obtain an overall measure of the effects on real income of the change in real output prices:[45]

$$\alpha^t \equiv \left[\alpha_L^t \alpha_P^t\right]^{\frac{1}{2}}; \qquad t = 1, 2, \ldots \quad (1.24)$$

Finally, we look at the problem of defining theoretical indexes for the effects on real income due to changes in input quantities. Define a family of *period t real input quantity growth factors* $\beta(x^{t-1}, x^t, p, s)$:[46]

$$\beta(x^{t-1}, x^t, p, s) \equiv \frac{g^s(p, x^t)}{g^s(p, x^{t-1})}; \qquad s = 1, 2, \ldots \quad (1.25)$$

[45]The indexes defined by (1.21)-(1.24) were defined by Diewert and Morrison (1986; 664) in the nominal GDP function context.

[46]This type of index was defined as a true index of value added by Sato (1976; 438) and as a real input index by Diewert (1980; 456).

Thus $\beta(x^{t-1}, x^t, p, s)$ measures the proportional change in the real income produced by the market sector that is induced by the change in input quantities used by the market sector going from period $t-1$ to t, using the technology that is available during period s and using the reference real output prices p. Thus each choice of the reference technology s and the reference real output price vector p will generate a possibly different measure of the effect on real income of a change in input quantities going from period $t-1$ to period t.

Again, it is natural to choose special reference vectors for the measures defined by (1.25): a *Laspeyres type measure* β_L^t that chooses the period $t-1$ reference technology and reference real output price vector p^{t-1} and a *Paasche type measure* β_P^t that chooses the period t reference technology and reference real output price vector p^t:

$$\beta_L^t \equiv \beta(x^{t-1}, x^t, p^{t-1}, t-1) = \frac{g^{t-1}(p^{t-1}, x^t)}{g^{t-1}(p^{t-1}, x^{t-1})}; \qquad t = 1, 2, \ldots \quad (1.26)$$

$$\beta_P^t \equiv \beta(x^{t-1}, x^t, p^t, t) = \frac{g^t(p^t, x^t)}{g^t(p^t, x^{t-1})}; \qquad t = 1, 2, \ldots \quad (1.27)$$

Since both measures of real input growth are equally valid, it is natural to average them to obtain an overall measure of the effects of input growth on real income:[47]

$$\beta^t \equiv [\beta_L^t \beta_P^t]^{\frac{1}{2}} \qquad t = 1, 2, \ldots \qquad (1.28)$$

Recall that market sector real income for period t was defined by (1.13) as ρ^t equal to nominal period t factor payments $W^t \cdot x^t$ deflated by the household consumption price deflator P_C^t. It is convenient to define γ^t as the *period t chain rate of growth factor for real income*:

[47]The theoretical indexes defined by (1.25)-(1.28) were defined in Diewert and Morrison (1986; 665) in the nominal GDP context.

$$\gamma^t \equiv \frac{\rho^t}{\rho^{t-1}}; \qquad t = 1, 2, \ldots \tag{1.29}$$

It turns out that the definitions for γ^t and the technology, output price and input quantity growth factors $\tau(p, x, t)$, $\alpha(p^{t-1}, p^t, x, s)$, $\beta(x^{t-1}, x^t, p, s)$ defined by (1.17), (1.21) and (1.25) respectively satisfy some interesting identities, which we will now develop. We have:

$$\begin{aligned}
\gamma^t &\equiv \frac{\rho^t}{\rho^{t-1}} && t = 0, 1, 2, ... \\
&= \frac{g^t(p^t, x^t)}{g^{t-1}(p^{t-1}, x^{t-1})} && \text{using definitions (1.12) and (1.13)} \\
&= \left[\frac{g^t(p^t, x^t)}{g^{t-1}(p^t, x^t)}\right]\left[\frac{g^{t-1}(p^t, x^t)}{g^{t-1}(p^{t-1}, x^t)}\right]\left[\frac{g^{t-1}(p^{t-1}, x^t)}{g^{t-1}(p^{t-1}, x^{t-1})}\right] \\
&= \tau_P^t \alpha(p^{t-1}, p^t, x^t, t-1)\beta_L^t && \text{using definitions (1.19), (1.21) and (1.26)}
\end{aligned} \tag{1.30}$$

In a similar fashion, we can establish the following companion identity:

$$\gamma^t \equiv \tau_L^t \alpha(p^{t-1}, p^t, x^{t-1}, t)\beta_P^t; \qquad \text{using definitions (1.18), (1.21) and (1.27)} \tag{1.31}$$

Thus multiplying (1.30) and (1.31) together and taking positive square roots of both sides of the resulting identity and using definitions (1.20) and (1.28), we obtain the following identity:

$$\gamma^t \equiv \tau^t[\alpha(p^{t-1}, p^t, x^t, t-1)\alpha(p^{t-1}, p^t, x^{t-1}, t)]^{\frac{1}{2}}\beta^t; \qquad t = 1, 2, \ldots \tag{1.32}$$

We can derive the following alternative decomposition for γ^t into growth factors in a similar way:

$$\gamma^t \equiv \tau^t \alpha^t [\beta(x^{t-1}, x^t, p^t, t-1)\beta(x^{t-1}, x^t, p^{t-1}, t)]^{\frac{1}{2}}; \qquad t = 1, 2, \ldots \tag{1.33}$$

It is quite likely that the real output price growth factor $[\alpha(p^{t-1}, p^t, x^t, t-1)\alpha(p^{t-1}, p^t, x^{t-1}, t)]^{1/2}$ is fairly close to α^t defined by (1.24) and it is quite likely that the input growth factor $[\beta(x^{t-1}, x^t, p^t, t-1)\beta(x^{t-1}, x^t, p^{t-1}, t)]^{1/2}$ is quite close to β^t defined by (1.28); i.e., we have the following approximate equalities:

$$[\alpha(p^{t-1}, p^t, x^t, t-1)\alpha(p^{t-1}, p^t, x^{t-1}, t)]^{\frac{1}{2}} \approx \alpha^t; \qquad t = 1, 2, \ldots \tag{1.34}$$

$$[\beta(x^{t-1}, x^t, p^t, t-1)\beta(x^{t-1}, x^t, p^{t-1}, t)]^{\frac{1}{2}} \approx \beta^t; \qquad t = 1, 2, \ldots \tag{1.35}$$

Substituting (1.34) and (1.35) into (1.32) and (1.33) respectively leads to the following approximate decomposition for the growth of real income into explanatory factors:

$$\gamma^t \approx \tau^t \alpha^t \beta^t; \qquad t = 1, 2, \ldots \tag{1.36}$$

where τ^t is a technology growth factor, α^t is a growth in real output prices factor and β^t is a growth in primary inputs factor.

Rather than look at explanatory factors for the growth in real market sector income, it is sometimes convenient to express the level of real income in period t in terms of *an index of the technology level* or of TFP in period t, T^t, of the *level of real output prices* in period t, A^t, and of the *level of* *primary input quantities* in period t, B^t.[48] Thus we use the growth factors τ^t, α^t and β^t as follows to define the levels T^t, A^t and B^t:

$$T^0 \equiv 1; \qquad T^t \equiv T^{t-1}\tau^t; \qquad t = 1, 2, \ldots \qquad (1.37)$$

$$A^0 \equiv 1; \qquad A^t \equiv A^{t-1}\alpha^t; \qquad t = 1, 2, \ldots \qquad (1.38)$$

$$B^0 \equiv 1; \qquad B^t \equiv B^{t-1}\beta^t; \qquad t = 1, 2, \ldots \qquad (1.39)$$

Using the approximate equalities (1.36) for the chain links that appear in (1.37)-(1.39), we can establish the following approximate relationship for the level of real income in period t, ρ^t, and the period t levels for technology, real output prices and input quantities:

$$\frac{\rho^t}{\rho^0} \approx T^t A^t B^t; \qquad t = 0, 1, 2, \ldots \qquad (1.40)$$

In the following subsection, we note a set of assumptions on the technology sets that will ensure that the approximate real income growth decompositions (1.36) and (1.40) hold as exact equalities.

1.8.3 The Translog GDP Function Approach

We now follow the example of Diewert and Morrison (1986; 663) and assume that the log of the period t (deflated) GDP function, $g^t(p, x)$, has the following translog functional form:[49]

$$\ln g^t(p, x) \equiv a_0^t + \sum_{m=1}^{M} a_m^t \ln p_m^t$$

[48] This type of levels presentation of the data is quite instructive when presented in graphical form. It was suggested by Kohli (1990) and used extensively by him; see Kohli (1991)(2003)(2004a)(2004b) and Fox and Kohli (1998).

[49] This functional form was first suggested by Diewert (1974; 139) as a generalization of the translog functional form introduced by Christensen, Jorgenson and Lau(1971). Diewert (1974; 139) indicated that this functional form was flexible.

$$+\frac{1}{2}\sum_{m=1}^{M}\sum_{k=1}^{M} a_{mk}\ln p_m^t \ln p_k^t$$
$$+\sum_{n=1}^{N} b_n^t \ln x_n^t + \frac{1}{2}\sum_{n=1}^{N}\sum_{j=1}^{N} b_{nj}\ln x_n^t \ln x_j^t$$
$$+\sum_{m=1}^{M}\sum_{n=1}^{M} c_{mn}\ln p_m^t \ln x_n^t; \qquad t = 0, 1, 2, \ldots \tag{1.41}$$

Note that the coefficients for the quadratic terms are assumed to be constant over time. The coefficients must satisfy the following restrictions in order for g^t to satisfy the linear homogeneity properties that we have assumed in Subsection 1.8.2:[50]

$$\sum_{m=1}^{M} a_m^t = 1 \quad \text{for} \quad t = 0, 1, 2, \ldots \tag{1.42}$$

$$\sum_{n=1}^{N} b_n^t = 1 \quad \text{for} \quad t = 0, 1, 2, \ldots \tag{1.43}$$

$$a_{mk} = a_{km} \quad \text{for} \quad \text{all } k, m \tag{1.44}$$

$$b_{nj} = b_{jn} \quad \text{for} \quad \text{all } n, j \tag{1.45}$$

$$\sum_{k=1}^{M} a_{mk} = 0 \quad \text{for} \quad m = 1, \ldots, M \tag{1.46}$$

$$\sum_{j=1}^{N} b_{nj} = 0 \quad \text{for} \quad n = 1, \ldots, N \tag{1.47}$$

[50] There are additional restrictions on the parameters which are necessary to ensure that $g^t(p, x)$ is convex in p and concave in x. Note that when we divide the original prices by one of the prices, then one of the scaled prices will be identically equal to one and hence its logarithm will be identically equal to zero.

$$\sum_{n=1}^{N} c_{mn} = 0 \quad \text{for} \quad m = 1, \ldots, M \tag{1.48}$$

$$\sum_{m=1}^{M} c_{mn} = 0 \quad \text{for} \quad n = 1, \ldots, N \tag{1.49}$$

Recall the approximate decomposition of real income growth going from period $t-1$ to t given by (1.36), $\gamma^t \approx \tau^t \alpha^t \beta^t$. Diewert and Morrison (1986; 663) showed that[51] if g^{t-1} and g^t are defined by (1.41)-(1.49) above and there is competitive profit maximizing behaviour on the part of all market sector producers for all periods t, then (1.36) holds as an exact equality; i.e., we have

$$\gamma^t = \tau^t \alpha^t \beta^t \qquad\qquad t = 1, 2, \ldots \tag{1.50}$$

In addition, Diewert and Morrison (1986; 663-665) showed that τ^t, α^t and β^t could be calculated using empirically observable price and quantity data for periods $t-1$ and t as follows,

$$\begin{aligned} \ln \alpha^t &= \sum_{m=1}^{M} \frac{1}{2} \left[\left(\frac{p_m^{t-1} y_m^{t-1}}{p^{t-1} \cdot y^{t-1}} \right) + \left(\frac{p_m^t y_m^t}{p^t \cdot y^t} \right) \right] \ln \left(\frac{p_m^t}{p_m^{t-1}} \right) \\ &= \ln P_T(p^{t-1}, p^t, y^{t-1}, y^t) \end{aligned} \tag{1.51}$$

$$\begin{aligned} \ln \beta^t &= \sum_{n=1}^{N} \frac{1}{2} \left[\left(\frac{w_n^{t-1} x_n^{t-1}}{w^{t-1} \cdot x^{t-1}} \right) + \left(\frac{w_n^t x_n^t}{w^t \cdot x^t} \right) \right] \ln \left(\frac{x_n^t}{x_n^{t-1}} \right) \\ &= \ln Q_T(w^{t-1}, w^t, x^{t-1}, x^t) \end{aligned} \tag{1.52}$$

[51] Diewert and Morrison established their proof using the nominal GDP function $g^t(P, x)$. However, it is easy to rework their proof using the deflated GDP function $g^t(p, x)$ using the fact that $g^t(p, x) = g^t(P/P_C, x) = g^t(P, x)/P_C$ and the linear homogeneity property of $g^t(P, x)$ in P.

$$\tau^t = \frac{\gamma^t}{\alpha^t \beta^t} \tag{1.53}$$

where $P_T(p^{t-1}, p^t, y^{t-1}, y^t)$ is the Törnqvist (Törnqvist (1936) and Törnqvist and Törnqvist (1937)) output price index and $Q_T(w^{t-1}, w^t, x^{t-1}, x^t)$ is the Törnqvist input quantity index.

Since Equations (1.50) now hold as exact identities under our present assumptions, Equations (1.40), the cumulated counterparts to Equations (1.36), will also hold as exact decompositions; i.e., under our present assumptions, we have

$$\frac{\rho^t}{\rho^0} = T^t A^t B^t \qquad t = 1, 2, \ldots \tag{1.54}$$

We will implement the real income decompositions (1.50) and (1.54) in Sections 1.3 and 1.4.

1.8.4 The Translog GDP Function Approach and Changes in the Terms of Trade

For some purposes, it is convenient to decompose the aggregate period t contribution factor due to changes in all deflated output prices α^t into separate effects for each change in each output price. Similarly, it can sometimes be useful to decompose the aggregate period t contribution factor due to changes in all market sector primary input quantities β^t into separate effects for each change in each input quantity. In this subsection, we show how this can be done, making the same assumptions on the technology that were made in the previous subsection.

We first model the effects of a change in a single (deflated) output price, say p_m, going from period $t - 1$ to t. Counterparts to the theoretical Laspeyres and Paasche type price indexes defined by (1.22) and (1.23) in

Subsection 1.8.2 for changes in all (deflated) output prices are the following *Laspeyres type measure* α^t_{Lm} that chooses the period $t-1$ reference technology and holds constant other output prices at their period $t-1$ levels and holds inputs constant at their period $t-1$ levels x^{t-1} and a *Paasche type measure* α^t_{Pm} that chooses the period t reference technology and reference input vector x^t and holds constant other output prices at their period t levels:

$$\alpha^t_{Lm} \equiv \frac{g^{t-1}(p_1^{t-1},\ldots,p_{m-1}^{t-1},p_m^t,p_{m+1}^{t-1},\ldots,p_M^{t-1},x^{t-1})}{g^{t-1}(p^{t-1},x^{t-1})}; \quad m=1,\ldots,M;\ t=1,2,\ldots \tag{1.55}$$

$$\alpha^t_{Pm} \equiv \frac{g^t(p^t,x^t)}{g^t(p_1^t,\ldots,p_{m-1}^t,p_m^{t-1},p_{m+1}^t,\ldots,p_M^t,x^t)}; \quad m=1,\ldots,M;\ t=1,2,\ldots \tag{1.56}$$

Since both measures of real output price change are equally valid, it is natural to average them to obtain an *overall measure of the effects on real income of the change in the real price of output m*:[52]

$$\alpha^t_m \equiv [\alpha^t_{Lm}\alpha^t_{Pm}]^{\frac{1}{2}}; \qquad m=1,\ldots,M;\ t=1,2,\ldots \tag{1.57}$$

Under the assumption that the deflated GDP functions $g^t(p,x)$ have the translog functional forms as defined by (1.41)-(1.49) in the previous subsection, the arguments of Diewert and Morrison (1986; 666) can be adapted to give us the following result:

[52] The indexes defined by (1.55)-(1.57) were defined by Diewert and Morrison (1986; 666) in the nominal GDP function context.

$$\ln \alpha_m^t = \frac{1}{2}\left[\left(\frac{p_m^{t-1}y_m^{t-1}}{p^{t-1}\cdot y^{t-1}}\right)+\left(\frac{p_m^t y_m^t}{p^t\cdot y^t}\right)\right]\ln\left(\frac{p_m^t}{p_m^{t-1}}\right); \quad m=1,\ldots,M;\ t=1,2,\ldots \quad (1.58)$$

Note that $\ln \alpha_m^t$ is equal to the m^{th} term in the summation of the terms on the right hand side of (1.51). This observation means that we have the following exact decomposition of the period t aggregate real output price contribution factor α^t into a product of separate price contribution factors; i.e., we have under present assumptions:

$$\alpha^t = \alpha_1^t \alpha_2^t \ldots \alpha_M^t; \qquad t=1,2,\ldots \quad (1.59)$$

The above decomposition is useful for analyzing how real changes in the price of exports (i.e., a change in the price of exports relative to the price of domestic consumption) and in the price of imports impact on the real income generated by the market sector. In the empirical illustration which follows later, we let M equal three. The three net outputs are:

1. Domestic sales $(C+I+G)$;
2. Exports (X) and
3. Imports (M).

Commodities 1 and 2 are outputs, so y_1 and y_2 will be positive but commodity 3 is an input into the market sector, so y_3 will be negative. Hence an increase in the real price of exports will *increase* real income but an increase in the real price of imports will *decrease* the real income generated by the market sector, as is evident by looking at the contribution terms defined by (1.58) for $m = 2$ (where $y_m^t > 0$) and for $m = 3$ (where $y_m^t < 0$).

As mentioned above, it is also useful to have a decomposition of the aggregate contribution of input growth to the growth of real income into separate contributions for each important class of primary input that is used by the market sector. We now model the effects of a change in a single input quantity, say x_n, going from period $t-1$ to t. Counterparts to the theoretical Laspeyres and Paasche type quantity indexes defined by (1.26) and (1.27) above for changes in input n are the following *Laspeyres type measure* β^t_{Ln} that chooses the period $t-1$ reference technology and holds constant other input quantities at their period $t-1$ levels and holds real output prices at their period $t-1$ levels p^{t-1} and a *Paasche type measure* β^t_{Pn} that chooses the period t reference technology and reference real output price vector p^t and holds constant other input quantities at their period t levels:

$$\beta^t_{Ln} \equiv \frac{g^{t-1}(p^{t-1}, x_1^{t-1}, \ldots, x_{n-1}^{t-1}, x_n^t, x_{n+1}^{t-1}, \ldots, x_N^{t-1})}{g^{t-1}(p^{t-1}, x^{t-1})}; \quad n = 1, \ldots, N;\ t = 1, 2, \ldots \tag{1.60}$$

$$\beta^t_{Pn} \equiv \frac{g^t(p^t, x^t)}{g^t(p^t, x_1^t, \ldots, x_{n-1}^t, x_n^{t-1}, x_{n+1}^t, \ldots, p_N^t)}; \quad n = 1, \ldots, N;\ t = 1, 2, \ldots \tag{1.61}$$

Since both measures of input change are equally valid, as usual, we average them to obtain *an overall measure of the effects on real income of the change in the quantity of input n*:[53]

$$\beta^t_n \equiv [\beta^t_{Ln}\beta^t_{Pn}]^{\frac{1}{2}}; \qquad n = 1, \ldots, N;\ t = 1, 2, \ldots \tag{1.62}$$

[53]The indexes defined by (1.60)-(1.62) were defined by Diewert and Morrison (1986; 667) in the nominal GDP function context.

Under the assumption that the deflated GDP functions $g^t(p,x)$ have the translog functional forms as defined by (1.41)-(1.49) in the previous subsection, the arguments of Diewert and Morrison (1986; 667) can be adapted to give us the following result:

$$\ln \beta_n^t \quad = \quad \frac{1}{2}\left[\left(\frac{w_n^{t-1}x_n^{t-1}}{w^{t-1}\cdot x^{t-1}}\right)+\left(\frac{w_n^t x_n^t}{w^t\cdot x^t}\right)\right]\ln\left(\frac{x_n^t}{x_n^{t-1}}\right); \qquad n=1,\ldots,N;\ t=1,2,\ldots \quad (1.63)$$

Note that $\ln \beta_n^t$ is equal to the n^{th} term in the summation of the terms on the right hand side of (1.52). This observation means that we have the following exact decomposition of the period t aggregate input growth contribution factor β^t into a product of separate input quantity contribution factors; i.e., we have under present assumptions:

$$\beta^t = \beta_1^t\beta_2^t\ldots\beta_N^t; \qquad t=1,2\ldots \quad (1.64)$$

1.8.5 The Deflated NDP Translog Approach

There is a severe flaw with all of the analysis presented in the previous subsections. The problem is that depreciation payments are part of the user cost of capital for each asset but depreciation does not provide households with any sustainable purchasing power. Hence our real income measure defined by (1.13) is overstated.

To see why GDP overstates income, consider the model of production that is described by the following quotations:

> "We must look at the production process during a period of time, with a beginning and an end. It starts, at the commencement of the Period, with an Initial Capital Stock; to this there is applied a Flow Input of labour, and from it there emerges a Flow Output called Consumption; then there is a Closing Stock of Capital left

> over at the end. If Inputs are the things that are put in, the Outputs are the things that are got out, and the production of the Period is considered in isolation, then the Initial Capital Stock is an Input. A Stock Input to the Flow Input of labour; and further (what is less well recognized in the tradition, but is equally clear when we are strict with translation), the Closing Capital Stock is an Output, a Stock Output to match the Flow Output of Consumption Goods. Both input and output have stock and flow components; capital appears both as input and as output" John R. Hicks (1961; 23).

> "The business firm can be viewed as a receptacle into which factors of production, or inputs, flow and out of which outputs flow...The total of the inputs with which the firm can work within the time period specified includes those inherited from the previous period and those acquired during the current period. The total of the outputs of the business firm in the same period includes the amounts of outputs currently sold and the amounts of inputs which are bequeathed to the firm in its succeeding period of activity." Edgar O. Edwards and Philip W. Bell (1961; 71-72).

Hicks and Edwards and Bell obviously had the same model of production in mind: in each accounting period, the business unit combines the capital stocks and goods in process that it has inherited from the previous period with "flow" inputs purchased in the current period (such as labour, materials, services and additional durable inputs) to produce current period "flow" outputs as well as end of the period depreciated capital stock components which are regarded as outputs from the perspective of the current period (but will be regarded as inputs from the perspective of the next period).[54]

[54]For more on this model of production and additional references to the literature, see the Appendices in Diewert (1977)(1980). The usual user cost of capital can be derived from this framework if depreciation is independent of use.

All of the "flow" inputs that are purchased during the period and all of the "flow" outputs that are sold during the period are the inputs and outputs that appear in the usual definition of cash flow. These are the flow inputs and outputs that are very familiar to national income accountants. But this is not the end of the story: the firm inherits an endowment of assets at the beginning of the production period and at the end of the period, the firm will have the net profit or loss that has occurred due to its sales of outputs and its purchases of inputs during the period. As well, *it will have a stock of assets that it can use when it starts production in the following period.* Just focusing on the flow transactions that occur within the production period will not give a complete picture of the firm's productive activities. Hence, to get a complete picture of the firm's production activities over the course of a period, it is necessary to add the value of the closing stock of assets less the beginning of the period stock of assets to the cash flow that accrued to the firm from its sales and purchases of market goods and services during the accounting period.

We illustrate the above theory by considering a very simple two output, two input model of the market sector. One of the outputs is output in period t, Y^t and the other output is an investment good, I^t. One of the inputs is the flow of non-capital primary input X^t and the other input is K^t, capital services. Suppose that the average prices during period t of a unit of Y^t, X^t and I^t are P_Y^t, P_X^t and P_I^t respectively. Suppose further that the interest rate prevailing at the beginning of period t is r^t. The value of the beginning of period t capital stock is assumed to be P_I^t, the investment price for period t. In order to induce households to let the business sector use the initial stock of capital, firms have to pay households interest equal to $r^t P_I^t K^t$. Then neglecting balance sheet items, the market sector's period t *cash flow* is:[55]

$$CF^t \equiv P_Y^t Y^t + P_I^t I^t - P_X^t X^t - r^t P_I^t K^t \tag{1.65}$$

[55]For equity financed firms, we need to include an imputed return for equity capital.

K^t is interpreted as the firm's beginning of period t stock of capital it has at its disposal and its end of period stock of capital is defined to be K^{t+1}. These capital stocks are valued at the balance sheet prices prevailing at the beginning and end of period t, P_I^t and P_I^{t+1} respectively.

The market sector period t *pure profit* is defined as its cash flow plus the value of its end of period t capital stock less the value of its beginning of period t capital stock:

$$\Pi^t \equiv CF^t + P_I^{t+1}K^{t+1} - P_I^t K^t \tag{1.66}$$

Now the end of period depreciated stock of capital is related to the beginning of the period stock by the following equation:

$$K^{t+1} = (1-\delta)K^t \tag{1.67}$$

where $0 < \delta < 1$ denotes the depreciation rate.

Now substitute (1.65) and (1.67) into the definition of pure profits (1.66) and we obtain the following expression:

$$\begin{aligned}
\Pi^t \;\; &\equiv \;\; P_Y^t Y^t + P_I^t I^t - P_X^t X^t - r^t P_I^t K^t \\
&\quad\; + P_I^{t+1}(1-\delta)K^t - P_I^t K^t \\
&= \;\; P_Y^t Y^t + P_I^t I^t - P_X^t X^t \\
&\quad\; -\{r^t P_I^t + \delta P_I^{t+1} - (P_I^{t+1} - P_I^t)\}K^t
\end{aligned} \tag{1.68}$$

The expression that precedes the capital stock K^t, $\{r^t P_I^t + \delta P_I^{t+1} - (P_I^{t+1} - P_I^t)\}$, can be recognized as the *user cost of capital*;[56] it is the gross rental price that must be paid to a capitalist in order to induce him or her to loan the services of a unit of the capital stock to the production sector.

[56] See Christensen and Jorgenson (1969) for a derivation in continuous time and Diewert (1980; 471) for a derivation in discrete time.

Some simplifications for (1.68) occur if we make two additional assumptions:

- Assume that producers and households expect price level stability so that the end of the period price for a new unit of capital P_I^{t+1} is expected to be equal to the beginning of the period price for a new unit of capital P_I^t; in this case, we can interpret r^t as the period t real interest rate;[57]
- Assume that pure profits are zero so that Π^t equals zero.

Substituting these two assumptions into Equation (1.68) leads to the following expression:

$$\Pi^t = P_Y^t Y^t + P_I^t I^t - P_X^t X^t - \{r^t P_I^t + \delta P_I^t\} K^t = 0 \qquad (1.69)$$

Equation (1.69) can be rearranged to yield the following value of output equals value of input equation:

$$P_Y^t Y^t + P_I^t I^t = P_X^t X^t + \{r^t P_I^t + \delta P_I^t\} K^t \qquad (1.70)$$

Equation (1.70) is essentially the closed economy counterpart to the (gross) value of outputs equals (gross) value of primary inputs equation (1.12), $P^t \cdot y^t = W^t \cdot x^t$, that we have been using thus far in this section. We now come to the point of this rather long digression: *the (gross) payments to primary inputs that is defined by the right hand side of (1.70) is not income*, in the sense of Hicks.[58] The owner of a unit of capital cannot spend the entire period t gross rental income $\{r^t P_I^t + \delta P_I^t\}$ on consumption during period t because the depreciation portion of the rental, δP_I^t, is required in order to keep his or her capital intact. Thus the owner of a new unit of capital at

[57]This assumption can be relaxed somewhat and we can still end up with much the same model; see Diewert (2006a).

[58]We will use Hicks' third concept of income here: "Income No. 3 must be defined as the maximum amount of money which the individual can spend this week, and still be able to expect to spend this week, and still be able to expect to spend the same amount in real terms in each ensuing week." J.R. Hicks (1946; 174).

the beginning of period t loans the unit to the market sector and gets the gross return $\{r^t P_I^t + \delta P_I^t\}$ at the end of the period plus the depreciated unit of the initial capital stock, which is worth only $(1-\delta)P_I^t$. Thus δP_I^t of this gross return must be set aside in order to restore the lender of the capital services to his or her original wealth position at the beginning of period t. This means that *period t Hicksian market sector income* is not the value of payments to primary inputs, $P_X^t X^t + \{r^t P_I^t + \delta P_I^t\}K^t$; instead it is the value of payments to labour $P_X^t X^t$ plus the reward for waiting, $r^t P_I^t K^t$. Using this definition of market sector (net) Hicksian income, we can rearrange Equation (1.70) as follows:

$$\begin{aligned} \text{Hicksian market sector income} &\equiv P_X^t X^t + r^t P_I^t K^t \\ &= P_Y^t Y^t + P_I^t I^t - \delta P_I^t K^t \\ &= \text{Value of consumption} \\ &\quad + \text{value of gross investment} \\ &\quad - \text{value of depreciation} \end{aligned} \tag{1.71}$$

Thus in this Hicksian net income framework, our new output concept is equal to our old output concept less the value of depreciation. We take the price of depreciation to be the corresponding investment price P_I^t and the quantity of depreciation is taken to be the depreciation rate times the beginning of the period stock, δK^t.

Hence the overstatement of income problem that is implicit in the approaches used in previous subsections can readily be remedied: all we need to do is to take the user cost formula for an asset and decompose it into two parts:

- One part that represents depreciation and foreseen obsolescence, $\delta P_I^t K^t$, and
- The remaining part that is the reward for postponing consumption, $r^t P_I^t K^t$.

In our empirical work, our user costs in the gross output approach took the following form:

$$u^t = (r^t + \delta^t + \tau^t)P_I^t \tag{1.72}$$

where r^t is the balancing period t real rate of interest, δ^t is a geometric depreciation rate for period t, τ^t is an average capital taxation rate on the asset and P_I^t is the period t investment price for the asset. However, when we used the net output approach, we split up each (gross product) user cost times the beginning of the period stock K^t into the depreciation component $\delta^t P_I^t K^t$ and the remaining term $(r^t + \tau^t)P_I^t K^t$ and we regarded the second term as a genuine income component but the first term was treated as an intermediate input cost for the market sector and was an offset to gross investment made by the market sector during the period under consideration. In the paper, when the net approach was used, the investment aggregate I was a *net investment aggregate* (gross investment components were indexed with a positive sign in the aggregate and depreciation components were indexed with a negative sign in the aggregate). The capital services aggregate in the net approach was a "reward for waiting" capital services aggregate rather than the gross return aggregate that was used in the gross output approach.[59]

1.8.6 Sectoral Contributions to Real Income Growth

The above theory applied to the market sector as a whole. However, it is of considerable interest to determine which separate industries contributed the most to the overall growth of real income generated by the market sector of the economy. Hence, in this subsection, we outline how this can be done if industry data on outputs, inputs and the corresponding prices

[59] This approach seems to be broadly consistent with an approach advocated by Rymes (1968) (1983), who stressed the role of waiting services: "Second, one can consider the 'waiting' or 'abstinence' associated with the net returns to capital as the non-labour primary input." T.K. Rymes (1968; 362). Denison (1974) also advocated a net output approach to productivity measurement.

are available.[60] However, at the outset, it should be noted that in general, we will not be able to single out the effects of changes in real international prices as we were able to do when the entire business sector is treated as a single industry.[61]

We assume that there are I industries in the market sector of the economy. As in Subsection 1.8.2, we assume that there is a common list of M (net) outputs which each industry produces or uses as intermediate inputs. The net output vector for industry i in period t is $y^{it} \equiv [y_1^{it}, \ldots, y_M^{it}]$, which are sold at the positive producer prices for industry i in period t, $P^{it} \equiv [P_1^{it}, \ldots, P_M^{it}]$, for $i = 1, \ldots, I$. There is also a common list of N primary inputs used by each industry. In period t, we assume that industry i uses non-negative quantities of N primary inputs, $x^{it} \equiv [x_1^{it}, \ldots, x_N^{it}]$ which are purchased at the positive primary input prices $W^{it} \equiv [W_1^{it}, \ldots, W_N^{it}]$ for $i = 1, \ldots, I$. In each period t, we assume that there is a feasible set of net output vectors y^i that can be produced by industry i if the vector of primary inputs x^i is utilised by that industry; denote this period t production possibilities set by S^{it}. We assume that S^{it} is a closed convex cone that exhibits a free disposal property. We shall take the net product point of view developed in the previous subsection for each industry in what follows.

[60] In Canada, such data are available from the Input-Output and Productivity Divisions of Statistics Canada. However, these data for the past five years are not available at present.

[61] The problem is not methodological; it is a data problem. In order to determine the effects of changing real import and export prices on the real income generated by an industry, we require information on the value and price of exports produced by the industry and on the value and price of imports used by the industry. However, the *System of National Accounts 1993* does not set up the production accounts so that the exports produced and imports used by an industry are recorded in the recommended system of production accounts. In theory, this problem can be remedied simply by distinguishing industry outputs as being either exported or delivered to domestic users and by distinguishing industry inputs as being either imports or supplied by a domestic producer; see Diewert (2007b)(2007c) for the details of the resulting modified industry accounts. In practice, it will be extremely difficult to collect the required information. For further discussion of these issues, see Section 2.1 in Chapter 2.

Given a vector of industry i net output prices P^{it} and a vector of available primary inputs x^{it} for that industry, we define *the industry i period t net product function*, $g^{it}(P^{it}, x^{it})$, as follows,

$$\begin{aligned} g^{it}(P^{it}, x^{it}) &\equiv \max_y \{P^{it} \cdot y : (y, x^{it}) \text{ belongs to } S^{it}\} \\ &= P^{it} y^{it}; \\ & \qquad\qquad i = 1, \ldots, I;\ t = 0, 1, 2, \ldots \end{aligned} \tag{1.73}$$

Since we have assumed constant returns to scale for each industry, it is natural to assume that the income generated by industry i in period t, $W^{it} \cdot x^{it}$, is equal to the corresponding value of net product, $P^{it} \cdot y^{it}$; i.e., we have:

$$P^{it} \cdot y^{it} = W^{it} \cdot x^{it} \qquad i = 1, \ldots, I;\ t = 0, 1, 2, \ldots \tag{1.74}$$

Define the *period t, industry i real input and output price vectors*, w^{it} and p^{it} respectively, as follows,

$$w^{it} \equiv \frac{W^{it}}{P_C^t}; \qquad p^{it} \equiv \frac{P^{it}}{P_C^t}; \qquad i = 1, \ldots, I;\ t = 0, 1, 2, \ldots \tag{1.75}$$

As in Subsection 1.8.2, we can define the *real income generated by industry i in period t*, ρ^{it}, as the nominal income generated by industry i in period t, $W^{it} \cdot x^{it}$, divided by the consumption price deflator for period t, P_C^t. Using (1.73)-(1.75), we have:

$$\begin{aligned} \rho^{it} &\equiv \frac{W^{it} \cdot x^{it}}{P_C^t} \qquad i = 1, \ldots, I;\ t = 0, 1, 2, \ldots \\ &= w^{it} \cdot x^{it} \end{aligned}$$

$$\begin{aligned} &= \frac{P^{it} \cdot y^{it}}{P_C^t} \\ &= p^{it} \cdot y^{it} \\ &= g^{it}(p^{it}, x^{it}) \end{aligned} \tag{1.76}$$

where the last equality follows using (1.73)-(1.75) and the linear homogeneity of $g^{it}(P^{it}, x^{it})$ in P^{it}.

We now rework the theoretical analysis presented in Subsections 1.8.2-1.8.4, except we apply it at the industry level instead of the economy-wide market sector level. Thus define γ^{it} as the *period t chain link rate of growth factor for the real income generated by industry i*:

$$\gamma^{it} \equiv \frac{\rho^{it}}{\rho^{it-1}}; \qquad i = 1, \ldots, I;\ t = 1, 2, \ldots \tag{1.77}$$

Now assume that the industry i, period t (deflated) GDP function, $g^{it}(p, x)$, has a translog functional form analogous to that defined above by (1.41)-(1.49). Repeat the analysis at the national level that led up to Equation (1.50), except now apply it at the industry level. We can derive the following industry counterparts to the national equation (1.50):

$$\frac{p^{it} \cdot y^{it}}{p^{it-1} \cdot y^{it-1}} = \frac{\rho^{it}}{\rho^{it-1}} = \gamma^{it} = \tau^{it}\alpha^{it}\beta^{it}; \qquad i = 1, \ldots, I;\ t = 0, 1, 2, \ldots \tag{1.78}$$

where the *period t, industry i chain link technical progress growth rate τ^{it}*, *output price growth rate α^{it}* and *input quantity growth rate β^{it}* can be calculated using the period t and $t-1$ price and quantity data for industry i as follows, for $i = 1, \ldots, I;\ t = 0, 1, 2, \ldots$:

$$\ln \alpha^{it} \equiv \sum_{m=1}^{M} \frac{1}{2} \left[\left(\frac{p_m^{it-1} y_m^{it-1}}{p^{it-1} \cdot y^{it-1}} \right) + \left(\frac{p_m^{it} y_m^{it}}{p^{it} \cdot y^{it}} \right) \right] \ln \left(\frac{p_m^{it}}{p_m^{it-1}} \right)$$

$$= \ln P_T(p^{it-1}, p^{it}, y^{it-1}, y^{it}) \quad (1.79)$$

$$\begin{aligned} \ln \beta^{it} &\equiv \sum_{n=1}^{N} \frac{1}{2} \left[\left(\frac{w_n^{it-1} x_n^{it-1}}{w^{it-1} \cdot x^{it-1}} \right) + \left(\frac{w_n^{it} x_n^{it}}{w^{it} \cdot x^{it}} \right) \right] \ln \left(\frac{x_n^{it}}{x_m^{it-1}} \right) \\ &= \ln Q_T(w^{it-1}, w^{it}, x^{it-1}, x^{it}) \end{aligned} \quad (1.80)$$

$$\tau^{it} \equiv \frac{\gamma^{it}}{\alpha^{it} \beta^{it}} \quad (1.81)$$

where $P_T(p^{it-1}, p^{it}, y^{it-1}, y^{it})$ is the period t, industry i Törnqvist output price index and $Q_T(w^{it-1}, w^{it}, x^{it-1}, x^{it})$ is the period t, industry i Törnqvist input quantity index.

Recall that in Subsection 1.8.3, we defined cumulated counterparts to the chain link Equations (1.50). We can do the same type of operation for the industry data. Thus define the industry i *level of total factor productivity* in period t relative to period 0 as T^{it}, the industry i *level of real output prices* in period t relative to period 0 as A^{it} and the industry i level of *primary input* in period t relative to period 0 as B^{it}. These industry levels can be defined in terms of the corresponding industry chain link factors, τ^{it}, α^{it} and β^{it} as follows,

$$T^{i0} \equiv 1; \qquad T^{it} \equiv T^{it-1} \tau^{it}; \qquad t = 1, 2, \ldots \quad (1.82)$$

$$A^{i0} \equiv 1; \qquad A^{it} \equiv A^{it-1} \alpha^{it}; \qquad t = 1, 2, \ldots \quad (1.83)$$

$$B^{i0} \equiv 1; \qquad B^{it} \equiv B^{it-1} \beta^{it}; \qquad t = 1, 2, \ldots \quad (1.84)$$

Since Equations (1.78) hold as exact identities under our present assumptions, the following cumulated counterparts to these equations will also hold as exact decompositions:

$$\frac{p^{it} \cdot y^{it}}{p^{i0} \cdot y^{i0}} = \frac{\rho^{it}}{\rho^{i0}} = T^{it} A^{it} B^{it}; \qquad i = 1, \ldots, I; \ t = 1, 2, \ldots \tag{1.85}$$

Thus three factors contribute to the period t level of real income generated by industry i relative to the period 0 level: the level of period t total factor productivity of industry i in period t (relative to period 0), T^{it}, the growth in real output prices for industry i going from period 0 to t, A^{it}, and the growth in primary inputs utilised by industry i going from period 0 to t, B^{it}.

The nominal value of market sector output in period t is the corresponding sum of industry nominal values, $\sum_{i=1}^{I} P^{it} \cdot y^{it}$, which can be converted into the *period t real income generated by the market sector*, ρ^t, by dividing this sum by the period t consumption price deflator, P_C^t:

$$\rho^t \equiv \sum_{i=1}^{I} \frac{P^{it} \cdot y^{it}}{P_C^t} = \sum_{i=1}^{I} p^{it} \cdot y^{it} = \sum_{i=1}^{I} \rho^{it}; \qquad t = 0, 1, \ldots \tag{1.86}$$

where the last equality follows using (1.76). Define industry i's share of market sector nominal (or real) net output in period 0 as,

$$s_i^0 \equiv \frac{\rho^{i0}}{\rho^0}; \qquad i = 1, \ldots, I \tag{1.87}$$

Using the above definitions, we can decompose the growth in market sector real income, going from period 0 to t, as follows,

$$
\begin{aligned}
\rho^t/\rho^0 &= \frac{\left[\sum_{i=1}^{I} \rho^{it}\right]}{\rho^0} && \text{using (1.86)} \\
&= \sum_{i=1}^{I} \left[\frac{\rho^{it}}{\rho^{i0}}\right] \left[\frac{\rho^{i0}}{\rho^0}\right] \\
&= \sum_{i=1}^{I} s_i^0 \left[\frac{\rho^{it}}{\rho^{i0}}\right] && \text{using (1.87)} \\
&= \sum_{i=1}^{I} s_i^0 T^{it} A^{it} B^{it} && \text{using (1.85)} \qquad (1.88)
\end{aligned}
$$

Equation (1.88) shows the factors that determine the evolution of market sector real income growth over time. There are four sets of factors at work:

- The industrial structure of net product in the base period; i.e., the base period industry shares of market sector net output, s_i^0;
- The total factor productivity performance of industry i cumulated from the base period to the current period; i.e., the industry productivity factors, T^{it};
- The growth in industry output prices (deflated by the price of the consumption aggregate) going from period 0 to t; i.e., the industry real output price factors, A^{it} and
- The growth in primary inputs utilised by industry i going from period 0 to t; i.e., the industry primary input growth factors, B^{it}.

Note that if an industry i experiences growth in its (net) output prices relative to the price of consumption, then the corresponding real output price factor A^{it} will be greater than one and this effect will contribute to overall real income growth. Traditional Total Factor Productivity decompositions does not include this type of factor; i.e., the traditional analysis ignores favourable (or unfavourable) output price effects.[62]

[62]Improvements in the country's terms of trade are also ignored by the traditional methodology. This does not mean that the traditional emphasis on pure efficiency improvements is "wrong"; it just does not answer the question that we are focusing on, which is: what is the rate of growth in consumption equivalents that the market sector of the economy is generating?

Chapter 2

Business Sector Data on Outputs and Inputs for Canada 1961-2007

2.1 Introduction

The basic approach to measuring productivity growth is to use recently released information on business sector outputs and inputs from Statistics Canada's KLEMS database along with information on aggregate final demand expenditures in order to construct "top down" measures of the productivity performance of the Canadian business sector.[63] We also make extensive use of Statistics Canada's National Balance Sheet estimates for information on various capital inputs used by the business sector. Thus the present approach to productivity measurement is an aggregate "top down" approach as opposed to the usual industry "bottom up" approach which makes use of detailed data on inputs used and outputs produced by industrial sectors and aggregates up sectoral productivity growth rates in order to obtain national business sector estimates.[64] With reliable data, the two approaches should give very similar answers.[65] Unfortunately, data on in-

[63]The database used in Chapter 1.8 was constructed in October, 2008.

[64]The "bottom up" approach is used by the Statistics Canada KLEMS program; see Baldwin, Wu and Yan (2007) for an overview and Baldwin and Gu (2007) for additional information on the construction of the Statistics Canada KLEMS capital services aggregates.

[65]In fact, if indirect tax effects could be ignored and if nominal and real input output tables were perfectly consistent, the two approaches should give exactly the same answer; see Diewert (2006b)(2007c).

dustry inputs and outputs are not likely to be as reliable as the corresponding national data for a variety of reasons[66] so it is useful to provide a check on the industry approach to productivity measurement by using the national aggregate approach.

There is another reason for undertaking a productivity study using final demand data and this reason is that the effects of changes in a country's terms of trade can be measured in this framework whereas these effects cannot be measured in the industry accounts framework using the existing System of National Accounts 1993 (SNA 1993); see Chapter 15 in Eurostat, IMF, OECD, UN and World Bank (1993). In particular, the Input Output accounts as outlined in Table 15.1 in the SNA 1993 do not show the role of international trade in goods and services by industry. Exports and imports enter the main supply and use tables (Table 15.1) as additions (or subtractions) to total net supply or to total domestic final demand in the familiar $C+I+G+X-M$ setup. This means that Table 15.1 in the main production accounts of SNA 1993 does not elaborate on which industries are actually using the imports or on which industries are actually doing the exporting by commodity.[67] Thus at present, data difficulties prevent us from looking at the effects of changes in the terms of trade using the "bottom up" industry aggregation approach.

Diewert and Lawrence (2000) undertook a study of Canada's business sector productivity using the national approach for the years 1962-1996 and Diewert (2002) extended their data to cover the years 1962-1998. The study in Chapter 1 is an extension of these previous studies but there are some differences:

- Statistics Canada has provided new data on national expenditure aggregates back to 1961 using annual chained index numbers and so it is

[66] For a detailed discussion of these reasons, see Diewert (2001).

[67] It should be noted that SNA 1993 does have a recommended optional Table 15.5 which is exactly suited to our present needs; i.e., this table provides the detail for imports by commodity and by industry. However, SNA 1993 does not provide a recommendation for a corresponding commodity by industry table for exports.

no longer necessary to work with the old fixed base data on the most disaggregated level possible and then use chain indexes to aggregate up these data.

- Statistics Canada has also provided new data on the outputs produced and inputs used by the Canadian business sector back to 1961 using chained Fisher indexes as part of their KLEMS productivity measurement program. In particular, we will use the KLEMS estimates of labour input, which are a big improvement over the estimates of labour input used by Diewert and Lawrence.

- Diewert and Lawrence (2000) worked with a rather narrow definition of the government sector; their definition included only the public administration industry. In this study, we adopt the Statistics Canada definition of the non-business sector (except that we add to it the residential rental housing industry) and include the general government sector and the publicly funded defence, hospital and education sectors in the non-business sector.[68] Since output in the non-business sector is measured by input, the use of the broader definition of the government sector should lead to higher estimates of productivity growth in the business sector compared to the estimates tabled in Diewert and Lawrence (2000) and Diewert (2002).

- Statistics Canada has reorganized its information on indirect taxes (less subsidies) into two categories: taxes that fall primarily on outputs and taxes that fall primarily on inputs. This new information is very useful in making adjustments to output prices for indirect tax effects.[69]

[68] The non-business sector consists of the following industries: (1) Government funding of hospitals; (2) Government funding of residential care; (3) Government funding of universities; (4) Government funding of other education; (5) Defence services; (6) Other municipal government services; (7) Other provincial government services and (8) Other federal government services.

[69] In early studies of the Total Factor Productivity of an economy like those done by Solow (1957) and Jorgenson and Griliches (1967), outputs were priced at final demand prices, which include indirect taxes. However, Jorgenson and Griliches (1972; 85) noted that this treatment was not consistent with competitive price taking behaviour on the part of producers, since producers do not derive any benefit from indirect taxes that fall

There had been a substantial revision of the Statistics Canada data used in Diewert (2008), therefore we use in this paper more recent published Statistics Canada data[70] as well as some unpublished disaggregated capital data made available to us from the Statistics Canada KLEMS database. Note that the business sector used here differs from the Statistics Canada business sector in that we have excluded all residential housing services (Owner Occupied Housing services plus Rental Housing services) from our business aggregate whereas Statistics Canada includes the services of rental housing in its business aggregate.[71]

The main conceptual changes in our present database from the data tabled in Diewert (2008) are as follows:

- The trade data were disaggregated;
- Machinery and equipment investment in Diewert (2008) has been disaggregated into ICT machinery and equipment and non-ICT machinery and equipment;[72]
- We used the Statistics Canada KLEMS data on the price of inventory stocks in the present study whereas before, we used another Statistics Canada price series to value inventory stocks;
- The depreciation rates for non-residential structures, ICT machinery and equipment and non-ICT machinery and equipment were re-estimated using balance sheet and KLEMS program information along with revised investment information.

on their outputs and thus these taxes should be removed.

[70] These data were obtained in October 2008.

[71] Our reason for excluding the services of rental housing from our business sector aggregate is due to the lack of accurate data on residential structures investment on rental housing and the lack of information on the quantity and value of land that is occupied by rental housing. Our measure of business sector labour input is exactly the same as that used by the Statistics Canada KLEMS program so only our output measure and capital services input measures differ from the corresponding KLEMS estimates.

[72] Our thanks to Wulong Gu for making the disaggregated data available to us.

In Section 2.2, we will list the basic final demand expenditure series that were used. Section 2.3 simply lists the three published business sector measures of quality adjusted labour input for the Canadian business sector that are available on CANSIM as part of the Statistics Canada KLEMS program. Section 2.4 studies the problems associated with forming estimates for capital inputs. Section 2.5 forms estimates of tax rates on primary inputs. This information is used to calculate estimates of balancing after tax real rates of return. Then this information is used along with the information developed in previous subsections in order to calculate user costs for five classes of capital input: machinery and equipment, non-residential structures, agricultural land, non-agricultural and non-residential business land and inventories. Section 2.6 concludes with some observations on the weak points in the data and recommendations for further work on developing a set of productivity accounts for Canada.

2.2 Estimates of Canadian Final Demand Expenditures

Much of the information tabled in this section is updated information that can be found in the Canadian Economic Observer, Statistics Canada (2007), Table 1: Gross Domestic Product (GDP) by Income and Expenditure (millions of dollars and in chained 2002 dollars). The October 2008 version of these data were used, using the Statistics Canada online data service CANSIM II, which were listed as quarterly data. If the quarterly data were seasonally adjusted, then the data for a year were summed and divided by four in order to obtain annual data. If the quarterly data were not seasonally adjusted, then they were simply summed in order to obtain annual data. In what follows, we will use the CANSIM individual series label to identify the exact series used.

The first two series are Personal Expenditures on Goods and Services in current and constant chained 2002 dollars, CANSIM II series V498087 and V1992044 respectively. Dividing the current dollar series V_{CT} by the constant dollar series Q_{CT} gives us an implicit price series P_{CT} for personal consumption.

We would like to exclude the imputed expenditures on Owner Occupied Housing (OOH) from the above series since there is no possibility of productivity gains occurring in this sector. However, if we exclude imputed rent from the business sector output series, we also need to exclude the services of the owner occupied housing capital stock as an input into the business sector. Unfortunately, we are not able to construct a reliable measure of the Owner Occupied Housing capital stock from available data; we can only construct a more reliable residential housing capital stock which includes the housing capital stock that is rented. We also were not able to split residential land input into reliable owner occupied and rental components.[73] Hence we excluded both imputed and paid rents from our list of business sector outputs and we excluded the entire residential housing stock and the associated land as inputs into the business sector.[74] Information on current dollar expenditures on imputed rents and paid rents (this is the series V_{PR} in Table 2.1) for the years 1961-2007 is available from CANSIM II series V498532 and V498533 respectively. The corresponding information on chained 1997 constant dollar expenditures on imputed rents and paid rents (Q_{PR}) is available from CANSIM II series V1992078 and V1992079 only for the years 1981-2006.[75] We divide V_{PR} by Q_{PR} in order to form

[73]The determination of the structures and land inputs into the production of rented residential housing is a difficult task since the investment data on residential housing is not decomposed into owned and rented investments. This lack of information was also a problem for the Statistics Canada KLEMS program: "Data on investment in rental residential buildings are not available. For the annual MFP programs, we divide the total investment in residential building into rental building and owner-occupied dwelling using paid rents for rental buildings and imputed rents for owner occupied dwelling as the split ratios. The investment in residential buildings and paid and imputed rents are available from the Income and Expenditure Accounts. On average, we find that about 30% of total rents are paid rents and the remaining 70% are imputed rents." Baldwin, Gu and Yan (2007; 43).

[74]This means our productivity estimates will be biased downward slightly since the inputs that are used in the rental housing market are included in our estimates but the corresponding outputs are not included.

[75]We did construct the corresponding expenditure based price series for imputed rents for the period 1981-2006 and compared this price index with the corresponding industry

a price index for paid rents, P_{PR}. We could follow the same strategy to form a price index for imputed rents for the years 1981-2007.[76] However, an alternative series on the imputed value of OOH services for the years 1961-2004 is available from the industry accounts. This series is CANSIM II series V3859926, Business Sector: Owner Occupied Dwellings, from Table 370023: Gross Domestic Product (GDP) at Basic Prices in Current Dollars, System of National Accounts, Benchmark Values, by North American Industry Classification System (NAICS) and is listed as V_{IMR} in Table 2.1.[77] The final demand value series for imputed rents (not listed) is about 13% higher than its industry counterpart, V_{IMR}. We use the industry series for imputed rents rather than the final demand series because we want our business sector value added to closely approximate the Statistics Canada KLEMS program business sector value added, except that our aggregate will not include paid residential rents.[78]

based price index for imputed rents described below for the years 1981-2004 and found that the movements were similar. We used the expenditure based price index for the years 2004-2007 to extend the industry based price index from 2004 to 2007.

[76] We explain below how this industry based value series for imputed rents was extended from 2004 to 2007.

[77] We explain below how this industry based value series for imputed rents was extended from 2004 to 2007.

[78] The KLEMS business sector value added aggregate excludes imputed rents whereas our business sector value added aggregate will exclude both imputed and paid rents. Our treatment of inventory change is also different.

Table 2.1: Housing Value, Quantity and Price Series for Imputed and Paid Rents

Year t	V^t_{IMR}	Q^t_{IMR}	V^t_{PR}	Q^t_{PR}	P^t_{IMR}	P^t_{PR}
1961	2292	2292	1107	1107	1.00000	1.00000
1962	2436	2380	1176	1149	1.02350	1.02350
1963	2660	2412	1290	1170	1.10275	1.10275
1964	2832	2477	1396	1221	1.14316	1.14316
1965	2976	2531	1503	1278	1.17565	1.17565
1966	3249	2620	1658	1337	1.23992	1.23992
1967	3585	2678	1860	1390	1.33856	1.33856
1968	3985	2707	2091	1420	1.47212	1.47212
1969	4416	2784	2342	1476	1.58633	1.58633
1970	4897	2833	2645	1530	1.72855	1.72855
1971	5388	2864	2918	1551	1.88118	1.88118
1972	5757	2866	3183	1584	2.00889	2.00889
1973	6307	2862	3451	1566	2.20366	2.20366
1974	7107	2923	3787	1558	2.43126	2.43126
1975	8313	2992	4290	1544	2.77854	2.77854
1976	10038	3072	4842	1482	3.26746	3.26746
1977	12126	3084	5443	1384	3.93199	3.93199
1978	14090	3051	6106	1322	4.61807	4.61807
1979	15797	2996	6829	1295	5.27283	5.27283
1980	17869	3053	7686	1313	5.85278	5.85278
1981	20512	3159	8822	1359	6.49322	6.49322
1982	23489	3213	10082	1410	7.31046	7.15154
1983	26285	3256	11295	1444	8.07270	7.82159
1984	28446	3294	12181	1471	8.63567	8.28079
1985	30694	3360	12967	1500	9.13517	8.64482
1986	33386	3463	13955	1539	9.64089	9.06928
1987	36117	3573	15090	1599	10.10837	9.43653

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Table 2.1 – Continued

Year t	V^t_{IMR}	Q^t_{IMR}	V^t_{PR}	Q^t_{PR}	P^t_{IMR}	P^t_{PR}
1988	39587	3801	16419	1662	10.41493	9.87670
1989	44078	4011	18201	1726	10.98935	10.54481
1990	48016	4221	19786	1798	11.37552	11.00446
1991	51779	4469	21133	1853	11.58636	11.40566
1992	54872	4627	22269	1899	11.85900	11.72872
1993	57263	4770	23108	1943	12.00486	11.89235
1994	60557	4887	24056	1982	12.39142	12.13540
1995	63613	5001	24869	2016	12.72013	12.33820
1996	65418	5116	25632	2049	12.78691	12.51068
1997	67405	5245	26425	2097	12.85127	12.59838
1998	69835	5389	27223	2139	12.95872	12.72809
1999	72144	5557	28173	2187	12.98263	12.87911
2000	74582	5704	29059	2231	13.07545	13.02515
2001	77093	5843	30092	2279	13.19410	13.20509
2002	80895	6074	31491	2341	13.31831	13.44940
2003	83916	6250	32829	2413	13.42651	13.60407
2004	87614	6482	34133	2487	13.51648	13.72279
2005	91546	6730	35435	2560	13.60266	13.83987
2006	96714	6985	37137	2638	13.84590	14.07851
2007	103152	7246	39262	2714	14.23568	14.46634

We now describe how we estimated a price index for the paid rents series for the years 1961-1981 and how we formed a price index for the industry value added series for the imputed rents for OOH for the years 1961-2007. An old series for the industry value added generated by OOH, CANSIM II series V334072, Canada: Current Prices; Business Sector; Owner Occupied Dwellings, from Table 3790001, Gross Domestic Product (GDP) at Factor Cost, System of National Accounts Benchmark Values, by Industry, is available for the years 1961-1997. The corresponding series in constant 1992 dollars is available for the years 1961-2000 as CANSIM II Series V328857 in Table 3790004. We use these two series to form a price index for imputed rent for the years 1961-1997, P_{IMR}^t in Table 2.1. A constant dollar industry series for the services of OOH for the years 1997-2007 can be obtained from CANSIM II Series V14183160, Canada; Seasonally Adjusted at Annual Rates; Chained 1997 Dollars; Owner Occupied Dwellings in Table 3790018, Gross Domestic Product (GDP) at Basic Prices by NAICS.[79] Dividing V_{IMR}^t by this constant dollar series will give us a price index for imputed rents running from 1997 to 2007 and we link this series to the earlier P_{IMR}^t series that ran from 1961 to 1997. We then normalized the price series to equal 1 in 1961 and formed the quantity series Q_{IMR}^t as V_{IMR}^t divided by P_{IMR}^t. V_{IMR}^t, Q_{IMR}^t and P_{IMR}^t are listed in Table 2.1. Recall that we have a value series for paid rents, V_{PR}^t, that covers the years 1961-2007 but the corresponding price index series, P_{PR}^t, covers only the years 1981-2007. We extend P_{PR}^t back to 1961 using the movements in P_{IMR}^t. The resulting price series is normalized to equal 1 in 1961 and a quantity series for paid rents, Q_{PR}^t, is obtained by dividing V_{PR}^t by P_{PR}^t. These three series are also listed in Table 2.1.[80]

[79] Somewhat mysteriously, this constant dollar series extends all the way to 2007 whereas the corresponding current dollar series ends at 2004. As noted above, we extended the industry price index for imputed rents from 2004 to 2007 using the movements in the corresponding expenditure based price index for imputed rents over the years 2004-2007. Given this extended price index plus the industry based constant dollar series for imputed rents, the industry based value series for imputed rents was extended to 2007.

[80] The units for all value and quantity series are millions of current dollars for the V series and millions of 1961 dollars for the Q series.

Recall the price and quantity series for a consumption aggregate (which includes all rents, paid and imputed), P_{CT} and Q_{CT}, along with the two price and quantity series for imputed and paid rents in Table 2.1. We changed the sign of the rent quantity series from plus to minus and then calculated a chained Fisher net consumption aggregate by aggregating all consumption (plus sign on the quantities) and rents (negative sign on the quantities). The resulting price and quantity series should closely approximate the price and quantity of consumption excluding housing services. However, the price series includes indirect taxes (less subsidies) on outputs but for productivity measurement purposes, as mentioned earlier, these tax wedges should be excluded. Statistics Canada has a series for indirect taxes less subsidies on products V_{IT}^t, CANSIM II series V1997473, for the years 1961-2007. We subtracted two other tax series from this indirect tax series because these other tax series will be taken into account separately in the price of exports of goods (this is the Oil Export Tax series, CANSIM series V499746) and in the price of imports of goods (this is the Customs Import Duties series, CANSIM series V499741). The resulting indirect taxes less subsidies on products (less trade taxes) series was used to remove the tax wedges on the price of consumption series. The resulting price and quantity of consumption series, P_C^t and Q_C^t, are listed in Tables 2.2 and 2.3.[81]

[81] We renormalize all price and quantity series so that the normalized price is 1 in 1961. The units for quantity and value series are in millions of current and 1961 dollars respectively.

Table 2.2: Prices Indexes for Business Sector Outputs: Consumption and Investment

Year	P_C^t	P_{IG}^t	P_{IR}^t	P_{ICT}^t	P_{IME}^t	P_{INR}^t	P_{II}^t
1961	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
1962	1.00538	1.00855	1.00504	0.99939	1.01477	1.00592	1.00240
1963	1.02055	1.03939	1.02769	0.99650	1.06598	1.03251	1.01346
1964	1.02437	1.06231	1.07312	1.00502	1.06773	1.06158	1.03169
1965	1.03690	1.13926	1.13368	1.02393	1.10198	1.12281	1.05486
1966	1.07553	1.21007	1.20765	1.02944	1.12251	1.19323	1.07231
1967	1.11050	1.23160	1.28518	1.07473	1.12792	1.24188	1.08449
1968	1.15168	1.23844	1.31431	1.10902	1.13973	1.25227	1.10971
1969	1.18980	1.28464	1.38118	1.14444	1.17197	1.32495	1.13490
1970	1.22208	1.33877	1.42615	1.19472	1.23029	1.39058	1.15046
1971	1.24828	1.40873	1.53179	1.22722	1.27216	1.46812	1.20264
1972	1.29847	1.48528	1.67349	1.26956	1.30444	1.55098	1.31611
1973	1.38744	1.64838	1.97123	1.30782	1.34535	1.71873	1.42683
1974	1.58382	2.01078	2.36134	1.35698	1.51430	2.03419	1.54691
1975	1.82198	2.23421	2.56072	1.45867	1.73112	2.27337	1.65112
1976	1.90726	2.34499	2.76853	1.45190	1.82918	2.40093	1.77007
1977	2.03175	2.48990	2.87768	1.44467	1.98862	2.52980	1.92666
1978	2.19264	2.66206	3.04069	1.40748	2.19453	2.71145	2.13561
1979	2.40645	2.88522	3.28046	1.38366	2.44348	2.96312	2.34120
1980	2.69497	3.19858	3.55455	1.21888	2.69736	3.32520	2.55883
1981	2.95335	3.68313	3.99273	1.12880	2.98813	3.68676	2.75849
1982	3.22860	3.92658	4.08226	1.16812	3.19883	3.96113	2.91040
1983	3.46323	4.01498	4.25350	1.02222	3.26756	3.93090	3.04428
1984	3.61506	4.17063	4.41785	0.96342	3.40812	4.08142	3.12590
1985	3.72257	4.20827	4.55564	0.89167	3.57237	4.21351	3.15838
1986	3.80422	4.20267	4.90827	0.82129	3.70845	4.27520	3.20668
1987	3.89726	4.22375	5.40819	0.75277	3.69804	4.47320	3.26271

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Table 2.2 – Continued

Year	P_C^t	P_{IG}^t	P_{IR}^t	P_{ICT}^t	P_{IME}^t	P_{INR}^t	P_{II}^t
1988	4.00205	4.33769	5.78293	0.71401	3.69075	4.72840	3.31521
1989	4.11690	4.43728	6.13195	0.64691	3.79390	4.92520	3.36284
1990	4.35206	4.53066	6.11231	0.61403	3.87130	5.08853	3.36458
1991	4.59099	4.31837	6.32257	0.54586	3.74170	5.00311	3.51938
1992	4.65258	4.31896	6.39710	0.51043	3.88288	4.97541	3.52557
1993	4.74252	4.34342	6.58445	0.50164	4.04523	5.03758	3.70024
1994	4.77089	4.42033	6.76485	0.48119	4.24754	5.20497	3.83041
1995	4.79147	4.51572	6.76717	0.44755	4.44740	5.27332	3.91857
1996	4.88952	4.53812	6.75581	0.41150	4.57050	5.43035	3.78206
1997	4.96547	4.57906	6.87512	0.39399	4.69221	5.56694	3.80677
1998	5.03224	4.59706	6.95993	0.36919	4.90374	5.71450	3.86651
1999	5.12045	4.57201	7.13210	0.33873	4.94358	5.82995	3.95640
2000	5.25425	4.68967	7.29782	0.32384	5.01831	6.02775	4.04039
2001	5.40970	4.68012	7.48766	0.31733	5.17017	6.07934	4.10861
2002	5.47743	4.72977	7.81242	0.30560	5.25354	6.18175	3.87128
2003	5.61543	4.72659	8.21290	0.27567	4.94953	6.30506	3.91048
2004	5.69551	4.79882	8.71618	0.24913	4.85253	6.70389	3.95736
2005	5.81654	4.91308	9.11452	0.23077	4.79667	7.12403	4.02157
2006	5.92386	5.09878	9.78750	0.21439	4.71044	7.64020	4.14724
2007	6.02712	5.28795	10.49192	0.20857	4.58255	8.04719	4.15442

Table 2.3: Quantity Indexes for Business Sector Outputs: Consumption and Investment

Year t	Q_C^t	Q_{IG}^t	Q_{IR}^t	Q_{ICT}^t	Q_{IME}^t	Q_{INR}^t	Q_{II}^t
1961	20265	1887	2211	312	1925	2618	1
1962	21331	2094	2271	358	2067	2545	560
1963	22290	2101	2354	399	2199	2637	936
1964	23529	2141	2715	412	2744	3050	532
1965	24974	2426	2825	472	3257	3320	1228
1966	26240	2668	2699	580	3899	3802	1313
1967	27228	2718	2754	617	3866	3613	454
1968	28525	2758	3132	592	3537	3593	619
1969	29923	2700	3551	673	3817	3592	1580
1970	30450	2645	3254	677	3868	3946	180
1971	32321	2985	3728	744	3924	4089	−232
1972	34891	2938	4066	806	4338	4074	148
1973	37676	2781	4371	932	5336	4396	2542
1974	39789	2845	4464	1167	5925	4675	4839
1975	41468	2962	4386	1310	6089	5286	−334
1976	43911	2855	5172	1568	6219	5168	250
1977	45480	2916	5242	1647	6057	5479	1319
1978	47255	2875	5291	1895	6202	5626	1300
1979	48694	2803	5251	2225	6988	6337	3691
1980	49521	2869	4977	3074	7165	7055	167
1981	49914	2967	5279	4423	8211	7620	891
1982	48210	3095	4340	4205	6867	6929	−4603
1983	49567	2991	5079	5184	6414	6361	−1049
1984	51955	3124	5131	6297	6397	6288	1744
1985	54842	3497	5578	7438	6909	6590	1467
1986	56973	3485	6267	8984	7454	6210	1029
1987	59433	3621	7190	12586	8084	6454	1701

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Table 2.3 – Continued

Year t	Q_C^t	Q_{IG}^t	Q_{IR}^t	Q_{ICT}^t	Q_{IME}^t	Q_{INR}^t	Q_{II}^t
1988	61835	3789	7340	14111	9704	7110	2078
1989	63760	4184	7640	17019	10096	7345	1406
1990	64001	4463	6835	18392	9331	7346	−583
1991	62103	4692	5824	19836	8856	7075	−3899
1992	62821	4621	6238	24332	7995	5960	−551
1993	63783	4560	6024	26001	7449	5993	−878
1994	65822	4894	6271	30044	8001	6533	709
1995	67161	4740	5340	33319	8373	6574	3164
1996	68967	4536	5852	39474	8500	6696	2417
1997	72495	4390	6330	49575	10434	7881	1780
1998	74536	4361	6106	60330	10647	7906	2329
1999	77521	5039	6324	72466	11106	8101	1249
2000	80901	5229	6656	85220	11270	8266	2915
2001	82720	5830	7363	84440	10798	8712	−1856
2002	85721	6044	8403	83843	10625	8195	3367
2003	88311	6370	8854	90145	11417	8651	−1722
2004	91157	6773	9519	105113	12185	9257	1058
2005	94522	7521	9845	115589	13473	10184	1981
2006	98708	8021	10061	130883	14066	11093	1104
2007	103366	8644	10363	140217	15069	11047	1757

We turn our attention to the investment components of final demand. Current dollar government gross fixed capital formation is available as CANSIM II series V498093 for the years 1961-2007. The corresponding chained 2002 dollar series is CANSIM II series V1992050 and we use these two series to form price and quantity series for general government sector investment, P^t_{IG} and Q^t_{IG}, which are listed in Tables 2.2 and 2.3.[82]

The current and constant chained dollar series for the years 1961-2006 for residential structures investment can be obtained as CANSIM II series V498096 and V1992053 respectively, the current and constant chained dollar series for non-residential structures investment can be obtained as CANSIM II series V498098 and V1992053 respectively and the resulting price and quantity series are denoted by P^t_{IR}, P^t_{INR}, Q^t_{IR} and Q^t_{INR} and are listed in Tables 2.2 and 2.3. Statistics Canada provided us with unpublished series on the price and value of ICT and non-ICT machinery and equipment investments for the years 1961-2006. The resulting price and quantity series for ICT investment and non-ICT machinery and equipment are denoted by P^t_{ICT}, Q^t_{ICT}, P^t_{IME} and Q^t_{IME} respectively,[83] as listed in Tables 2.2 and 2.3. These tables also include the price and quantity of inventory change, P^t_{II} and Q^t_{II} change but the description of how they were constructed is deferred until we discuss how we formed estimates of the beginning of the year stocks of inventories.

[82]The price series for investment should be adjusted for indirect taxes that fall on investment outputs. Since these taxes are relatively small and it is difficult to collect consistent information on these taxes over our sample period, we neglect these indirect tax wedges on investment components of final expenditure.

[83]We used the rates of increase in the price and quantity of all investment in machinery and equipment going from 2006 to 2007 from the published Statistics Canada expenditure accounts (see the current and constant chained dollar series for machinery and equipment investment, CANSIM II series V498099 and V1992056 respectively) to extend the ICT and non-ICT machinery and equipment price and quantity series to 2007. When we aggregated up the two unpublished ICT and other machinery and equipment investment series using chained Fisher indexes and compared the resulting aggregate KLEMS based machinery and equipment investment series with the corresponding national accounts based series, we found that the value series were very close but the KLEMS based price series grew 2.32 fold over the years 1961-2006 whereas the national accounts based price series grew 2.60 fold, which is 12% higher. We chose to use the KLEMS based data series for investment in machinery and equipment.

All of the outputs described above can be regarded as outputs produced by the business sector and sold to final demanders. However, the business sector also sells goods and services to the non-business sector and it also purchases smaller amounts of goods and services from the non-business sector. We now describe how we formed price and quantity estimates for the net sales of the business sector to the non-business sector.

For the years 1961-2007 from the National Income and Expenditure Accounts, CANSIM II series V498092; Government Current Expenditure on Goods and Services, Table 3800002, we have estimates of total government gross current expenditure on goods and services (less sales of goods and services to the business sector) in current dollars. From the same table and for the same years, CANSIM II series V1992049; Government Current Expenditure on Goods and Services, Table 3800002, we have estimates of total government gross current expenditure on goods and services (less sales of goods and services to the business sector) in chained 2002 dollars. We use these two series to form price and quantity series for final demand government sector expenditures, P_G^t and Q_G^t, which are listed in Table 2.4.

Table 2.4: Business Sector, Non-business Sector, Government Final Demand and KLEMS Business Sector Price and Quantity Aggregates

Year t	Q_B^t	Q_N^t	Q_G^t	Q_{BKLEMS}^t	P_B^t	P_N^t	P_G^t	P_{BKLEMS}^t
1961	33097	5204	6624	30805	1.00000	1.00000	1.00000	1.00000
1962	35338	5480	6928	33059	1.00919	1.03863	1.02916	1.00509
1963	37217	5713	7164	35013	1.02992	1.08205	1.05990	1.01881
1964	39810	5952	7542	37567	1.04877	1.14227	1.09761	1.03600
1965	42658	6120	7883	40122	1.07554	1.21527	1.15160	1.06938
1966	45529	6409	8581	42827	1.12248	1.34490	1.24333	1.11745
1967	46616	6870	9334	43728	1.16053	1.45671	1.32836	1.15516
1968	49335	7263	9944	46133	1.19304	1.54780	1.41575	1.18948
1969	51965	7585	10376	48537	1.23452	1.71317	1.53846	1.23074
1970	52968	7962	11287	49889	1.29437	1.84146	1.64279	1.27609
1971	55844	8255	11631	51843	1.33615	1.95964	1.75921	1.33535
1972	59086	8549	11995	54998	1.40300	2.12810	1.89268	1.40260
1973	63467	8887	12559	59206	1.54872	2.31234	2.04912	1.55366
1974	65346	9295	13357	61310	1.79635	2.65779	2.33927	1.79872
1975	65545	9790	14251	62061	2.03754	3.05325	2.65962	2.01795
1976	70082	10097	14525	66118	2.17572	3.45337	2.99471	2.15434
1977	72425	10348	15205	68823	2.32657	3.73913	3.24567	2.27212
1978	74875	10644	15473	71979	2.51505	3.96850	3.45708	2.42047
1979	77878	10805	15635	75134	2.80145	4.29236	3.77635	2.69350
1980	79169	11138	16169	76938	3.12982	4.66836	4.14895	2.98837
1981	81847	11496	16441	80244	3.40152	5.22919	4.64970	3.21385
1982	78970	11693	16767	77088	3.65996	5.83630	5.18504	3.44460
1983	81077	11952	17045	79192	3.89493	6.12278	5.48059	3.65571
1984	86041	12198	17222	84752	4.03944	6.37296	5.69544	3.76522
1985	90944	12471	17959	89260	4.13895	6.57967	5.90593	3.87314
1986	93580	12708	18283	91514	4.19906	6.81314	6.09362	3.92907

Continued on Next Page...

Table 2.4 – Continued

Year t	Q_B^t	Q_N^t	Q_G^t	Q_{BKLEMS}^t	P_B^t	P_N^t	P_G^t	P_{BKLEMS}^t
1987	97824	12840	18525	96022	4.38354	7.17180	6.36273	4.08969
1988	102723	13057	19370	100981	4.58086	7.53056	6.60377	4.26785
1989	105427	13224	19903	103685	4.75619	8.03351	6.95695	4.41096
1990	106128	13541	20605	103235	4.85194	8.60166	7.34874	4.52286
1991	104194	13849	21208	99027	4.90597	9.01919	7.64969	4.63908
1992	105171	14045	21414	99628	4.92162	9.36188	7.88200	4.64471
1993	108151	14150	21422	102483	4.97722	9.50865	7.98997	4.69377
1994	113766	14218	21156	108795	5.08269	9.55910	8.11082	4.75837
1995	117124	14279	21034	112401	5.23638	9.61980	8.19895	4.89045
1996	119744	14025	20786	114956	5.33957	9.72826	8.23447	4.99301
1997	125797	13787	20579	121417	5.40168	9.95401	8.34626	5.04144
1998	131475	13890	21240	127127	5.37429	10.07510	8.44225	5.00882
1999	139515	14320	21687	135542	5.47529	10.18237	8.57899	5.10349
2000	147808	14614	22356	144108	5.71191	10.65177	8.94989	5.34163
2001	149733	14926	23229	146512	5.80825	10.88586	9.11375	5.41622
2002	153895	15241	23802	150269	5.82601	11.29659	9.42889	5.42824
2003	156933	15608	24551	153124	6.02555	11.73665	9.71085	5.62745
2004	162130	15921	25044	158534	6.23215	11.96951	9.87845	5.82088
2005	167081	16154	25429	163342	6.45631	12.39824	10.23229	6.04364
2006	171718	16519	26385	168301	6.65413	12.80917	10.57143	6.21454
2007	175972	16945	27359	172358	6.89723	13.13041	10.83655	6.44335

Recall that the Statistics Canada KLEMS productivity program business sector value added aggregate *includes* rental residential housing but *excludes* the services of owned residential housing (whereas our business sector value added aggregate excludes all forms of residential rents). The Industry Division of Statistics Canada produces yet another business sector estimate of nominal and real value added (at factor cost) which includes all residential rents, both imputed and paid. We will denote this value added aggregate by V_B^t in year t. Statistics Canada also produces a companion non-business sector value added aggregate (at factor cost) which we will denote by V_N^t in year t. If the value of indirect taxes less subsidies on products for year t, V_{IT}^t, is added to the sum of these two industry value added aggregates, we get an estimate of the value of GDP at final demand prices in year t; i.e., we have the following identity:

$$V_B^t + V_N^t + V_{IT}^t = V_{GDP}^t \qquad (2.1)$$

We will now describe how we formed estimates for V_B^t and V_N^t along with the corresponding price and quantity decompositions. From Table 3790024, Gross Domestic Product (GDP) at Basic Prices in Current Dollars, SNA, Benchmark Values, Special Industry Aggregations Based on the North American Industry Classification System (NAICS), we can obtain the V_B^t series (title is Canada: Business Sector Industries) for the years 1961-2004 from CANSIM II Series V3860037. From the same Table 3790024, we can obtain the V_N^t series (title is Canada: Non-Business Sector Industries) for the years 1961-2004 from CANSIM II Series V3860040. We can obtain price indexes P_B^t, P_N^t and quantity indexes Q_B^t, Q_N^t for V_B^t and V_N^t for the years 1961-1997 by using the series V334562, V335071, V334565 and V335074 from CANSIM Table 3790002, Gross Domestic Product (GDP) at Factor Cost, System of National Accounts Benchmark Values by Industry (Special Aggregations). These series give business and non-business sector value added at basic prices in current dollars and in constant 1992 dollars. Using CANSIM Table 3790020, we can find estimates for Q_B^t (Series V14182646) and for Q_N^t (Series V14182651) in chained 1997 dollars for the years 1997-

2007. Hence using these series in conjunction with our earlier value series V_B^t and V_N^t which run from 1961 to 2004, we can obtain price series for business and non-business sector value added at basic prices for the years 1997-2004. These price series can be linked to our earlier price series P_B^t and P_N^t which extended to 1997 so that the resulting price series will run from 1961 to 2004. However, we still do not have price or value series for the B and N sectors for 2004-2007, although we do have quantity series for these years. We extended the price series P_N^t from 2004 using an implicit price index for government goods and services, which was constructed using CANSIM Table 3800002, series V498092 in current dollars and series V1992049 for chained 2002 dollars. It turns out that the total of V_B^t and V_N^t is available in another CANSIM II series V3860274. Canada, Gross Domestic Product (GDP) at Basic Prices in Table 3800030: GDP and GNP at Market Prices and Net National Income at Basic Prices. Thus we have enough information to deduce the price P_B^t and the value of business sector output V_B^t for the years 2004-2007. The business and non-business sector price and quantity series, P_B^t, P_N^t and Q_B^t, Q_N^t for real value added at basic prices are listed in Table 2.4.

It is also of some interest to compare the price and quantity of the above Industry Division business sector prices and quantities P_B^t and Q_B^t with the corresponding business sector prices and quantities P_{BKLEMS}^t and Q_{BKLEMS}^t that originate with the Statistics Canada productivity program.[84] These series are also listed in Table 2.4. The source for Q_{BKLEMS}^t for the years 1961-2007 is CANSIM II series V41712932: Canada, Real Gross Domestic Product (GDP), Business Sector from Table 3830021: Multifactor Productivity, Value Added, Capital Input and Labour Input in the Aggregate Business Sector and Major Sub-sectors by the North American Industry Classification (NAICS). The corresponding nominal value added series V_{BKLEMS}^t is available in the same table for the years 1961-2004 as CANSIM

[84] Recall that the Productivity Program business sector value added aggregate V_{KLEMS}^t should be equal to the Industry Division value added aggregate V_B^t less the value of imputed rents from the Industry Division, V_{IMR}^t.

II series V41713153: Canada: Gross Domestic Product (GDP), Business Sector. The values V^t_{BKLEMS} for the missing years 2005-2007 can be obtained by adding the value of imputed rents, V^t_{IMR}, to the Industry Division value added for the Business Sector, V^t_B. Finally, P^t_{BKLEMS} can be obtained by dividing V^t_{BKLEMS} by Q^t_{BKLEMS}. As usual, we normalized the resulting price and quantity series so that P^t_{BKLEMS} equals 1 when t equals 1961. The resulting P^t_{BKLEMS} and Q^t_{BKLEMS} are listed in Table 2.4.

Recall the GDP identity defined by (2.1), which expressed the nominal value of GPD, V^t_{GDP}, at final demand prices as being equal to the value added of the Industry Division business sector value added at basic prices, V^t_B, plus non-business sector value added, V^t_N, plus the value of indirect taxes less subsidies on products, V^t_{IT}. We can also express the value of GDP at final demand prices as the familiar sum of final demand values; i.e., as the following sum of final demand expenditures on consumption plus investment plus government expenditures on goods and services plus exports less imports:

$$V^t_{GDP} = V^t_{CT} + V^t_I + V^t_G + V^t_X - V^t_M \tag{2.2}$$

We define a new consumption aggregate at basic prices V^t_{CN} as the value of consumption at final demand prices, V^t_{CT}, less indirect taxes less subsidies on products, V^t_{IT}:

$$V^t_{CN} \equiv V^t_{CT} - V^t_{IT} \tag{2.3}$$

Now equate the two expressions for the value of GDP given by (2.1) and (2.2) and use the resulting equation to express business sector value added V^t_B in terms of final demand components and the value of non-business sector value added V^t_N. Making use of (2.3), the resulting equation is the following one:[85]

[85]The identity (2.4) is not quite consistent with our treatment of indirect taxes less subsidies since we also made some indirect tax adjustments to the prices of exports and imports as explained above; i.e., since we used a slight modification of (2.3) to adjust

$$V_B^t = V_{CN}^t + V_I^t + V_X^t - V_M^t + (V_G^t - V_N^t) \tag{2.4}$$

Conceptually, the aggregate $V_G^t - V_N^t$ should be equal to the sales of the business sector of goods and services to the non-business sector less the purchases of intermediate inputs of the business sector from the non-business sector. Put another way, the business sector's net sales of goods and services should equal its net deliveries to final demand sectors $(V_C^t + V_I^t + V_X^t - V_M^t)$ plus its net deliveries to the non-business sector $(V_G^t - V_N^t)$.

Recall that we did not use the Industry Division's concept of Business Sector value added; we subtracted the value of imputed and paid residential rent from our business sector aggregate. Let V_R^t be equal to the sum of imputed residential rent V_{IMR}^t and paid residential rent V_{PR}^t (see Table 2.1 for these series). Conceptually, if we subtract rents V_R^t from V_{CN}^t, we should get V_C^t, the consumption aggregate whose price and quantity is listed in Tables 2.2 and 2.3. Thus subtracting V_R^t from both sides of (2.4) leads to the following identity:

$$V_B^t - V_R^t = V_C^t + V_I^t + V_X^t - V_M^t + (V_G^t - V_N^t) \tag{2.5}$$

Thus our business sector value added aggregate can be formed using either the left or right hand sides of the identity (2.5). We will use the right hand side of (2.5) to form our value measure of business sector net output since we want to focus on the effects of changing international prices on the performance of the business sector.

How should the corresponding real quantities that correspond to the value aggregates on either side of (2.5) be calculated? Obviously, each cell in the supply and use tables that correspond to the value aggregate on the left hand side of (2.5) could be aggregated up using a chained superlative index

final demand consumption prices for indirect tax wedges, we used a corresponding slight modification of the identity (2.4).

number formula provided that an appropriate price deflator were available for each cell.[86] On the other hand, the value cells that are components on the right hand side of (2.5) that correspond to final demand components (at basic prices) could be aggregated up using a chained superlative index number formula. We can then ask: under what conditions would the corresponding quantity aggregates be equal? This question is addressed by Moyer, Reinsdorf and Yuskavage (2006) and in more detail by Diewert (2006b)(2007b)(2007c). The answer to this question is that if the detailed data are constructed in an appropriate manner and the Fisher formula is used, then the direct industry aggregation and the aggregation of final demand component approaches are perfectly consistent.[87] In addition, if two stage aggregation procedures are used and a superlative index number formula is used at each stage of aggregation, then the theoretical and empirical results in Diewert (1978) show that the commonly used single stage superlative indexes will approximate their two or more stage counterparts to a high degree of approximation if the chain principle is used.[88]

Using the above results, we will construct our measure of business sector real value added by aggregating up the value components on the right hand side of (2.5). Rather than work with both V_G^t and V_N^t as final demand components, we will aggregate over these two components to form the value aggregate V_{GN}^t equal to $(V_G^t - V_N^t)$, and conceptually, this value aggregate should be equal to the net deliveries of goods and services of our business sector to the non-business sector less the purchases of intermediate inputs by our business sector from the non-business sector. The year t price and quantity aggregates, P_{GN}^t and Q_{GN}^t, that correspond to these value aggregates V_{GN}^t are calculated using chained Fisher indexes with Q_N^t getting a negative weight in the index number formula. P_{GN}^t and Q_{GN}^t are listed in

[86]Quantities in the Make matrix would have a positive sign while quantities in the Use matrix would have a negative sign.

[87]See Diewert (2006b)(2007b) and the numerical examples in Diewert (2007c) in particular.

[88]The results of Hill (2006) show that these approximation results will not necessarily hold for mean of order r superlative indexes if r is large in magnitude.

Table 2.5.

Table 2.5: Price Indexes for Business Sector Outputs: Net Sales to the Non-business Sector

Year t	P_{GN}^t	Q_{GN}^t
1961	1.00000	1420
1962	0.99388	1447
1963	0.97566	1446
1964	0.92683	1596
1965	0.91239	1798
1966	0.88328	2320
1967	0.89087	2684
1968	0.96139	2950
1969	0.96769	3068
1970	1.00582	3858
1971	1.10291	3885
1972	1.14412	3942
1973	1.22092	4247
1974	1.35752	4819
1975	1.48446	5397
1976	1.64265	5254
1977	1.78697	5963
1978	1.92861	5833
1979	2.18540	5796
1980	2.48896	6062
1981	2.79431	5845
1982	3.10614	6019
1983	3.37412	5998
1984	3.48567	5838
1985	3.67204	6539
1986	3.74218	6635
1987	3.79747	6789

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Table 2.5 – Continued

Year t	P^t_{GN}	Q^t_{GN}
1988	3.78607	7814
1989	3.82606	8423
1990	3.86395	9043
1991	3.92576	9508
1992	3.94383	9458
1993	3.96988	9223
1994	4.17941	8537
1995	4.29853	8165
1996	4.20205	8263
1997	4.10280	8414
1998	4.13974	9511
1999	4.29033	9380
2000	4.43225	10022
2001	4.45850	11040
2002	4.56662	11443
2003	4.56905	12088
2004	4.60878	12331
2005	4.77387	12551
2006	4.93210	13651
2007	5.05578	14632

We now turn our attention to the export and import components of final demand. Current dollar exports of goods are available as CANSIM II series V498104 for the years 1961-2007. The corresponding chained 2002 dollar series is CANSIM II series V1992061 and we use these two series to form price and quantity series for the exports of goods. However, in this study, we will form series for more detailed components of the exports and imports of goods. Current dollar exports of services are available as CANSIM II series V498105 for the years 1961-2007. The corresponding chained 2002 dollar series is CANSIM II series V1992062 and we use these two series to form price and quantity series for the exports of services, P_{16}^t and Q_{16}^t, which are listed in Tables 2.6 and 2.7.

Our starting point for obtaining disaggregated data on the exports and imports of goods is CANSIM Table 3800012, Exports and Imports of Goods and Services, Canada, Current Prices. It is possible to obtain disaggregated information on the value of exports for the following seven classes for the years 1971-2007:

- Q_9, Exports of agricultural and fish products;
- Q_{10}, Exports of energy products;
- Q_{11}, Exports of forest products;
- Q_{12}, Exports of industrial goods and materials (excluding energy and forest product exports);
- Q_{13}, Exports of machinery and equipment (excluding automotive products);
- Q_{14}, Exports of automotive products and
- Q_{15}, Exports of other consumer goods (excluding automotive products).

The CANSIM series numbers for the first seven classes of exports are V498730-V498736. It is also possible to find corresponding constant dollar series in 1992 constant dollars over the period 1971-1997 in CANSIM Table 3800012 and the CANSIM series numbers are V498767-V498773. Finally, constant dollar chained estimates for these export categories (in 1997 chained dollars) can be found for the years 1981-2007 in CANSIM Table 3800012 and the series numbers are V1992162- V1992168. We used these series to form chained price and quantity series for these seven export categories for the years 1981-2007. The constant dollar price series were linked to each chained price series at the year 1981 in order to extend the chained series back to 1971.[89]

There remains the problem of obtaining price series for the above classes of exports to cover the years 1961-1971. From Leacy (1983), Series G415-428 Foreign trade, domestic exports, excluding coin and bullion, by main commodity sections, current values, we can obtain value series covering exports for the years 1946-1975 for the following five commodity classes:

- Live animals (G415);
- Food, feed, beverages and tobacco (G417);
- Crude materials (inedible) (G419);
- Fabricated materials (inedible) (G421);
- End products (inedible) (G423).

From the same source, price indexes for each of the above five classes of exports are available as Series K57-K61 in the Table with the title: Export price indexes, trade of Canada commodity classification, 1926-1975. Thus we can find price and quantity series for these five classes of exports that cover the years 1961-1971. Unfortunately, these price indexes are of the fixed base

[89] There were two other categories in the export and import classifications: Special transactions and Other balance of payments adjustments. These categories were small and were omitted in our analysis.

variety with a base year of 1948 so they are likely to differ substantially from the corresponding chain indexes (which are not publicly available). However, Leacy (1983) also lists as part of export price Series K57-K61 (Panel A) for the above 5 classes of exports some indexes that have a 1971 base year but these price indexes cover only the years 1968-1975. We use these latter price indexes to construct export price indexes for the years 1968-1971 and then we use the 1948 based indexes to further extend these five series back to 1961.

The above operations give us five disaggregated export price and quantity series for the period 1961-1971 but we have seven classes of exports of goods for the years 1971-2007. We generated Fisher chained price and quantity indexes for exports of Live animals and for exports of Food, feed, beverages and tobacco for the years 1961-1971 and linked these series to our earlier series, P_9^t and Q_9^t, exports of agricultural and fish products. But we need some additional series so that we can match the export and import series for the 1960s to the series that cover the post 1971 period. We will create separate export series for energy, forest products, automotive products and other consumer goods. Our sources for these extra series are the input output tables for the Canadian economy that cover the years 1961-1981 (see Statistics Canada (1987a)(1987b)).

In order to create a price and quantity series for aggregate Energy exports for the years 1961-1971, we aggregated data for six classes of energy exports using the M level of aggregation: Coal, Crude mineral oils, Natural gas, Gasoline and fuel oil, Other petroleum and coal products and Electric power. These components were aggregated using Fisher (1922) chained indexes. The resulting price and quantity series were linked to our earlier price and quantity series, P_{10}^t and Q_{10}^t, for energy at the year 1971.

In order to create aggregate Forestry exports for the years 1961-1971, we aggregated data for seven classes of forest product exports using the M level of aggregation: Lumber and timber, Veneer and plywood, Other wood fabricated materials, Furniture and fixtures, Pulp, Newsprint and other paper stock, and Paper products. These components were aggregated using Fisher (1922) chained indexes. The resulting price and quantity series were linked to our earlier price and quantity series, P_{11}^t and Q_{11}^t, for forest product exports at the year 1971.

We aggregated the input output data for two classes of automotive product exports using the M level of aggregation: Motor vehicles and Motor vehicle parts. These components were aggregated using Fisher (1922) chained indexes. The resulting price and quantity series were linked to our earlier price and quantity series, P_{14}^t and Q_{14}^t, for automotive product exports at the year 1971.

In order to create an aggregate for Exports of other consumer goods (excluding automotive products) for the years 1961-1971, we aggregated data for eight classes of consumer goods type exports using the M level of aggregation: Leather and leather products, Other textile products, Hosiery and knitted wear, clothing and accessories, appliances and receivers (households), Pharmaceuticals, Other chemical products and Other manufactured products. These components were aggregated using Fisher (1922) chained indexes. The resulting price and quantity series were linked to our earlier price and quantity series, P_{15}^t and Q_{15}^t, for exports of other consumer goods at the year 1971.

We generated price and quantity series over the years 1961-1971 for Exports of industrial goods and materials (excluding energy and forest product exports), P_{12}^t and Q_{12}^t, as a chained Fisher aggregate of our price and quantity series for Crude materials (inedible) (G419) and Fabricated materials (inedible) (G421) less our series for exports of energy products P_{10}^t and Q_{10}^t) and exports of forest products (P_{11}^t and Q_{11}^t).[90] The resulting export price

[90] All four prices are entered as positive numbers in the index number formula while the first two quantities are entered positively and the last two quantities are entered negatively.

and quantity series for the years 1961-1971 are linked to our earlier series for P_{12}^t and Q_{12}^t at the year 1971.

Finally, we generated price and quantity series over the years 1961-1971 for Exports of machinery and equipment (excluding automotive products), P_{13}^t and Q_{13}^t, as a chained Fisher aggregate of our price and quantity series for exports of end products (inedible)(G423) less our series for exports of automotive products P_{14}^t and Q_{14}^t) and less exports of other consumer goods (P_{15}^t and Q_{15}^t).[91] The resulting export price and quantity series for the years 1961-1971 are linked to our earlier series for P_{13}^t and Q_{13}^t at the year 1971.

There is one additional adjustment which affects the price of energy exports. During the years 1974-1985, Canada imposed an export tax on its energy exports, which is included in the price of exports. However, producers do not receive this export tax revenue and so it must be subtracted from the export price. This adjustment of the export price index for exports of goods can be accomplished using the Oil Export Tax series, CANSIM series V499746 from the National Income and Expenditure Accounts. After making this adjustment, the resulting price and quantity series are P_{10}^t and Q_{10}^t, which are listed in Tables 2.6 and 2.7 along with the other price and quantity series for the eight classes of exports.

[91] All three prices are entered as positive numbers in the index number formula while the first quantity is indexed with a positive sign and the last two quantities are indexed with negative signs.

Table 2.6: Price Indexes for Eight Commodity Classes of Exports, 1961-2007

Year t	P_9^t	P_{10}^t	P_{11}^t	P_{12}^t	P_{13}^t	P_{14}^t	P_{15}^t	P_{16}^t
1961	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
1962	1.05659	0.98534	1.03706	1.01977	1.03488	1.01167	0.99880	1.01858
1963	1.05292	1.01104	1.04975	1.02746	1.04642	1.02781	1.00853	1.04402
1964	1.06146	0.99854	1.06857	1.04333	1.06452	1.03785	1.02909	1.07736
1965	1.07552	1.01886	1.08666	1.06777	1.09035	1.03617	1.03692	1.12159
1966	1.13905	1.02441	1.10752	1.12360	1.12856	1.05032	1.05855	1.18364
1967	1.15369	0.96541	1.12890	1.15308	1.17596	1.06607	1.07630	1.26762
1968	1.14873	1.00454	1.15804	1.22731	1.25191	1.08830	1.10360	1.34554
1969	1.11043	1.05284	1.21130	1.26468	1.28144	1.09898	1.14735	1.41327
1970	1.07460	1.06679	1.20448	1.33958	1.36481	1.12160	1.14015	1.50120
1971	1.10272	1.12301	1.24675	1.28936	1.37181	1.15193	1.15590	1.57903
1972	1.16574	1.15550	1.34600	1.30236	1.41712	1.17423	1.18547	1.66505
1973	1.65562	1.34434	1.61655	1.49521	1.46833	1.18656	1.25988	1.79018
1974	2.47603	2.37211	1.97968	1.94140	1.65047	1.27902	1.42184	2.02338
1975	2.44172	3.47049	2.31660	2.10541	1.86186	1.40313	1.56638	2.29526
1976	2.27544	4.36340	2.39386	2.22651	1.90587	1.48840	1.66746	2.51896
1977	2.13627	5.37242	2.62455	2.50906	2.02758	1.61582	1.76846	2.72893
1978	2.37658	5.96944	2.90165	2.77108	2.11566	1.78223	1.88273	2.90258
1979	2.88982	7.40098	3.47704	3.53655	2.27395	1.96622	2.00068	3.14587
1980	3.28365	10.39436	3.73797	4.45064	2.41362	2.17714	2.24946	3.49696
1981	3.56932	11.17124	3.96546	4.55036	2.55522	2.41373	2.49659	3.94719
1982	3.46707	11.69844	3.85284	4.31903	2.72280	2.63304	2.66992	4.34103
1983	3.39310	11.53824	3.83642	4.35230	2.75291	2.73815	2.80369	4.66353
1984	3.53005	11.27486	4.26336	4.45480	2.69323	2.90539	2.88654	4.87299
1985	3.51503	10.86479	4.32498	4.41174	2.68327	3.12972	3.00305	5.13320
1986	3.43645	7.75428	4.78008	4.59745	2.97757	3.01503	3.28669	5.40392
1987	3.32350	7.55588	5.20316	4.73208	3.02031	3.02347	3.40733	5.59379

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Table 2.6 – Continued

Year t	P_9^t	P_{10}^t	P_{11}^t	P_{12}^t	P_{13}^t	P_{14}^t	P_{15}^t	P_{16}^t
1988	3.49449	6.35623	5.36339	5.05742	3.04258	2.91102	3.52049	5.72724
1989	3.73084	6.87199	5.59564	5.03255	3.06798	2.86952	3.71759	5.93246
1990	3.47655	7.84685	5.24427	4.74911	3.11615	2.87959	3.73982	6.08151
1991	3.14681	6.82156	4.69849	4.45427	3.07176	2.96769	3.82601	6.29162
1992	3.48817	7.07296	4.84492	4.47367	3.06279	3.15213	3.82959	6.33223
1993	3.71935	7.47530	5.37177	4.53039	3.09777	3.35449	3.89234	6.51684
1994	3.96389	7.25372	6.18573	5.11913	3.17302	3.52359	3.99910	6.66734
1995	4.40988	7.11026	7.36498	5.72144	3.21973	3.65787	4.09757	6.88429
1996	4.71556	8.77046	6.80562	5.32837	3.18323	3.74681	4.16933	7.03680
1997	4.46079	9.00830	6.77946	5.28875	3.12343	3.83816	4.19780	7.22032
1998	4.38396	7.35245	7.02909	5.13339	3.13173	4.05650	4.25986	7.34563
1999	4.31935	9.26009	7.12821	5.03383	3.08837	4.03743	4.31663	7.46192
2000	4.37477	15.28916	7.16500	5.39152	3.06944	4.02821	4.36260	7.72519
2001	4.62634	15.71996	7.30172	5.31976	3.09180	4.17233	4.43899	7.74816
2002	4.63446	13.37888	6.82281	5.26906	3.10623	4.21091	4.46478	7.87210
2003	4.53195	16.64222	6.33572	5.24802	2.97965	3.84484	4.47389	7.93621
2004	4.46913	18.36274	6.82304	5.79875	2.92001	3.66998	4.48713	8.09962
2005	4.14794	23.46718	6.44732	6.11917	2.87531	3.46196	4.51188	8.29947
2006	4.09923	22.90367	6.08392	6.87211	2.82144	3.31328	4.54101	8.42538
2007	4.38863	23.04150	5.71715	7.39951	2.78882	3.16568	4.54902	8.58781

Table 2.7: Quantity Indexes for Eight Commodity Classes of Exports, 1961-2007

Year t	Q_9^t	Q_{10}^t	Q_{11}^t	Q_{12}^t	Q_{13}^t	Q_{14}^t	Q_{15}^t	Q_{16}^t
1961	1432.1	252.3	1573.6	2057.2	402.1	50.1	63.7	1036.0
1962	1328.6	363.9	1593.1	2130.2	511.5	62.5	77.7	1132.0
1963	1571.9	364.1	1684.6	2242.7	581.5	93.7	90.9	1204.0
1964	1963.5	408.9	1834.5	2531.7	792.8	187.7	102.2	1285.6
1965	1798.9	425.8	1869.5	2721.2	791.3	347.5	112.1	1359.7
1966	1954.0	484.2	1964.9	2809.4	910.9	985.6	135.7	1492.0
1967	1613.2	578.7	1927.6	2997.6	1147.4	1620.4	146.5	1864.9
1968	1589.7	657.2	2127.4	3282.7	1239.5	2533.5	183.3	1499.0
1969	1492.5	757.0	2290.6	3091.0	1378.2	3181.6	214.8	1657.1
1970	1967.9	951.2	2339.2	3675.8	1437.1	3137.5	236.2	1767.3
1971	2168.3	1154.0	2374.2	3611.1	1436.8	3613.9	243.1	1747.3
1972	2268.9	1479.9	2662.0	3707.9	1662.5	4001.8	270.8	1720.7
1973	2217.2	1789.7	2825.7	4085.7	1950.5	4539.2	319.8	1893.1
1974	1778.2	1508.4	2809.5	3986.3	2088.5	4430.7	323.6	2094.5
1975	1879.8	1216.3	2185.5	3513.3	2165.0	4554.8	289.8	1997.6
1976	2047.5	977.6	2718.2	3824.4	2325.5	5499.2	311.3	2048.5
1977	2445.0	919.8	3001.2	3955.3	2345.1	6388.1	338.2	2052.1
1978	2524.7	937.6	3313.3	4281.0	2914.9	6954.2	404.7	2272.8
1979	2538.2	1101.5	3369.6	4292.6	3880.9	6004.4	506.8	2556.4
1980	2785.9	951.8	3286.8	4633.9	4469.2	5002.0	570.8	2658.0
1981	2923.8	950.1	3126.5	4529.3	4810.1	5585.9	548.3	2738.1
1982	3142.7	1009.7	2962.3	4133.5	4586.9	6387.7	525.1	2508.2
1983	3256.3	1079.1	3284.3	4169.5	4413.1	7748.3	546.8	2534.8
1984	3299.9	1210.3	3501.3	4965.2	5761.5	10115.0	652.0	2685.2
1985	2979.2	1461.0	3544.7	5178.9	6360.5	10539.3	666.0	2839.4
1986	3178.0	1416.6	3708.8	5606.6	6826.0	10494.1	767.4	3254.1
1987	3565.5	1701.0	4031.4	5790.7	6884.4	10540.5	775.7	3294.5

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Table 2.7 – Continued

Year t	Q_9^t	Q_{10}^t	Q_{11}^t	Q_{12}^t	Q_{13}^t	Q_{14}^t	Q_{15}^t	Q_{16}^t
1988	3527.3	2009.2	4025.0	6316.1	7120.6	11928.4	798.8	3546.0
1989	3101.7	1997.4	3836.1	6412.9	7810.3	11838.6	709.3	3704.0
1990	3830.8	1779.1	3877.8	6765.1	9259.5	12042.3	895.2	3857.1
1991	4169.0	2068.3	3958.3	7016.2	9536.5	10949.5	908.0	3892.6
1992	4397.4	2184.7	4131.5	7237.9	10413.1	12087.4	1167.0	4156.5
1993	4342.7	2374.6	4352.4	7773.7	11895.0	14490.7	1440.8	4519.2
1994	4746.4	2646.9	4708.9	8301.8	14402.7	16349.5	1775.9	5093.3
1995	4754.3	2868.3	4989.3	8896.4	17402.0	17200.2	2029.5	5395.8
1996	4913.1	2970.5	5073.4	9821.5	19457.0	16912.7	2278.7	5850.5
1997	5553.7	3016.9	5178.1	10708.6	22070.0	18099.8	2555.4	6263.6
1998	5711.7	3238.6	5042.1	11525.7	25770.1	19342.2	2949.8	7084.9
1999	5929.8	3226.3	5623.2	11889.3	28713.2	24097.5	3239.8	7400.4
2000	6309.4	3476.8	5969.8	12608.7	35853.8	24300.2	3484.0	7936.8
2001	6717.8	3547.7	5517.3	12744.0	33169.5	22176.3	3673.6	7967.1
2002	6661.8	3687.1	5458.9	13317.5	31256.9	22958.2	3959.7	8276.2
2003	6450.4	3636.6	5448.2	12730.0	29760.9	22727.9	3841.6	7982.5
2004	6863.6	3708.9	5777.2	13443.3	31200.7	24629.3	3848.1	8268.8
2005	7256.1	3705.8	5653.2	13721.1	32346.3	25417.7	3800.7	8284.5
2006	7613.6	3789.4	5478.7	13664.5	33058.2	24838.7	3922.2	8185.4
2007	7831.6	3977.5	5118.7	14111.7	33500.8	24419.5	4118.9	8042.4

We now turn our attention to imports. Current dollar information on imports of services can be found as CANSIM II series V498108 for the years 1961-2007 and the corresponding constant 2002 chained dollar series is CANSIM II series V1992065. We use these two series to form price and quantity series for the imports of services, P_{23}^t and Q_{23}^t, which are listed in Tables 2.8 and 2.9. Note that since imported goods and services are inputs into the business sector, when we form a value added aggregate, a minus sign is appended to any quantity series pertaining to imports.

As was the case for our treatment of exports, the starting point for obtaining disaggregated data on imports of goods is CANSIM Table 3800012, Exports and Imports of Goods and Services, Canada, Current Prices. Using this table, it is possible to obtain disaggregated information on the value of imports for the same seven classes of imported good that was used for exports for the years 1971-2007. However, imports of forest products was small throughout the sample period and so this import component was aggregated with imports of industrial goods and materials (excluding forest and energy imports).[92] Thus we used CANSIM Table 38000012 in order to generate prices and quantities for the following six classes of imports for the years 1971-2007:[93]

- Q_{17}, Imports of agricultural and fish products;
- Q_{18}, Imports of energy products;
- Q_{19}, Imports of industrial goods and materials (including imports of forest products but excluding imports of energy products);
- Q_{20}, Imports of machinery and equipment (excluding automotive products);
- Q_{21}, Imports of automotive products and
- Q_{22}, Imports of other consumer goods.

[92] Chained Fisher indexes were used in order to do the aggregation.
[93] As in the case of export indexes, we used chained indexes whenever they were available.

There remains the problem of obtaining price series for the above six classes of imports to cover the years 1961-1971. From Leacy (1983), Series G429-442: Foreign trade, imports, excluding coin and bullion, by main commodity sections, current values, 1946-1975, millions of dollars (all countries), we can obtain value series covering imports for the years 1946-1975 for the following five commodity classes:

- Live animals (G429);
- Food, feed, beverages and tobacco (G431);
- Crude materials (inedible) (G433);
- Fabricated materials (inedible) (G435);
- End products (inedible) (G437).

From the same source, price indexes for each of the above five classes of imports are available as Series K62-K67 in the Table with the title: Import price indexes, trade of Canada commodity classification, 1926-1975. Thus we can find price and quantity series for these five classes of exports that cover the years 1961-1971. Unfortunately, these price indexes are of the fixed base variety with a base year of 1948 so they are likely to differ substantially from the corresponding chain indexes. However, as was the case for export price indexes, Leacy (1983) also lists as part of import price Series K62-K67 (Panel A) for the above five classes of imports counterpart indexes that have a 1971 base year but these price indexes cover only the years 1968-1975. We used these latter price indexes to construct import price indexes for the years 1968-1971 and then we use the 1948 based indexes to further extend these 5 series back to 1961.

The above operations gave us five disaggregated export price and quantity series for the period 1961-1971 but we have six classes of imports of goods for the years 1971-2007. We generated Fisher chained price and quantity indexes for imports of Live animals and for exports of Food, feed, beverages and tobacco for the years 1961-1971 and linked these series to our earlier series, P_{17}^t and Q_{17}^t, imports of agricultural and fish products. As was the case for extending our export series back to the 1960s, we need some additional series so that we can match the import series for the 1960s to the series that cover the post 1971 period. We will create separate import series for energy, automotive products and other consumer goods using the input output tables for the Canadian economy that cover the years 1961-1981 (see Statistics Canada (1987a)(1987b)). The rest of our import series computations parallel our export series computations, except that we did not generate a separate series for forest product imports due to their small size throughout the sample period.

The price of imports does not include import duties that are added to the international cost of these imported goods. Hence we must add these import duties to the price of imports. We assumed that energy, automotive and service imports were exempt from import duties and we assumed a uniform rate for the remaining import categories.[94] The series on customs import duties is CANSIM II series V499741 and after adjusting the price of imports using this series, the resulting price and quantity series for the imports of goods and services are listed in Tables 2.8 and 2.9.

[94] This is only a very rough approximation to the truth.

Table 2.8: Price Indexes for Seven Commodity Classes of Imports, 1961-2007

Year t	P_{17}^t	P_{18}^t	P_{19}^t	P_{20}^t	P_{21}^t	P_{22}^t	P_{23}^t
1961	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
1962	1.04883	1.02856	1.05578	1.09816	1.05195	1.01253	1.05228
1963	1.30508	1.00981	1.08637	1.09743	1.06958	1.01429	1.07921
1964	1.28197	1.00471	1.10651	1.09682	1.09414	1.02308	1.09777
1965	1.06938	1.02524	1.12598	1.12082	1.07648	1.02077	1.13619
1966	1.05080	1.05430	1.13068	1.15070	1.09270	1.03586	1.17024
1967	1.02344	0.98958	1.16189	1.18684	1.12302	1.05402	1.22610
1968	1.05513	1.04752	1.14800	1.19862	1.16016	1.06806	1.28761
1969	1.06398	1.00624	1.17757	1.21963	1.18860	1.08873	1.36902
1970	1.13052	1.01555	1.19414	1.22480	1.20108	1.09806	1.42900
1971	1.16283	1.11732	1.16445	1.25747	1.24031	1.10649	1.49900
1972	1.24651	1.20329	1.15700	1.26668	1.26989	1.14591	1.53952
1973	1.52015	1.43514	1.27659	1.29789	1.29640	1.18635	1.63282
1974	1.87300	4.22172	1.65984	1.42128	1.40659	1.29665	1.75102
1975	1.97450	5.43394	1.83511	1.67222	1.63529	1.44968	1.98130
1976	1.85375	5.63358	1.85932	1.67883	1.71458	1.52194	2.04366
1977	2.24663	6.42113	2.09118	1.81185	1.93225	1.71419	2.34119
1978	2.49806	7.14772	2.42204	1.83462	2.20965	1.95044	2.69834
1979	2.79922	9.22856	2.93293	1.94108	2.44387	2.14927	3.04229
1980	3.05858	14.04487	3.40659	1.71574	2.71841	2.44883	3.39335
1981	3.35205	16.89476	3.70305	1.67637	3.26363	2.79785	3.81611
1982	3.27980	16.65354	3.79588	1.82550	3.52543	2.94081	4.10352
1983	3.19245	15.35401	3.78529	1.74893	3.62370	2.95617	4.30819
1984	3.39093	15.57686	3.91220	1.78888	3.82410	3.17305	4.63802
1985	3.29961	16.05971	3.85316	1.81429	4.02632	3.27951	4.98855
1986	3.52718	10.45556	3.94881	1.83440	4.20229	3.51229	5.29276
1987	3.44257	10.91648	3.94832	1.74520	4.15738	3.53064	5.28864

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Table 2.8 – Continued

Year t	P_{17}^t	P_{18}^t	P_{19}^t	P_{20}^t	P_{21}^t	P_{22}^t	P_{23}^t
1988	3.50154	9.09050	4.05930	1.67407	4.03524	3.50861	5.09254
1989	3.45272	9.69611	4.06260	1.63403	4.08857	3.52386	5.09401
1990	3.45595	11.94481	4.01098	1.61746	4.16440	3.57930	5.24914
1991	3.43419	10.19284	3.86391	1.58265	4.12731	3.59254	5.31731
1992	3.43112	10.16216	3.93946	1.63533	4.39452	3.79083	5.63381
1993	3.44632	9.84044	4.05394	1.70897	4.68083	4.02323	6.19826
1994	3.70890	9.83576	4.32449	1.78245	4.99133	4.27046	6.68231
1995	3.92677	10.17736	4.70222	1.74664	5.15679	4.39186	6.90224
1996	3.88275	11.94335	4.52874	1.66405	5.19805	4.36419	7.01253
1997	3.99625	11.84732	4.52516	1.62932	5.26105	4.38392	7.26074
1998	3.97357	9.76539	4.64624	1.67064	5.51748	4.66991	7.80221
1999	3.85703	11.43514	4.55850	1.62996	5.52100	4.67035	7.97505
2000	3.84946	16.95310	4.72363	1.59815	5.52428	4.69368	8.18543
2001	3.99707	16.32263	4.90529	1.63313	5.67016	4.91888	8.64576
2002	4.05634	16.80830	4.85791	1.63385	5.73431	4.93873	8.84642
2003	3.91718	18.58307	4.58281	1.46138	5.39577	4.49645	8.39644
2004	3.81803	21.35868	4.74735	1.34910	5.21353	4.18264	8.24087
2005	3.72978	27.03564	4.82559	1.26664	5.00314	4.01666	8.14870
2006	3.62982	30.53146	5.01981	1.20443	4.84982	3.84873	8.19437
2007	3.73318	31.10128	4.92307	1.14851	4.63116	3.67501	8.15599

Table 2.9: Quantity Indexes for Seven Commodity Classes of Imports, 1961-2007

Year t	Q_{17}^t	Q_{18}^t	Q_{19}^t	Q_{20}^t	Q_{21}^t	Q_{22}^t	Q_{23}^t
1961	824.1	478.0	1850.2	1840.7	615.1	754.0	1535.0
1962	840.3	480.7	1926.5	1797.9	699.1	811.6	1479.6
1963	786.0	541.8	1952.1	1788.1	707.1	799.6	1466.8
1964	810.8	547.7	2235.8	2092.0	857.4	842.2	1618.7
1965	934.5	583.4	2482.1	2400.7	1157.2	948.7	1692.5
1966	1026.7	592.8	2666.5	2826.7	1573.4	1066.8	1850.0
1967	1086.6	638.9	2528.6	3077.0	1963.9	1109.3	1934.6
1968	1127.9	685.5	2726.8	3135.8	2649.7	1240.3	2013.8
1969	1290.9	737.9	3052.2	3522.5	3030.9	1461.0	2336.7
1970	1279.6	766.3	3041.7	3548.7	2758.7	1459.4	2471.7
1971	1293.5	817.1	3359.3	3712.9	3249.2	1650.7	2476.3
1972	1424.2	895.9	3855.8	4450.5	3819.2	2010.7	2585.9
1973	1625.4	928.1	4182.5	5370.1	4619.0	2325.5	2888.3
1974	1674.4	788.6	4742.9	6357.6	4931.1	2642.7	3277.5
1975	1675.3	766.1	4071.1	6031.1	4954.5	2583.3	3550.2
1976	1940.0	719.6	4177.8	6189.4	5417.1	2998.7	3971.3
1977	1846.2	654.2	4160.4	6312.2	5864.7	2943.3	3883.1
1978	1872.6	625.7	4499.4	7651.1	5918.6	2988.3	3824.2
1979	1855.1	624.7	5082.4	9325.4	6096.9	3148.4	3637.1
1980	1921.5	598.8	4917.6	12269.7	4900.3	3016.1	3760.0
1981	1994.6	573.7	5163.8	15342.7	4799.6	3113.5	3860.0
1982	1914.8	404.5	4146.0	11976.5	4128.6	2890.3	3594.5
1983	1985.9	336.2	4779.6	13552.5	5142.3	3228.1	3689.7
1984	2169.3	393.7	5469.4	16671.9	6668.0	3613.1	3774.9
1985	2190.2	395.2	6052.7	17490.1	7684.4	3557.1	3904.9
1986	2287.9	486.3	6369.6	19038.1	7845.2	3806.2	4267.7
1987	2388.1	541.7	6424.7	21231.5	7844.3	3991.8	4536.3

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Table 2.9 – Continued

Year t	Q^t_{17}	Q^t_{18}	Q^t_{19}	Q^t_{20}	Q^t_{21}	Q^t_{22}	Q^t_{23}
1988	2381.6	569.4	7298.0	26838.5	8225.8	4266.7	5184.6
1989	2625.7	641.6	7645.9	29100.6	7812.7	4681.5	5792.5
1990	2779.6	686.3	7577.4	29167.1	7319.2	4868.6	6405.6
1991	2871.4	650.4	7342.9	29676.0	7501.5	5065.0	6664.1
1992	3100.3	637.4	7950.1	31183.3	7664.1	5459.7	6738.8
1993	3437.0	708.1	8947.7	33412.5	8533.4	5711.6	6865.2
1994	3617.1	707.6	10111.7	39325.5	9583.4	5854.9	6755.0
1995	3597.8	711.1	10694.6	45780.5	9712.7	6144.3	6763.0
1996	3839.3	804.2	11268.5	48400.6	9832.0	6242.8	7110.7
1997	4101.5	897.0	13177.8	58701.8	11561.6	7109.8	7374.5
1998	4531.5	884.1	14104.5	63169.9	12105.0	7726.6	7366.6
1999	4760.9	936.4	14810.3	69069.7	13753.7	8239.7	7683.6
2000	4998.2	1053.1	15872.4	79742.9	14016.8	8861.7	8114.0
2001	5301.6	1087.2	15123.8	71310.1	12799.3	9072.2	7954.1
2002	5594.2	985.7	15449.5	67567.7	14207.5	9805.4	8090.6
2003	5735.7	1066.2	15563.8	70541.0	14176.3	10757.9	8830.5
2004	5842.3	1160.3	16838.7	80434.0	14839.8	11893.8	9363.0
2005	6159.0	1245.4	17648.1	91268.2	15667.0	12840.8	9823.2
2006	6731.2	1134.1	18076.1	99174.3	16464.5	14081.0	10104.3
2007	7118.8	1175.8	18659.2	105849.0	17274.7	15541.1	10697.4

We now turn our attention to forming estimates of business sector labour input.

2.3 Business Sector Labour Input Estimates

Quality adjusted measures of the quantity of three types of labour for the years 1961-2007 are available from the Statistics Canada KLEMS productivity program; see CANSIM Table 3830021 which has the title: Multifactor Productivity, Value Added, Capital Input and Labour Input in the Aggregate Business Sector and Major Sub-Sectors, by the North American Industry Classification System (NAICS). The three series are V41713000 (the title is Canada: Labour Input of Workers with Primary or Secondary Education; Business Sector), V41713017 (Labour Input of workers with Some or Completed Post-Secondary Certificate or Diploma; Business Sector) and V41713034 (Labour Input of Workers with University Degree or Above, Business Sector). The corresponding value of labour input or labour compensation series are found in the same table and their CANSIM series numbers are V41713187, V41713204 and V41713221 respectively. These value series however only cover the years 1961-2004.[95] These KLEMS labour series allowed us to construct the three business sector labour input series Q^t_{L1}, Q^t_{L2} and Q^t_{L3} for the years 1961-2007 (see Table 2.10 for a listing of these data) and the corresponding wage index series P^t_{L1}, P^t_{L2} and P^t_{L3} for the years 1961-2003 (see Table 2.10).

[95] This is very puzzling: the quantity series run from 1961 to 2007 but the corresponding value series stops at 2004.

Table 2.10: Price and Quantity Indexes for Three Types of Business Sector Labour

Year t	P^t_{L1}	P^t_{L2}	P^t_{L3}	Q^t_{L1}	Q^t_{L2}	Q^t_{L3}
1961	1.00000	1.00000	1.00000	17122	710	1370
1962	1.02980	1.18632	1.01126	17345	1216	1448
1963	1.05959	1.21347	1.04509	17259	1723	1487
1964	1.10555	1.24560	1.09234	17482	2230	1566
1965	1.18267	1.29309	1.15814	17774	2762	1657
1966	1.26544	1.33357	1.24479	18152	3345	1788
1967	1.34988	1.36529	1.31145	18066	3852	1853
1968	1.44254	1.40528	1.40547	17740	4282	1853
1969	1.55946	1.46444	1.53399	17740	4789	1918
1970	1.66484	1.50846	1.62547	17379	5195	1983
1971	1.77957	1.67298	1.59351	17190	5777	2166
1972	1.93443	1.81847	1.60097	17190	6411	2336
1973	2.13905	1.97009	1.63324	17705	7247	2505
1974	2.49530	2.23902	1.78277	17826	7931	2740
1975	2.90404	2.52097	1.99402	17328	8362	2870
1976	3.39630	2.82284	2.16028	16916	8793	2897
1977	3.75369	3.03206	2.22664	16675	9300	3066
1978	3.90502	3.15557	2.39954	16967	10110	3314
1979	4.17384	3.37618	2.61573	17482	11149	3640
1980	4.51590	3.71514	2.83118	17654	11960	3901
1981	5.00927	4.09363	3.43078	17843	12492	4188
1982	5.50893	4.47191	3.61769	16761	11985	4149
1983	5.58062	4.79842	3.92881	16727	12188	4254
1984	5.95405	4.90205	4.14250	17053	12771	4697
1985	6.20453	5.19867	4.38987	17499	13455	5062
1986	6.33749	5.30440	4.65051	17946	14241	5480
1987	6.64512	5.43184	4.69809	18530	15153	5911

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Table 2.10 – Continued

Year t	P_{L1}^t	P_{L2}^t	P_{L3}^t	Q_{L1}^t	Q_{L2}^t	Q_{L3}^t
1988	7.12085	5.79003	4.88684	19045	16040	6432
1989	7.26900	5.96671	5.70897	19268	16648	6798
1990	7.26005	6.49660	5.97755	18908	16927	7007
1991	7.42364	6.73848	6.66739	17843	16547	7137
1992	7.57474	6.90164	6.68101	17242	16471	7450
1993	7.69212	6.83616	6.46124	16864	17079	8246
1994	7.69473	6.84046	6.22327	16795	18371	8768
1995	7.81823	7.01644	6.20187	16692	19537	9055
1996	7.93652	6.96834	6.54102	16812	20322	9538
1997	8.12992	7.18146	7.03193	16332	21918	10073
1998	8.34882	7.36378	7.31313	16383	22679	10856
1999	8.51971	7.52497	7.58425	16984	23414	11325
2000	8.92053	7.90809	7.95222	17311	24199	12082
2001	9.06503	8.10605	8.30514	16967	24706	12695
2002	9.14718	8.18965	8.50473	17173	25339	13048
2003	9.33522	8.37832	8.56340	16778	26226	13517
2004	9.56758	8.56262	8.80245	17156	27113	14313
2005	9.92027	8.90341	9.10008	17122	27062	15292
2006	10.37190	9.30873	9.51436	17396	27189	15983
2007	10.74529	9.64385	9.85688	17242	28101	16818

The Statistics Canada productivity program aggregate labour input measure is described as follows:

> "The labour input is an aggregate of the hours worked of all persons classified by their education, work experience and class of employment (paid versus self-employed workers). This aggregate labour input measure is constructed by aggregating hours at work data for each of 56 types of workers classified by their educational attainment (4), work experience (7) and class of workers (2) using an annual chained-Fisher index. The effect of Fisher aggregation is to produce a measure of labour input that reflects both changes in total hours of work and changes in the composition of workers." John R. Baldwin, Wulong Gu and Beiling Yan 2007; 37.

Baldwin, Gu and Yan (2007; 26) describe their more disaggregated measures of labour input as follows:

> "Labour input for MFP measures reflects the compositional shifts of workers by education, experience and class of workers (paid versus self-employed). The growth of labour input (labour services) is an aggregate of the growth of hours worked by different classes of workers, weighted by the hourly wages of each class."

Thus each of the three types of labour classified by educational attainment Q^t_{L1}, Q^t_{L2} and Q^t_{L3} is a Fisher quantity aggregate over the other characteristics, holding constant the relevant educational levels. Baldwin, Gu and Yan (2007; 26) also comment on the difficulties associated with breaking up the net operating surplus generated by the self-employed into labour and capital compensation components:

> "We have modified the assumptions about the share of labour going to the self-employed workers to reflect changes that occurred during the 1990s. In the past, it had been assumed that

> the self employed essentially earned incomes similar to the employed. The Census of Population up to 1990 showed that this was a reasonable assumption; however, during the 1990s, self-employed income fell behind that of production workers. The new measure of self-employed for calculating labour input assumes that the hourly earning of self-employed workers is proportional to that of paid workers with the same level of education and experience. The proportional or scaling factor for each level of education and experience is based on the relative hourly earnings of paid versus self-employed workers derived from the Census of Population."

Overall, we believe that Statistics Canada has done an excellent job in constructing their new measures of labour input and we will use these measures in the present study.[96] The effect of using the Statistics Canada measures of quality adjusted labour input is to increase the growth of labour input by about 37% over the sample period compared to using hours worked as the measure of labour input.[97] Basically, there was a big shift in labour inputs from less skilled and less educated workers to more educated workers over this period which served to greatly increase quality adjusted labour input compared to unweighted hours worked by all types of labour.

As noted above, the KLEMS estimates of real labour input for the three types of labour run from 1961-2007 but the corresponding value series stop

[96]The labour input that is used in the residential rental of housing industry should be deducted from our measure of labour input (since we exclude all residential housing outputs from our definition of the business sector while the KLEMS program business sector excludes only the services of Owner Occupied Housing). However, the KLEMS database that is available in CANSIM does not include information on the three types of labour input that is used in the residential housing rental industry so we were not able to deduct these labour inputs from total business sector labour input. Thus our productivity estimates will have a tiny downward bias due to this factor.

[97]Estimates of total hours worked in the KLEMS business sector for the years 1961-2007 are available from CANSIM II series V41712966, (Canada, Hours Worked, Business Sector) in Table 3830021 (Multifactor Productivity, Value Added, Capital Input and Labour Input in the Aggregate Business Sector and Major Sub-Sectors, by North American Industry Classification System (NAICS)).

at 2004. Hence we need to estimate either wages or values for the three types of labour for the years 2004-2007. In order to accomplish this task, we formed our own estimates of the total value of labour input over the years 1961-2007. Estimates of wages, salaries and supplementary labour income for the business sector are available from CANSIM II series V498167 for the years 1961-2007. However, this measure of business sector payments for labour services neglects the labour input of the self-employed (and unpaid family workers); i.e., it includes only the gross wages of employees. The value of the labour services rendered by the self employed are part of the gross operating surplus of the household sector, which includes also the returns to the capital and land used by the self employed. An upper bound to the value of self employed labour services is the sum of unincorporated business net income which is available for 1961-2007 as CANSIM II series V498170. We assumed that two thirds of unincorporated net income is a return to labour and one third is the return to capital. We added this imputed labour income of the self employed to the labour income of employees in the business sector and compared this measure of total business sector labour compensation to the corresponding total labour compensation from the KLEMS database[98] and found that these two series were very close until about 1995 and then they gradually diverged to end up about 4% apart in 2003. We used the rates of growth of our imperfect measure of business sector labour income growth to extend the official KLEMS business sector labour compensation series from 2004 to 2007. We then divided this extended measure of total labour compensation by the KLEMS business sector measure of aggregate labour input[99] in order to obtain an implicit wage rate for aggregate business sector labour for the years 2004-2007. We used the movements in this implicit wage rate to extend the KLEMS wage indexes P_{L1}^t, P_{L2}^t and P_{L3}^t from 2004 to 2007; see Table 2.10 for the results of these manipulations.

[98] See the CANSIM II series V41713170, Canada, Labour Compensation, Business Sector, in Table 3830021, Multifactor Productivity, Value Added, Capital Input and Labour Input in the Aggregate Business Sector and Major Sub-Sectors, by NAICS.

[99] See the CANSIM II series V41712949 with the title Canada, Labour Input, Business Sector.

We now turn our attention to the problems associated with the estimation of beginning of the year capital stocks for the business sector.

2.4 Business Sector Capital Stock Estimates

Our general strategy in this section will be to use estimates from the National Balance Sheets to obtain estimates of inventory and land stocks used by the business sector (see Statistics Canada (1997)). This balance sheet information is also used to calibrate estimates of depreciation for reproducible capital stocks used by the business sector.

For the years 1962-2008, beginning of the year estimates of various national wealth components can be obtained from the CANSIM II database. National totals for the value of various assets can be obtained from CANSIM Table 3780004 (National Balance Sheet Accounts, by Sectors) for residential structures (see series V34675), non-residential structures (V34676), machinery and equipment (V34677), inventories (V34679) and land (V34680). The same table has the corresponding asset values for the persons and unincorporated business sector; for residential structures (see series V33464), non-residential structures (V33465), machinery and equipment (V33466), inventories (V33468) and land (V33469). Table 3780004 also has the corresponding asset values for corporations and government business enterprises; for residential structures (see series V31693), non-residential structures (V31694), machinery and equipment (V31695), inventories (V31696) and land (V31697). Finally, Table 3780004 has the corresponding asset values for the government sector; for residential structures (see series V32575), non-residential structures (V32576), machinery and equipment (V32577), inventories (V32578) and land (V32579). We subtracted the government sector value of non-residential structures, machinery and equipment and inventories from the corresponding total economy asset values in order to obtain business sector estimates of the value of beginning of the year t business sector non-residential structure stocks VK^t_{NR}, business machinery and equipment stocks, VK^t_{ME}, and business inventory stocks VK^t_{BI}; see Table

2.11 for a listing of these business sector stock values. Although residential structures are not part of our domain of definition for business sector output, it will prove useful to have some information on the value of residential structures and residential land for comparison purposes. Thus the total value of residential structures from the national balance sheets for Canada, VK^t_{RS}, is also listed in Table 2.11.

We ended up not using the balance sheet information on the value of business sector machinery and equipment. Instead, we used the investment series on ICT machinery and equipment, P^t_{IICT} and Q^t_{IICT}, and on non-ICT machinery and equipment, P^t_{IME} and Q^t_{IME}, listed in Tables 2.2 and 2.3 that were provided to us by Statistics Canada from their KLEMS database. Statistics Canada also provided us with the companion business sector price and quantity series for the beginning of the year capital stocks for ICT and non-ICT machinery and equipment. This allowed us to compare the two price series for ICT. The KLEMS ICT investment price decreased from 1 in 1961 to 0.214 in 2006 whereas the KLEMS ICT capital stock price decreased from 1 in 1961 to 0.462 in 2006, which is a considerable difference.[100] If there were no asset heterogeneity in the class of ICT investments (which there certainly is), then using the geometric model of depreciation (which is used by the KLEMS program), we would expect these two price series to be very close to each other. The KLEMS non-ICT machinery and equipment investment price increased from 1 in 1961 to 4.71 in 2006 whereas the KLEMS non-ICT capital stock price increased from 1 in 1961 to 5.23 in 2006, which again indicates some asset heterogeneity, but the divergence between these two series is not nearly as large as the divergence in the two ICT investment and capital stock price series. The question now arises: which of these two price series should we use for a geometric model of depreciation?

[100] There are even bigger differences in the rates of growth of the KLEMS ICT capital stocks versus the corresponding KLEMS measures of ICT services growth: the ICT stock grew 110 fold over the period 1961-2006 while the flow of ICT services grew 591 fold over the same period. This seems implausible.

Using the geometric or declining balance depreciation model of depreciation, the starting capital stock of a generic asset in period $t+1$, QK^{t+1}, is equal to one minus the depreciation rate in period t, δ^t, times the previous period's starting stock, QK^t, plus the new investment in the previous period, Q_I^t; i.e., we have:

$$QK^{t+1} = (1-\delta^t)QK^t + Q_I^t \tag{2.6}$$

Given information on beginning of the year capital stocks and investment during each year, the above equation can be solved for a balancing depreciation rate, δ^t, that reconciles the investment information with the balance sheet information:

$$\delta^t = [QK^t - QK^{t+1} + Q_I^t]/QK^t \tag{2.7}$$

Using the Statistics Canada KLEMS database for ICT investment and capital, we tried deflating the value data by either the ICT investment price deflator or the ICT capital stock price deflator. Using the latter deflator, the implied ICT depreciation rate trended up from 0.238 in 1961 to 0.837 in 2005. These depreciation rates seem to be too large. However, when we implemented Equation (2.7) using the ICT investment price deflator, the implied ICT depreciation rate trended up from 0.239 in 1961 to 0.329 in 2005. These depreciation rates seem to be very reasonable so we decided to use the ICT investment price deflator as the price of both ICT investments and capital stocks. Since the implied depreciation rates for ICT capital using Equation (2.7) had a pronounced upward trend, we regressed these rates on a constant and a time trend. The estimated constant was 0.19909 with a standard error of 0.01644 and the estimated trend parameter was 0.00263 with a standard error of 0.0006437 so that both estimated parameters were significant. Thus we decided to assume a starting depreciation rate of 0.200 in 1961 and we increased this depreciation rate by 0.00263 each subsequent year. We then used Equation (2.6) above along with the Statistics Canada 1961 value of the ICT capital stock as our starting value for the 1961 quantity of ICT capital in order to generate a new series for the business sector beginning of the year ICT capital stock, QK^t_{ICT} (see Table 2.12). An entirely analogous procedure was used to generate a new series for the business sector beginning of the year non-ICT machinery and equipment capital stock, QK^t_{ME}. Again, we used the KLEMS investment price deflator for non-ICT machinery and equipment, P^t_{IME} listed above in Table 2.2 as the deflator for the value of the non-ICT machinery and equipment capital stocks and the associated values of investments from the KLEMS database and we calculated the implied depreciation rates using Equation (2.7). The resulting implied depreciation rates had a small upward trend, starting at 0.160 in 1961 and ending up at 0.175 in 2005. Since this implied depreciation rates for ICT capital had an upward trend, we regressed these rates on a constant and a time trend. The estimated constant was 0.15034 with a standard error of 0.005459 and the estimated trend parameter was 0.00067351 with a standard error of 0.0002137 so that both estimated parameters were significant. Thus we decided to assume a starting depreciation rate of 0.150 in 1961 and we increased this depreciation rate by 0.00067 each subsequent year. We then used Equation (2.6) along with the Statistics Canada KLEMS program 1961 value of the non-ICT machinery and equipment capital stock as our starting value for the 1961 quantity of non-ICT machinery and equipment capital in order to generate a new series for the business sector beginning of the year ICT capital stock, QK^t_{ME} (see Table 2.12).[101]

[101] We used the rate of price inflation in Machinery and Equipment investment (using national accounts data) over the years 2006-2007 in order to extend P^t_{IICT} and P^t_{IME} to 2007.

Table 2.11: Beginning of Year Asset Values for Residential Structures and Land and Six Business Sector Capital Stocks

Year t	VK^t_{ICT}	VK^t_{ME}	VK^t_{NR}	VK^t_{BI}	VK^t_{AL}	VK^t_{BL}	VK^t_{RL}	VK^t_{RS}
1961	1236	11994	27850	13594	5954	6376	10680	28710
1962	1297	12291	29388	13698	6203	6820	11423	29923
1963	1384	13161	31414	14292	6573	7281	12083	31707
1964	1506	13526	33599	15398	7303	7840	12548	34310
1965	1633	14853	37288	16224	8156	8537	13682	37875
1966	1778	16465	41694	17884	9132	9621	14974	42144
1967	2079	18394	46012	19588	10281	10971	16365	46525
1968	2361	20118	48638	20303	11298	12138	17719	49296
1969	2575	21618	53654	21462	11476	13161	19830	54058
1970	2892	23849	58457	23742	11534	14717	22130	58649
1971	3129	25718	64343	24275	11709	16421	24498	65459
1972	3440	27339	70782	25097	12542	18614	28056	74892
1973	3777	29576	81305	27660	15088	21533	32837	92703
1974	4266	36087	100032	33614	19533	26117	40030	116929
1975	5202	44936	116373	43928	24583	32759	47559	133160
1976	5841	51020	128858	46336	28876	38954	53411	150350
1977	6670	58919	141312	50117	33354	43763	59187	164910
1978	7226	67818	157802	57091	39666	49318	66442	183222
1979	7968	78428	179306	66060	49189	55774	73636	207120
1980	7976	91337	210699	81062	62176	64557	83608	234113
1981	8990	106059	245999	89024	70108	75224	101065	272325
1982	12096	121176	278898	98428	70197	86636	118825	288844
1983	12154	125826	287481	90451	68838	93532	117239	307383
1984	13465	131389	306422	91417	65974	96021	127037	328929
1985	14798	137700	323505	99318	62107	101438	139331	348994
1986	16116	144732	336131	104983	57733	105796	142788	388346
1987	17570	147727	357496	109889	54270	113337	165711	444678

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Table 2.11 – Continued

Year t	VK^t_{ICT}	VK^t_{ME}	VK^t_{NR}	VK^t_{BI}	VK^t_{AL}	VK^t_{BL}	VK^t_{RL}	VK^t_{RS}
1988	21135	152490	384524	117358	53316	122547	195773	498048
1989	23038	167116	409950	126135	56789	134213	223325	551991
1990	26275	180720	433558	132675	61388	145366	262598	574912
1991	26883	179871	435196	130781	63028	155133	258677	614114
1992	28186	189167	439422	123077	61853	159092	287087	633754
1993	32035	195633	445261	121352	62227	162090	307046	667294
1994	34428	201705	460244	124117	64707	169691	330460	698905
1995	36200	210289	468982	131198	69745	179044	352720	713616
1996	37274	216893	485422	146615	75539	185095	343616	719997
1997	40724	223783	500321	150648	81546	193888	352946	743640
1998	45118	244159	522564	158409	86376	202313	374636	766757
1999	49415	255591	541413	169901	89497	211188	394371	797843
2000	56416	269491	568533	178794	92140	221506	425256	829875
2001	65453	286828	582195	194366	95020	234213	452800	867239
2002	69434	296458	602645	190023	97613	243534	502343	926184
2003	66302	282138	621034	192080	99905	254448	573841	1003732
2004	63616	282551	669186	187291	102197	270107	633362	1099801
2005	64580	287617	723667	193723	104627	293163	733545	1190816
2006	65678	295028	795080	204832	107323	313706	834713	1323948
2007	70684	299576	862641	215812	111010	334379	949764	1468026

Determining the value of business sector land is difficult. The problem is that the household sector owns a considerable amount of land that is used for business purposes; i.e., unincorporated persons own farm land and rental business properties and the land used in these enterprises should appear as inputs into the business sector. The corporate business sector also owns some land associated with residential rental properties and we are trying to exclude these inputs from our measure of business sector input. We will make some rough approximations in an attempt to solve these difficulties.

We first find estimates for the price and quantity of agricultural land, P^t_{AL} and QK^t_{AL}. Estimates of the area of agricultural land are available for the Census years 1981, 1986, 1991, 1996, 2001 and 2006 from CANSIM II series V32166910 and we interpolated the quantity of land in use in agriculture between these years using constant rates of growth (geometric interpolation). From Leacy (1983), series M-23, Area of Land in Farm Holdings, Census Data in thousands of acres, we can obtain estimates of the area of farm land for 1961 and 1971. After converting from acres to hectares, these data can be appended to the previous data and again geometric interpolation between the various census years can be used to complete our estimates for QK^t_{AL}; see Table 2.12 for a listing.[102] CANSIM Table 20020 (Balance Sheet of the Agricultural Sector at December 31) has asset value data for the end of the year for 1981-2007, which is beginning of the year values for the years 1982-2008. The two series that are of interest to us from this table are V157698 (the value of farm real estate) and V157699 (the value of farm land), which we denote by VK^t_{AL} for year t. Thus for the years 1982-2008, the price of agricultural land, the price of agricultural land, P^t_{AL} can be obtained by dividing VK^t_{AL} by QK^t_{AL}. For the years 1961-1980, we link P^t_{AL} to CANSIM series V381831 (the title is Canada, Value per Acre) in Table 20003, Value per Acre of Farm Land and Buildings. This last series runs from 1961 to 2008 and we found that it was quite close to P^t_{AL} for the overlap years 1981-2008. With estimates for the price and quantity of agricultural land for the

[102] As usual, the listed data are normalised so that the corresponding price is unity in 1961.

years 1961-1980, we can form estimates for the corresponding values, VK^t_{AL}; see Table 2.11. The price and quantity of agricultural land, P^t_{AL} and QK^t_{AL}, are listed in Tables 2.13 and 2.14.

We assumed that agricultural land is an input into our business sector. We also assumed that the value of residential land, VK^t_{RL}, is equal to the total value of household and unincorporated business land less the value of agricultural land. Finally, we assumed that the value of non-agricultural business land is equal to equal to the value of corporate enterprise land, VK^t_{BL}; see Table 2.11.

We also assumed that the quantity of residential land QK^t_{RL} and the quantity of business non-agricultural land QK^t_{BL} are constant over the sample period and hence the corresponding price series P^t_{RL} and P^t_{BL} are proportional to the corresponding value series VK^t_{RL} and VK^t_{BL} for the years 1962-2007. We extended these two price series back to 1961 using the movement from 1961 to 1962 in another land price series; namely series S319 in Leacy (1983): Average Land Cost per Dwelling Unit, NHA, Single Detached. These land price series, P^t_{RL} and P^t_{BL} are listed in Table 2.13 and the corresponding quantity series, QK^t_{RL} and QK^t_{BL} are listed in Table 2.14.[103]

From Table 2.2, we have price deflators for non-residential structures for year t, P^t_{INR}, and we use these deflators to divide VK^t_{NR} by P^t_{INR} in order to obtain preliminary beginning of the year capital stock quantity series QK^t_{ME} and QK^t_{NR}.[104] Recall that a series for the annual quantity of investment in

[103]The Statistics Canada KLEMS program made available to us their aggregate price and quantity series for land used in the business sector. These series cover our agricultural land and our nonagricultural and nonresidential land series and also cover the part of residential land that applies to rental housing. The KLEMS capital stock of land grew 2.01 fold over the period 1961-2006 and the corresponding price series grew 18.7 fold. On the other hand, our estimate of the growth in the quantity of agricultural land and nonresidential and nonagricultural business land is essentially zero, with corresponding 18.6 fold and 48.5 fold increases in the price of these two business land components. We estimate even higher growth rates in the price of residential land but more research in this area is needed.

[104]The use of these prices (which are average prices over the year) for stock deflation purposes is not quite appropriate because conceptually, we should be using the prices that

non-residential structures, Q^t_{INR}, is available from Table 2.3. Now we will apply Equation (2.7) again and generate a series of geometric depreciation rates δ^t_{NR} for the non-residential stock of structures for the years 1962-2006. The mean of these depreciation rates turned out to be 0.0616 with a standard deviation of 0.03253, so there was a considerable amount of variability in these rates. There appeared to be a slight upward trend in these depreciation rates so we regressed them on a time trend. The estimated constant was 0.045439 with a standard error of 0.009565 and the estimated trend parameter was 0.0007034 with a standard error of 0.0003621. Thus we decided to assume a starting depreciation rate of 0.045 in 1961 and we increased this depreciation rate by 0.0007 each subsequent year. We then used Equation (2.6) along with the Statistics Canada balance sheet value of the stock of non-residential structures in 1962 as our starting value in order to generate a new series for the business sector beginning of the year non-residential capital stock, QK^t_{NR} (see Table 2.14).

From Table 2.2, we have price deflators for residential structures for year t, P^t_{IR}, and we use these deflators to divide VK^t_{RS} by P^t_{IR} in order to obtain preliminary beginning of the year capital stock quantity series, QK^t_{RS}. Recall that a series for the annual quantity of investment in residential structures, Q^t_{IR}, is available from Table 2.3. Now we are in a position to apply Equation (2.7) again and generate a series of geometric depreciation rates δ^t_{RS} for the residential structures capital stock for the years 1962-2006. The mean of these depreciation rates turned out to be 0.040239 with a standard deviation of 0.01795. There appeared to be no trends in these depreciation rates so we decided to assume a constant geometric depreciation rate of 0.04 for each year. We then used Equation (2.6) along with the Statistics Canada balance sheet value of the stock of residential structures in 1962 as our starting value in order to generate a new series for the business sector beginning of the year residential capital stock, QK^t_{RS} (see Table 2.14).

prevail for these stock components at the beginning of the year rather than the average prices in the year which follows. However, for our purposes, the errors made here will not be material.

The smoothed geometric depreciation rates δ^t_{ICT}, δ^t_{ME}, δ^t_{NR} and δ^t_{RS} are listed in Table 2.12.

Table 2.12: Smoothed Geometric Depreciation Rates for ICT, Non-ICT Machinery and Equipment, Non-residential Structures and Residential Structures Capital Stocks Implied by the Balance Sheets and Investment Flow Data

Year t	δ^t_{ICT}	δ^t_{ME}	δ^t_{NR}	δ^t_{RS}
1961	0.20000	0.15000	0.0450	0.04
1962	0.20263	0.15067	0.0457	0.04
1963	0.20526	0.15134	0.0464	0.04
1964	0.20789	0.15201	0.0471	0.04
1965	0.21052	0.15268	0.0478	0.04
1966	0.21315	0.15335	0.0485	0.04
1967	0.21578	0.15402	0.0492	0.04
1968	0.21841	0.15469	0.0499	0.04
1969	0.22104	0.15536	0.0506	0.04
1970	0.22367	0.15603	0.0513	0.04
1971	0.22630	0.15670	0.0500	0.04
1972	0.22893	0.15737	0.0527	0.04
1973	0.23156	0.15804	0.0534	0.04
1974	0.23419	0.15871	0.0541	0.04
1975	0.23682	0.15938	0.0548	0.04
1976	0.23945	0.16005	0.0555	0.04
1977	0.24208	0.16072	0.0562	0.04
1978	0.24471	0.16139	0.0569	0.04
1979	0.24734	0.16206	0.0576	0.04
1980	0.24997	0.16273	0.0583	0.04
1981	0.25260	0.16340	0.0590	0.04
1982	0.25523	0.16407	0.0597	0.04
1983	0.25786	0.16474	0.0604	0.04

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Table 2.12 – Continued

Year t	δ^t_{ICT}	δ^t_{ME}	δ^t_{NR}	δ^t_{RS}
1984	0.26049	0.16541	0.0611	0.04
1985	0.26312	0.16608	0.0618	0.04
1986	0.26575	0.16675	0.0625	0.04
1987	0.26838	0.16742	0.0632	0.04
1988	0.27101	0.16809	0.0639	0.04
1989	0.27364	0.16876	0.0646	0.04
1990	0.27627	0.16943	0.0653	0.04
1991	0.27890	0.17010	0.0660	0.04
1992	0.28153	0.17077	0.0667	0.04
1993	0.28416	0.17144	0.0674	0.04
1994	0.28679	0.17211	0.0681	0.04
1995	0.28942	0.17278	0.0688	0.04
1996	0.29205	0.17345	0.0695	0.04
1997	0.29468	0.17412	0.0702	0.04
1998	0.29731	0.17479	0.0709	0.04
1999	0.29994	0.17546	0.0716	0.04
2000	0.30257	0.17613	0.0723	0.04
2001	0.30520	0.17680	0.0730	0.04
2002	0.30783	0.17747	0.0737	0.04
2003	0.31046	0.17814	0.0744	0.04
2004	0.31309	0.17881	0.0751	0.04
2005	0.31572	0.17948	0.0758	0.04
2006	0.31835	0.18015	0.0765	0.04
2007	0.32098	0.18082	0.0772	0.04

Table 2.13: Prices for Residential Structures and Land and Six Business Sector Capital Stocks

Year t	PK^t_{ICT}	PK^t_{ME}	PK^t_{NR}	PK^t_{BI}	P^t_{AL}	P^t_{BL}	P^t_{RL}	P^t_{RS}
1961	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
1962	0.99939	1.01477	1.00592	1.00758	1.04000	1.06956	1.06956	1.00504
1963	0.99650	1.06598	1.03251	1.01000	1.10000	1.14186	1.13138	1.02769
1964	1.00502	1.06773	1.06158	1.02114	1.22000	1.22953	1.17489	1.07312
1965	1.02393	1.10198	1.12281	1.03951	1.36000	1.33883	1.28108	1.13368
1966	1.02944	1.12251	1.19323	1.06286	1.52000	1.50884	1.40204	1.20765
1967	1.07473	1.12792	1.24188	1.08044	1.72000	1.72055	1.53236	1.28518
1968	1.10902	1.13973	1.25227	1.09271	1.90000	1.90357	1.65913	1.31431
1969	1.14444	1.17197	1.32495	1.11812	1.94000	2.06400	1.85677	1.38118
1970	1.19472	1.23029	1.39058	1.14350	1.96000	2.30803	2.07210	1.42615
1971	1.22722	1.27216	1.46812	1.15918	2.00000	2.57526	2.29387	1.53179
1972	1.26956	1.30444	1.55098	1.21176	2.16000	2.91918	2.62704	1.67349
1973	1.30782	1.34535	1.71873	1.32609	2.62000	3.37696	3.07471	1.97123
1974	1.35698	1.51430	2.03419	1.43765	3.42000	4.09586	3.74822	2.36134
1975	1.45867	1.73112	2.27337	1.55864	4.34000	5.13750	4.45312	2.56072
1976	1.45190	1.82918	2.40093	1.66364	5.14000	6.10905	5.00114	2.76853
1977	1.44467	1.98862	2.52980	1.78349	5.92000	6.86323	5.54193	2.87768
1978	1.40748	2.19453	2.71145	1.94126	7.02000	7.73441	6.22122	3.04069
1979	1.38366	2.44348	2.96312	2.15180	8.68000	8.74688	6.89491	3.28046
1980	1.21888	2.69736	3.32520	2.35895	10.94000	10.12430	7.82863	3.55455
1981	1.12880	2.98813	3.68676	2.57823	12.30000	11.79717	9.46319	3.99273
1982	1.16812	3.19883	3.96113	2.77940	12.28000	13.58689	11.12613	4.08226
1983	1.02222	3.26756	3.93090	2.93246	12.00746	14.66837	10.97760	4.25350
1984	0.96342	3.40812	4.08142	3.06736	11.47452	15.05871	11.89508	4.41785
1985	0.89167	3.57237	4.21351	3.14959	10.77083	15.90824	13.04615	4.55564
1986	0.82129	3.70845	4.27520	3.18232	9.98330	16.59100	13.36985	4.90827
1987	0.75277	3.69804	4.47320	3.23099	9.38642	17.77433	15.51626	5.40819

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Table 2.13 – Continued

Year t	PK^t_{ICT}	PK^t_{ME}	PK^t_{NR}	PK^t_{BI}	P^t_{AL}	P^t_{BL}	P^t_{RL}	P^t_{RS}
1988	0.71401	3.69075	4.72840	3.28744	9.22342	19.21871	18.33108	5.78293
1989	0.64691	3.79390	4.92520	3.34034	9.82631	21.04826	20.91090	6.13195
1990	0.61403	3.87130	5.08853	3.38833	10.62426	22.79735	24.58825	6.11231
1991	0.54586	3.74170	5.00311	3.39008	10.91042	24.32908	24.22111	6.32257
1992	0.51043	3.88288	4.97541	3.54606	10.69755	24.94996	26.88125	6.39710
1993	0.50164	4.04523	5.03758	3.55229	10.75269	25.42013	28.75011	6.58445
1994	0.48119	4.24754	5.20497	3.72829	11.17139	26.61217	30.94243	6.76485
1995	0.44755	4.44740	5.27332	3.85944	12.03048	28.07898	33.02674	6.76717
1996	0.41150	4.57050	5.43035	3.94827	13.01832	29.02794	32.17431	6.75581
1997	0.39399	4.69221	5.56694	3.81073	14.07653	30.40692	33.04791	6.87512
1998	0.36919	4.90374	5.71450	3.83563	14.93456	31.72819	35.07889	6.95993
1999	0.33873	4.94358	5.82995	3.89582	15.49944	33.12003	36.92678	7.13210
2000	0.32384	5.01831	6.02775	3.98639	15.98327	34.73818	39.81866	7.29782
2001	0.31733	5.17017	6.07934	4.07102	16.50975	36.73098	42.39774	7.48766
2002	0.30560	5.25354	6.18175	4.13975	16.95600	38.19277	47.03668	7.81242
2003	0.27567	4.94953	6.30506	3.90062	17.34990	39.90438	53.73129	8.21290
2004	0.24913	4.85253	6.70389	3.94012	17.74345	42.36014	59.30452	8.71618
2005	0.23077	4.79667	7.12403	3.98736	18.16070	45.97595	68.68515	9.11452
2006	0.21439	4.71044	7.64020	4.05205	18.62402	49.19765	78.15794	9.78750
2007	0.20857	4.58255	8.04719	4.17868	19.25890	52.43974	88.93074	10.49192

Table 2.14: Quantities of Residential Structures and Land and Six Business Sector Capital Stocks

Year t	QK^t_{ICT}	QK^t_{ME}	QK^t_{NR}	QK^t_{BI}	QK^t_{AL}	QK^t_{BL}	QK^t_{RL}	QK^t_{RS}
1961	1236	11994	27850	13594	5954	6376	10680	28710
1962	1298	12112	29215	13595	5965	6376	10680	29773
1963	1389	12346	30425	14150	5976	6376	10680	30853
1964	1499	12668	31650	15079	5986	6376	10680	31972
1965	1595	13478	33210	15607	5997	6376	10680	33409
1966	1727	14668	34942	16826	6008	6376	10680	34898
1967	1934	16308	37050	18130	5977	6376	10680	36201
1968	2129	17651	38840	18580	5946	6376	10680	37507
1969	2250	18446	40495	19195	5915	6376	10680	39139
1970	2420	19385	42038	20763	5885	6376	10680	41124
1971	2550	20216	43827	20942	5854	6376	10680	42733
1972	2710	20958	45637	20711	5806	6376	10680	44752
1973	2888	21984	47305	20858	5759	6376	10680	47028
1974	3144	23831	49175	23381	5711	6376	10680	49518
1975	3566	25958	51190	28184	5664	6376	10680	52001
1976	4023	27892	53670	27852	5618	6376	10680	54307
1977	4617	29628	55859	28101	5634	6376	10680	57307
1978	5134	30903	58198	29409	5650	6376	10680	60257
1979	5759	32097	60513	30700	5667	6376	10680	63137
1980	6544	33862	63364	34364	5683	6376	10680	65863
1981	7965	35493	66725	34529	5700	6376	10680	68205
1982	10355	37881	70409	35413	5716	6376	10680	70756
1983	11890	38508	73134	30845	5733	6376	10680	72266
1984	13976	38552	75077	29803	5750	6376	10680	74455
1985	16596	38546	76778	31534	5766	6376	10680	76607
1986	19623	39028	78623	32989	5783	6376	10680	79121
1987	23340	39947	79920	34011	5782	6376	10680	82223

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Table 2.14 – Continued

Year t	QK^t_{ICT}	QK^t_{ME}	QK^t_{NR}	QK^t_{BI}	QK^t_{AL}	QK^t_{BL}	QK^t_{RL}	QK^t_{RS}
1988	29601	41317	81322	35699	5781	6376	10680	86124
1989	35612	44049	83235	37761	5779	6376	10680	90019
1990	42792	46682	85203	39156	5778	6376	10680	94058
1991	49249	48072	86985	38578	5777	6376	10680	97130
1992	55220	48718	88319	34708	5782	6376	10680	99069
1993	63861	48362	88388	34162	5787	6376	10680	101344
1994	71547	47487	88424	33291	5792	6376	10680	103314
1995	80884	47284	88935	33994	5797	6376	10680	105453
1996	90581	47455	89391	37134	5803	6376	10680	106574
1997	103363	47692	89874	39533	5793	6376	10680	108164
1998	122207	49790	91445	41299	5784	6376	10680	110167
1999	145882	51702	92868	43611	5774	6376	10680	111867
2000	174209	53702	94319	44851	5765	6376	10680	113715
2001	206260	55477	95766	47744	5755	6376	10680	115823
2002	227207	56430	97488	45902	5757	6376	10680	118553
2003	240511	57003	98498	49243	5758	6376	10680	122214
2004	255354	58228	99821	47534	5760	6376	10680	126179
2005	279847	59962	101581	48584	5761	6376	10680	130651
2006	306347	62633	104065	50550	5763	6376	10680	135269
2007	338899	65373	107198	51646	5764	6376	10680	139920

End of the year current market value starting stocks of inventories for the entire economy and for the government sector are available from the National Balance Sheet Accounts; see CANSIM series V34679 and V32578 (Table 3780004) for the years 1961-2007. Subtracting the government inventory stocks from the total inventory stocks will give us estimates for the value of the business sector beginning of the year inventory stocks for the years 1962-2008, VK_{BI}^t. We can subtract the value of inventory change for 1961 (see CANSIM II series V498100; Table 3800002; Canada, Current Prices, Business Investment in Inventories) from the starting stock of inventories in 1962 in order to extend the value of inventory stock series back to 1961. Diewert (2002), drawing on Diewert and Lawrence (2000), used older national balance sheet information to construct current and constant dollar estimates of beginning of the year stocks of inventories for the years 1962-1999. These series may be used to construct a price of inventory series P_{BI}^t for the years 1962-1999. We extended this price series to the years 1961 and 2000-2005 by using the Industrial Product Price Index for Canada and for All Commodities, CANSIM II series V1574377, table 3290039. The inventory value series VK_{BI}^t can be divided by the inventory stock price series P_{BI}^t, in order to obtain a real beginning of the year business sector stock of inventories, QK_{BI}^t. The resulting price and quantity series (after normalization so that the price is unity in 1961) are listed in Table 2.13 for P_{BI}^t and Table 2.14 for QK_{BI}^t.

It is possible to generate an alternative value of inventory stock series by cumulating information on the value of inventory change from the System of National Accounts. Thus the CANSIM II series V498100 estimates the current value of business investment in inventories, which conceptually, should equal the value of inventory change over the year. Using the balance sheet estimates of the starting stock of inventories for 1962 (which was $13,698 million) and the above series, we can cumulate inventory changes and obtain an alternative SNA based estimated value of inventory change, which ended up at $91,315 million at the start of 2007. However, using the balance sheet estimates for the beginning of 2008 value of business inventories, we obtained the estimate \$215,812 million, which is 2.35 times as big as the implied SNA estimate. Thus the SNA based estimates basically give us an inventory to output ratio that is implausibly low at the end of the sample period. It is true that inventory to output ratios have been falling due to just in time delivery and other inventory management techniques but the number of goods that are being produced has also been growing, which implies an increasing need for inventories. In any case, we will take the balance sheet estimates of inventory stocks as the "truth".[105]

Recalling Tables 2.2 and 2.3, a preliminary price series for inventory change P_{II}^t in year t is set equal to P_{BI}^{t+1} listed in Table 2.13.[106] A preliminary series for the quantity of inventory change in year t listed, Q_{II}^t, is set equal to the stock at the beginning of year $t+1$, QK_{BI}^{t+1}, less the stock at the beginning of year t, QK_{BI}^t. These preliminary series, P_{II}^t and Q_{II}^t are then re-normalized so that P_{II}^t equals unity in 1961 and these re-normalized series are the series which appear in Tables 2.2 and 2.3.

2.5 Primary Input Tax Rates, Balancing Real Rates of Return and User Costs

Non-residential structures (office buildings, factories, etc.) and business land have to pay property taxes on these inputs whereas machinery and equipment and inventory stocks are generally exempt from paying these taxes. Thus it is necessary to take into account property taxes when constructing user costs of capital for business non-residential structures and business land. Information on property taxes for the years 1961-2007 is available from Statistics Canada; see CANSIM II series V499942, Table

[105]This choice will lead to an increase in measured Total Factor Productivity compared to estimates that rely on the SNA estimates of inventory change. See Diewert and Smith (1994) for a detailed accounting framework for inventories that is consistent with the Hicks (1961) and Edwards and Bell (1961) model of production and Diewert (2005b) for a critical review of SNA conventions for measuring inventory change.

[106]Diewert (2005b) showed that in order to obtain a user cost of inventories that is consistent with other user costs and the measurement of output, inventory changes should be valued at end of year prices.

3800035 (Real Property Taxes of Local Governments) and CANSIM II series V499841, Table 3800033 (Real Property Taxes of Provincial Governments). We approximate the asset base on which these taxes fall as the total beginning of the year national value of land, residential structures and non-residential structures. Data on these values are available for the years 1962-2008 from the National Balance Sheets and these data are described at the beginning of Section 2.4. These series were summed and the sum was used as the tax base for the sum of the two property tax series, V499942 plus V499841. The resulting property tax rates are reported as the series τ_P^t in Table 2.15[107] and it will be used in the construction of the user costs of business sector land and non-residential structures.[108]

It is of some interest to calculate the average business tax rate for taxes that apply to the use of financial capital in the business sector so we provided estimates for this tax rate by year. These business taxes that fall on the return to capital are defined to be the sum of the following taxes:

- Taxes less subsidies on factors of production (CANSIM II series V1992216, Table 3800001) less local government and provincial government property taxes;
- Total government taxes on income from corporations and government business enterprises (CANSIM II series V499131, Table 3800007) and
- Total government taxes on income from non-residents (CANSIM II series V499132, Table 3800007).

The sum of the above three sources of general business taxes that fall on capital stock components was divided by the corresponding sum of the beginning of the year value of assets for our six types of business sector asset;

[107]The tax rate for 1961 was set equal to the corresponding rate for 1962.

[108]This is a very rough approximation to the actual property tax rates on business sector land and non-residential structures since actual property tax rates are different across different sectors and assets. For example, business sector property assets are generally taxed more heavily than household property assets.

i.e., the above sum of taxes for year t was divided by $PK_{ICT}^t \times QK_{ICT}^t$ (year t starting value of ICT machinery and equipment) plus $PK_{ME}^t \times QK_{ME}^t$ (year t starting value of non-ICT machinery and equipment) plus $PK_{NR}^t \times QK_{NR}^t$ (year t starting value of non-residential structures) plus $PK_{BL}^t \times QK_{BL}^t$ (year t starting value of business sector land) plus $PK_{AL}^t \times QK_{AL}^t$ (year t starting value of agricultural land) plus $P_{BI}^t \times QK_{BI}^t$ (year t value of starting stocks of inventories) and the resulting year t general business tax rate is denoted as τ_B^t, which is listed in Table 2.15.

Using the property tax rates τ_P^t, the general business tax rates τ_B^t, the ICT machinery and equipment depreciation rate δ_{ICT}^t, the non-ICT machinery and equipment depreciation rates δ_{ME}^t and the non-residential structures depreciation rates δ_{NR}^t, the *user costs* of ICT and non-ICT machinery and equipment, non-residential structures, business land, agricultural land and inventories, U_{ICT}^t, U_{ME}^t, U_{NR}^t, U_{BL}^t, U_{AL}^t and U_{BI}^t respectively, can be defined as follows,[109]

$$U_{ICT}^t \equiv [r^t + \tau_B^t + \delta_{ICT}^t]PK_{ICT}^t \tag{2.8}$$

$$U_{ME}^t \equiv [r^t + \tau_B^t + \delta_{ME}^t]PK_{ME}^t \tag{2.9}$$

$$U_{NR}^t \equiv [r^t + \tau_B^t + \tau_P^t + \delta_{NR}^t]PK_{NR}^t \tag{2.10}$$

$$U_{BI}^t \equiv [r^t + \tau_B^t]PK_{BI}^t \tag{2.11}$$

$$U_{AL}^t \equiv [r^t + \tau_B^t + \tau_P^t]PK_{AL}^t \tag{2.12}$$

$$U_{BL}^t \equiv [r^t + \tau_B^t + \tau_P^t]PK_{BL}^t \tag{2.13}$$

[109] For additional material on user costs and many historical references, see Jorgenson (1989)(1996a) (1996b)and Diewert (2005a)(2006a) .

where r^t is suitable real rate of return that applies to the business sector in year t. In the present study, we will follow national income accounting conventions and will take r^t to be the *balancing real rate of return*;[110] i.e., it is the rate of return that is consistent with the year t value of business sector net output being equal to the value of primary inputs used by the business sector in year t, where the user costs (2.8)-(2.13) are used as prices for the beginning of the year capital inputs. Thus r^t can be determined as the solution to the following linear in r^t equation:

$$\begin{aligned} & P^t_C Q^t_C + P^t_{IG} Q^t_{IG} + P^t_{IR} Q^t_{IR} + P^t_{INR} Q^t_{INR} + P^t_{IME} Q^t_{IME} \\ & + P^t_{II} Q^t_{II} + P^t_{GN} Q^t_{GN} + P^t_{XG} Q^t_{XG} + P^t_{XS} Q^t_{XS} + P^t_{MG} Q^t_{MG} + P^t_{MS} Q^t_{MS} \\ = \; & P^t_{L1} Q^t_{L1} + P^t_{L2} Q^t_{L2} + P^t_{L3} Q^t_{L3} + [r^t + \tau^t_B + \delta^t_{ICT}] PK^t_{ICT} QK^t_{ICT} \\ & + [r^t + \tau^t_B + \delta^t_{ME}] PK^t_{ME} QK^t_{ME} \end{aligned}$$

[110] For most purposes, it is probably preferable to use an exogenous real rate of return in the user costs (2.8)-(2.13) since the resulting prices will probably approximate market rental prices better. For discussion of this topic, see Diewert (2006a). However, in our study of productivity growth, there was little difference in the empirical results if the sample average real rate of return (4.827%) was used in place of the balancing real rate; i.e., in the gross output model, average TFP growth changed from 1.01% to1.25% per year and in the net output model, average TFP growth changed from 1.04% to 1.25% per year. This is similar to results obtained by Diewert and Lawrence (2005)(2006) for Australia. Their first study used the sample average balancing real rate for Australia whereas their second study used the year by year balancing real rates of return. However, Baldwin and Gu (2007; 27) found substantial differences for the Canadian business sector in their TFP growth rates for the period 1961-1981 where their estimated average TFP growth rates increased from the 0.90 to 1.01% per year range using balancing or endogenous interest rates to the 1.18 to 1.26% range using an exogenous interest rate. The differences that Baldwin and Gu (2007; 28) found for the 1981-2001 period were not nearly as large: an increase from the 0.30-0.38% range to the 0.32-0.43% range. Baldwin and Gu (2007; 18) mention that they used a constant real rate of interest equal to 5.1 % in their exogenous interest rate models, which is very close to the 4.827 % real rate that we used in our exogenous real rate computations.

$$+[r^t + \tau_B^t + \tau_P^t + \delta_{NR}^t]PK_{NR}^t QK_{NR}^t + [r^t + \tau_B^t + \tau_P^t]PK_{BL}^t QK_{BL}^t$$

$$+[r^t + \tau_B^t + \tau_P^t]PK_{AL}^t QK_{AL}^t + [r^t + \tau_B^t]PK_{BI}^t QK_{BI}^t \tag{2.14}$$

where the various price and quantity series are defined in the tables of this Chapter.[111] The resulting series of balancing real rates of return is listed in Table 2.15. Once r^t has been determined, then the six series of user costs defined by (2.8)-(2.13) can also be calculated; these series are also listed in Table 2.15. Note that r^t is a real after tax rate of return because we do not include a capital gains term in our user costs and all user costs are evaluated at the average prices for the corresponding investment good for year t.

[111] P_{XG}^t and Q_{XG}^t are chained Fisher aggregates of our seven classes of exports of goods, P_{XS}^t and Q_{XS}^t are the price and quantity of exports of services, P_{MG}^t and Q_{MG}^t are chained Fisher aggregates of our six classes of imports of goods and P_{MS}^t and Q_{MS}^t are the price and quantity of imports of services.

Table 2.15: Business Sector Tax Rates, Balancing Real Rates of Return and User Costs

Year t	τ_P^t	τ_B^t	r^t	U_{ICT}^t	U_{ME}^t	U_{NR}^t	U_{BI}^t	U_{AL}^t	U_{BL}^t
1961	0.01528	0.03225	0.03650	0.26875	0.21875	0.12903	0.06875	0.08403	0.08403
1962	0.01528	0.03281	0.03578	0.27106	0.22250	0.13034	0.06912	0.08723	0.08971
1963	0.01525	0.03318	0.04750	0.28494	0.24733	0.14696	0.08149	0.10552	0.10954
1964	0.01534	0.03468	0.05119	0.29524	0.25400	0.15745	0.08769	0.12348	0.12445
1965	0.01536	0.03353	0.04779	0.29882	0.25786	0.16222	0.08453	0.13148	0.12944
1966	0.01533	0.03249	0.05042	0.30478	0.26520	0.17510	0.08812	0.14933	0.14823
1967	0.01524	0.03054	0.03555	0.30294	0.24827	0.16210	0.07141	0.13989	0.13993
1968	0.01590	0.03299	0.03652	0.31930	0.25552	0.16944	0.07595	0.16227	0.16258
1969	0.01624	0.03428	0.03291	0.32986	0.26082	0.17758	0.07513	0.16185	0.17220
1970	0.01607	0.03153	0.03428	0.34584	0.27292	0.18519	0.07525	0.16047	0.18897
1971	0.01554	0.03206	0.02737	0.35065	0.27495	0.18640	0.06889	0.14993	0.19306
1972	0.01506	0.03382	0.02783	0.36891	0.28570	0.20072	0.07471	0.16570	0.22394
1973	0.01380	0.03757	0.05809	0.42794	0.34131	0.27990	0.12685	0.28677	0.36963
1974	0.01255	0.04094	0.06004	0.45483	0.39326	0.34100	0.14518	0.38829	0.46503
1975	0.01217	0.03639	0.02907	0.44093	0.38922	0.30106	0.10203	0.33691	0.39882
1976	0.01283	0.03314	0.03320	0.44398	0.41412	0.32335	0.11038	0.40696	0.48369
1977	0.01333	0.03120	0.04273	0.45653	0.46663	0.36292	0.13185	0.51658	0.59888
1978	0.01317	0.03105	0.04783	0.45546	0.52730	0.40389	0.15314	0.64625	0.71202
1979	0.01205	0.03217	0.06274	0.47357	0.62792	0.48763	0.20424	0.92848	0.93563
1980	0.01198	0.03248	0.05146	0.40699	0.66535	0.51280	0.19800	1.04933	0.97109
1981	0.01207	0.03143	0.04056	0.36639	0.70337	0.52742	0.18560	1.03391	0.99164
1982	0.01218	0.02773	0.02063	0.35463	0.67952	0.47628	0.13440	0.74340	0.82251
1983	0.01273	0.02880	0.04443	0.33845	0.77758	0.57532	0.21474	1.03215	1.26088
1984	0.01254	0.03198	0.05234	0.33220	0.85111	0.64470	0.25864	1.11142	1.45859
1985	0.01260	0.03173	0.05501	0.31196	0.90318	0.67898	0.27321	1.07001	1.58038
1986	0.01276	0.03070	0.05025	0.28474	0.91858	0.66783	0.25761	0.93553	1.55481
1987	0.01262	0.03305	0.06412	0.27517	0.97846	0.77381	0.31395	1.03052	1.95141

Continued on Next Page...

Table 2.15 – Continued

Year t	τ_P^t	τ_B^t	r^t	U_{ICT}^t	U_{ME}^t	U_{NR}^t	U_{BI}^t	U_{AL}^t	U_{BL}^t
1988	0.01253	0.03318	0.05905	0.25936	0.96079	0.79750	0.30321	0.96627	2.01340
1989	0.01267	0.03323	0.04822	0.22971	0.94929	0.78175	0.27209	0.92490	1.98116
1990	0.01303	0.03249	0.03650	0.21200	0.92299	0.74964	0.23376	0.87139	1.86982
1991	0.01360	0.03066	0.01785	0.17872	0.81795	0.64092	0.16443	0.67758	1.51093
1992	0.01418	0.03054	0.02931	0.17425	0.89545	0.70016	0.21221	0.79188	1.84691
1993	0.01418	0.03271	0.02850	0.17325	0.94110	0.71929	0.21742	0.81059	1.91629
1994	0.01392	0.03528	0.04441	0.17635	1.06954	0.84170	0.29711	1.04577	2.49121
1995	0.01369	0.03729	0.05185	0.16943	1.16489	0.90509	0.34405	1.23716	2.88751
1996	0.01371	0.04085	0.05500	0.15962	1.23083	0.97235	0.37844	1.42627	3.18027
1997	0.01366	0.04436	0.04773	0.15238	1.24910	0.97949	0.35092	1.48857	3.21548
1998	0.01386	0.04021	0.04498	0.14121	1.27485	0.97115	0.32674	1.47920	3.14252
1999	0.01395	0.04567	0.04749	0.13315	1.32792	1.04185	0.36292	1.66008	3.54736
2000	0.01320	0.05092	0.06134	0.13434	1.44719	1.19200	0.44748	2.00514	4.35800
2001	0.01296	0.04095	0.06042	0.12901	1.43815	1.13880	0.41265	1.88744	4.19919
2002	0.01255	0.03963	0.07025	0.12765	1.50961	1.21244	0.45488	2.07595	4.67601
2003	0.01239	0.04193	0.06610	0.11536	1.41639	1.22833	0.42137	2.08922	4.80516
2004	0.01212	0.04536	0.07973	0.10916	1.47468	1.42330	0.49287	2.43457	5.81222
2005	0.01167	0.04517	0.08577	0.10307	1.48894	1.55589	0.52207	2.58973	6.55621
2006	0.01110	0.04621	0.07823	0.09493	1.43474	1.62001	0.50423	2.52426	6.66814
2007	0.01065	0.04605	0.07965	0.09316	1.40462	1.71843	0.52524	2.62584	7.14985
Average	0.01351	0.03569	0.04827	0.26874	0.78978	0.64956	0.23351	0.95212	1.91810

Note that the sample average of the balancing after tax real rates of return r^t was a rather large 4.827% per year.[112] The average property tax rate τ_P^t was 1.351% while the average business tax rate on assets was 3.569%. Thus the before business tax real rate of return averaged 8.396%. Thus it appears that governments are taking about 42.5% of the before tax return to capital assets on average.[113] However, it must be kept in mind that these balancing rates of return may not be very reliable; they contain the net effect of all the measurement errors that were made in constructing this data set. The volatility in the above real rates of return is a source of concern since it is likely that a considerable proportion of the volatility is caused by various measurement errors. The volatility in the real rates of return also causes volatility in the user costs and possible volatility in productivity growth rates. However, we repeated our productivity calculations using a constant after tax real rate of return (equal to the sample average real rate of 4.827%) and found no material difference in our productivity growth rates. Hence the volatility in the productivity growth rates is mainly due to volatility in our output measures.

[112]The corresponding balancing real rate of return for Australia averaged around 3 percent; see Diewert and Lawrence (2006). Normally, after tax real rates of return are in the 1 to 3 percent rate whereas our average rate is close to 5 percent. This suggests that our estimates of the value of output are too high or that the value of labour input are too low or that our estimated asset values for business sector capital inputs are too small. We think that the last possibility is the most probable one. Using the data tabled for this chapter, we calculated a business sector nominal and real value of business sector output and we also calculated the corresponding business sector nominal and real capital stock inputs where the real measures were calculated using chained Fisher indexes. We found that the nominal business sector capital output ratio fell from 2.417 in 1961 to 1.861 in 2007 while the real capital output ratio fell from 2.417 in 1961 to 1.538 in 2007. These falls in the capital output ratio seem unlikely. See Diewert and Fox (2001) for a discussion of output mismeasurement problems.

[113]This relatively high rate of business taxation has two negative effects: (i) it raises the user cost of capital and hence lessens the beneficial effects of capital deepening and (ii) the high rates lead to a relatively large loss of productive efficiency; i.e., the deadweight losses of such large tax rates are likely to be large. See Diewert and Lawrence (2002) for a methodology for estimating the deadweight losses due to capital taxation.

2.6 Sources of Error

There are many problems with the data constructed in this paper. Some of the more important possible sources of error are listed as follows,

- Our adjustments for converting final demand prices (those facing the final demanders of the goods and services produced by the business sector) into basic prices (prices facing the producers of the goods and services) were rather crude and some aggregation error will be associated with our procedures. In particular, only crude adjustments for the effects of indirect taxes on the components of consumption were made. Also our method for estimating the net supplies of the business sector to the non-business sector is rather indirect and subject to some error.[114]

- Our tax adjustments for the price of imports and exports were also not completely satisfactory due to various aggregation errors; i.e., we were not able to assign taxes accurately to the various components of imports and exports.

- Our measure of labour input relies on the Statistics Canada KLEMS program estimates for quality adjusted labour and there may be some amount of error in these estimates. In particular, it is very difficult to account for the hours of work and labour compensation for the self-employed.

- It proved to be difficult to reconcile balance sheet information with investment information. Our treatment of investment and capital services was highly aggregated and hence contains some aggregation errors. We also relied heavily on the Statistics Canada Balance Sheet estimates and these estimates are highly aggregated; in particular, there is not enough detail on the allocation of land. Moreover, the Balance Sheet stocks appear to give asset values that are too small.[115]

[114] In particular, we did not have access to *chained* price indexes for the non-business sector for the years prior to 1997 and this will lead to some aggregation errors.

[115] Evidence of this possible undercounting of asset values in the Balance Sheet accounts

- Our treatment of property taxes is very approximate.
- Our user costs of capital were constructed using a particular set of assumptions (no capital gains and endogenous real rates of return) and these assumptions are not universally accepted.
- The roles of infrastructure capital and R&D investments were not taken into account.
- The role of resource depletion was also not taken into account.

The next international version of the System of National Accounts (SNA) will recognize capital services in the production accounts. This will be a big step forward since it will allow inputs in the SNA production accounts to be decomposed into price and quantity components and hence the revised SNA will facilitate the development of productivity accounts for each country that implements the revised SNA. However, just introducing capital services into the SNA will not be sufficient in order to develop accurate sectoral productivity accounts. The revised SNA also needs to consider the following problems:

- More attention needs to be given to the development of basic prices by industry and by commodity; i.e., we need accurate information on the exact location of indirect taxes (and commodity subsidies) by commodity and industry on both outputs and intermediate inputs.
- In order to deal adequately with the complications introduced by international trade, the existing Input Output production accounts need to be reworked so that the role of traded goods and services can be tracked by industry.

are the declining capital output ratios that are implied by our data. Moreover, the assessed value of real property (land and structures) in British Columbia for 2007 was just over one trillion dollars. If we add up the value of land and structures in the National Balance Sheets for the beginning of 2007, we get a value of about 4 trillion dollars. If we multiply the British Columbia value by a factor of 8, it seems that the national value of real property should be equal to about 8 trillion instead of the 4 trillion in the accounts.

- The treatment of inventory change in the present SNA seems inadequate for the needs of productivity accounts. Inventory change should be integrated with the balance sheet accounts and the user cost accounts.

- The investment accounts need to be integrated with the corresponding balance sheet accounts, both in nominal and real terms.

- The treatment of land in the balance sheets requires additional work; i.e., there are problems in obtaining information on the quantity of land used by each industry and sector and valuing the land appropriately.[116]

- Difficult decisions must be made on the exact form of the user cost formula to be used when measuring capital services; i.e., the revised SNA should make specific recommendations on how user costs should be constructed so that some measure of international comparability can be achieved in the accounts.

- The problems involved in making imputations for the labour input of the self-employed (and unpaid family workers) should also be addressed.

The introduction of capital services into the SNA will provide challenges for statistical agencies. However, as national statistical agencies make productivity accounts a part of their regular production of the national accounts, there will be benefits to the statistical system as a whole since a natural output of the new system of accounts will be balancing real rates of return by sector or industry. These balancing real rates of return will provide a check on the accuracy of the sectoral data: if the rates are erratic or very large or very small, this can indicate measurement error in the sectoral data and hence will give the statistical agency an early indication of problems with the data.

[116]There are some difficult conceptual and practical problems involved in separating structure value from land value; see Diewert (2007a) for a discussion of some of these problems.

Statistics Canada already has an extensive productivity program. It is to be hoped that as the program evolves in the future, the data will be presented to the public in some detail and hopefully, at some level of aggregation, revised series will be made available back to 1961.[117]

2.7 Recommendations for the Statistics Canada Productivity Program

There are substantial difficulties in accessing data on the prices and quantities of primary inputs used by the business and non-business sectors from CANSIM. Also it is evident that the coverage of primary input usage by industry by Statistics Canada is not nearly as extensive as the corresponding coverage of gross outputs and intermediate inputs. With the next revision of the System of National Accounts recommending a decomposition of gross operating profits into price and quantity components, it seems time for Statistics Canada to devote more effort into improving measurement with respect to primary inputs used by industries in the Canadian economy. Without accurate information on the flow of labour and capital services by industry, governments and businesses will not be able to plan ahead for Canada's future. It is important to know past trends in TFP growth by industry so that future trends can be anticipated and so that budgetary planning can be carried out on a more rational basis. Hopefully, other national departments interested in Canadian productivity growth (the Bank of Canada, the Department of Finance and Industry Canada to name a few) will support an initiative that will put more resources into the hands of Statistics Canada so that they can provide better information on productivity growth.

Important priorities for improving Statistics Canada's productivity program include the following ones:

[117] It is important to have data back to the early 1960's since the 1950's and 1960's were decades of very high productivity growth. Hence if we want to explain the productivity slowdown that took place in the 1970's, it is important to have comparable data for the 1960's.

- The National Balance Sheet accounts need to be fully integrated with the productivity program; i.e., Statistics Canada collects information on 30 classes of assets with some degree of industry breakdown but publishes only a crude four type of asset by households, corporations and governments breakdown. The household sector needs to be split into a self employed business component and a “consumer of goods and services” component and the corporate sector should be decomposed into industries with price and quantity information for the 30 classes of asset made available by quarter and by industry.

- The National Balance Sheet information on the value of land, residential structures and non-residential structures needs to be greatly expanded so that more information on the price and quantity of real property by industry is made available.[118] The problems associated with finding adequate constant quality price indexes for residential and non-residential structures are formidable[119] but given the importance of real property in the Canadian economy, it is necessary to put additional resources into this area of economic measurement.

- The KLEMS program has developed very useful price and quantity information on 56 types of labour used by the Canadian business sector but has only made a highly aggregated form of this information (the information on three types of labour service used in this study) available on CANSIM II. However, this information is extremely useful to the general community. If it is felt that the disaggregated information is not reliable enough to be released in this form, then it should be aggregated up and released at some level of detail that is more detailed than the present three price and quantity series that are available on CANSIM II. Furthermore, corresponding information on disaggregated labour input by type of worker should also be provided

[118] We have some concerns that the National Balance Sheets are perhaps missing some growth in the value of real assets. Indirect evidence that points in this direction includes declining capital output ratios for the Canadian business sector. Part of the problem may be the very high depreciation rates that are being used by the KLEMS program.

[119] For a review of these problems, see Diewert (2007a).

for the non-business sector.[120]

- More information on the incidence of taxes needs to be provided in the Input-Output accounts; i.e., we need to know exactly in which cell of the Input-Output accounts various indirect and direct taxes are applied.[121] Not only is this information required to reconcile final demand indexes with production accounts indexes, it is also required in order to evaluate the efficiency of our tax system.[122]

- The estimations in Chapter 1 has shown that over short periods of time, changes in the real price of exports and imports can have substantial effects on living standards. The methodology used in the paper is applied only to the aggregate business sector. In Section 1.8 of Chapter 1, we showed how the methodology can be extended to the industry level but in order to implement this methodology to show the effects of changes in the terms of trade by industry, it will be necessary to expand existing Input-Output tables to include information on exports produced and imports used by industry.[123] Government departments who have an interest in productivity measurement by industry will have to consider whether it would be worthwhile extending the production accounts in this direction. These extended accounts would enable researchers to study issues related to outsourcing and globalization in a more scientific manner.

- Baldwin and Gu (2007; 15-22) have a nice discussion about many of

[120] Statistics Canada has been a pioneer in developing and publishing very detailed information on the prices and quantities of outputs produced and intermediate inputs used by industry back to 1961 in its input output tables. What we are asking here is that these tables be extended to also cover the 56 types of labour input and 30 types of capital input that are being used in the Statistics Canada KLEMS program. Note that extending the Input-Output tables to cover primary input allocations will also involve extensions to the corresponding final demand accounts, which in the case of inputs, will be corresponding household and government supplies of labour and capital.

[121] Recall that we were forced to make guesses about the incidence of various consumption, import, property and capital taxes in order to reconcile final demand prices with producer prices. For additional material on how to accomplish this reconciliation, see Diewert (2006b)(2007b).

[122] See Diewert (2001; 97-98) for an elaboration of this point.

[123] Diewert (2007b)(2007c) explains these expanded production accounts in more detail.

the unresolved issues in constructing an appropriate user cost formula in order to price capital services and note that an unambiguous "best practice" measure has not yet emerged. Given this state of affairs, we recommend that Statistics Canada provides not only the actual user costs by asset and year that they used in the KLEMS program but that they provide supplementary information on the various ingredients (interest rates, property taxes, business taxes, asset price appreciation terms and asset prices) that go into the making of the user costs so that researchers can construct their own preferred versions of user costs. Eventually, a view will form on what the "best practice" user cost is but we are not at this point yet and hence it is essential that Statistics Canada provides analysts with information on the various components of user costs.

Chapter 3

Does Lobbying Affect Antidumping Case Determinations in Canada?

3.1 Introduction

A large number of petitions against dumping[124] were filed globally in the last decade[125] indicating that many countries are involved either as plaintiffs or defendants in antidumping litigation. Canada is no exception. In fact, Canada is a seasoned user of antidumping legislation. According to the World Trade Organisation (WTO), Canada ranks 6th among its 45 reporting members in the total number of antidumping initiations from 1995 to 2007.[126]

GATT Article 6 of the WTO stated that all countries are allowed to introduce their own antidumping legislation. Thus, a domestic firm that believes it is victimised by dumping can file an antidumping petition with its government. In Canada, antidumping cases are determined according to the antidumping legislation mandate which states that factors such as prices and market share cannot be used in the injury determination. Most importantly, the determinations are supposed to be immune from political pressure. This suggests that there should be no need for firms to apply

[124] Dumping means an export good is being sold below the cost of its production or below the price it is normally charged in the country of production.
[125] According to the World Trade Organization Antidumping Gateway, there were over 2,800 antidumping initiation filed by member countries between 1998 to 2008.
[126] Statistics taken from the World Trade Organisation Antidumping Gateway.

political influence after they file antidumping petition. In fact, however, Canadian firms have often lobbied antidumping agencies after they filed petitions. This indicates that Canadian antidumping legislation mandate may not be as apolitical as it was designed to be.

This paper examines antidumping cases in Canada from 1996 to 2003, focussing on the relationship between the outcomes of the cases and various economic and political factors, in order to determine whether the mandate is independent of political influences. Using the Canadian Lobbyists Registration data, we construct a new political variable to test for the effect of the political influence on Canadian antidumping cases determinations. We find that antidumping case determinations in Canada are not independent of political influence.

This paper contributes to the literature in two ways. First, while several previous studies have found evidence that political influence affects antidumping cases in the United States, this is the first paper to study the role of lobbying in affecting antidumping cases in Canada. Finger et al. (1982) is the pioneer of empirical studies in antidumping and found some evidence that political pressure was able to influence U.S. antidumping cases.[127] Leipziger and Shin (1991), Hansen and Park (1994), Hansen and Prusa (1997), Bown, Hoekman and Ozden (2003), Drope and Hansen (2004), Francois and Niels (2004), and Evans and Sherlund (2006) also found evidence of non-economic influences on U.S. antidumping case determinations. In particular, Hansen and Park (1994), Hansen and Prusa (1997), and Drope and Hansen (2004) found that political factors are significant in affecting the decisions made by the antidumping agencies in the U.S. These studies used a large variety of political variables ranging from indus-

[127] Most subsequent empirical studies shifted the focus towards economic determinants and their influences on antidumping cases, such as Herander and Schwartz (1984), Feinberg (1989), Coughlin et al. (1989), Leidy (1997), Prusa and Skeath (2001), Knetter and Prusa (2003) and Feinberg (2005). These studies found that microeconomic variables such as industry capacity utilisation rate, wage to value-added ratio and unionisation coverage; and macroeconomic variables such as inflation, real exchange rate and real GDP growth are significant in influencing the decision of filings.

try concentration to number of political party representatives to political contributions by industry to represent political pressures.[128] However, a problem with these variables is that it is hard to tell if the political pressure is truly targeted to influence antidumping cases.[129]

Second, unlike previous empirical studies that have had to rely on proxies to construct political pressures, this paper is able to utilise a new set of data on Canadian lobbyists. The details of the Canadian Lobbyists Registration data make it possible to identify the lobbyists who lobbied antidumping legislation agency, thus making the political variable constructed in this paper more appropriate than those previously used.

The rest of the paper is organised as follows: Section 3.2 introduces the background of antidumping legislation, petition filing process and lobbyists registration in Canada. Section 3.3 includes the empirical analysis with details on data choices and methodology, and the discussion of results. Finally, in Section 3.4, there is a brief conclusion of the empirical analysis.

3.2 Antidumping and Lobbying

Dumping is said to occur if the exporter charges a price that is lower than either the price at which it is sold in the exporter country or the cost of production. Dumping can lead to consequences such as reduced domestic prices, reduced sales, reduced market share or reduced profit, all of which can injure the domestic producers. Domestic producers who believed they are victimised can file antidumping petitions with the government agency

[128]There is also a small theoretical literature that investigates the role of political influence in antidumping cases. For example, Anderson (1994) developed a two-stage game which allows the firm to make a decision on filing in the first stage and then consider whether to lobby the antidumping agency for a specific outcome in the second stage. Gasmi et al. (2004) also examined a model in which a domestic firm can choose to lobby an agency that administers international antidumping legislation in order to influence a determination.

[129]Nelson (2006) pointed out that empirical works in antidumping have very little connection with the theoretical development due to reasons like this.

responsible for antidumping cases. Upon the receipt of a petition, the agency will start an investigation and can levy antidumping duties if injury from dumping is found.

In Canada, the Special Import Measures Act (SIMA) that went into effect on December 1, 1984, states that industries producing the same goods as imports and suspect the imports are dumped, may file complaints with the Canada Border Services Agency (CBSA). Suspected cases are usually filed by the industry or by a representative firm that believes it has been victimised. At least 25% of the Canadian production of that industry must support the complaint, and the proportion of support must also be larger than the opposition. A complaint must include information on the domestic goods, the imports, the domestic industry and the conditions in the Canadian market. The complaint must also include evidence of injury. If satisfied that the complaint is properly documented, CSBA will launch an investigation to determine whether the named imports are dumped by the named countries. CSBA is also responsible for determining the amount of antidumping duties to be imposed.[130]

Another antidumping agency that works independently from the CBSA is the Canadian International Trade Tribunal (CITT). The tribunal consists of nine full time members appointed by the government. Their responsibilities include conducting inquiries into whether dumped imports have caused injury to domestic producers and hearing appeals of cases determined by CSBA. It also conducts antidumping injury inquiry through public hearings and is responsible for the final decision on injury after the inquiries. The SIMA restricts the factors that can be included in the determination of injury to include only domestic production values, market prices, market share of the complaining firms, profits, employment level, capital utilisation and investment expenditure.

[130] See CBSA website for details of antidumping cases investigation procedure.

Upon preliminary affirmative ruling, a temporary duty will be imposed by Canada Border Service Agency. In the case where a final injury decision is issued in favour of the Canadian industry, an antidumping duty will be implemented on imports from the named countries that were dumped.[131] Exporters named in the investigation can alternatively, before full investigation is instigated, choose to work on an undertaking that commits them to change their pricing practices that are causing harm to the Canadian industry. Any proceedings or rulings of the cases are published in the Canada Gazette. Over 150 complaints had been filed with the Tribunal and were given rulings since the introduction of the Special Import Measures Act in 1984.

For the past two decades, about two-third of the antidumping cases filed in Canada eventually led to injury findings and only a few of the cases resulted in a price undertaking. Table 3.1 shows a summary of the antidumping cases filed from 1990 to 2006 and Table 3.2 shows the country classifications of the named countries from 1990 to 2004.[132] There were a total of 87 complaints that named 74 countries during this period.[133] Most of the antidumping complaints in Canada were initiated by four industries: steel products, textiles, food products and chemical products. The most named trade partners were the U.S. followed by China and Taiwan. European countries like the United Kingdom and Germany were named regularly but less frequently. However, the U.S. and France were the only countries that ever accepted undertaking during this period.

[131] This is different from the U.S. where duties begin at the stage before ruling.

[132] Classification is from International Monetary Fund Economic Outlook 2007. Bown, Hoekman and Ozden (2003) reported that in the U.S., developing countries are often named and they believed this is partly because those countries have limited resources to retaliate, are unable to raise the already high protection further and are unfamiliar with litigation procedure for appeal. However, in Canada, advance economies have been named slightly more often than developing countries have been named.

[133] Author's own recoding, details described in the Section 3.3.

Table 3.1: Antidumping Cases in Canada 1990-2006

Country	**Times Named**[b]	**Injury Found**	**Undertaking Accepted**
United States	56	29	8
China	24	15	0
India	11	8	0
Taiwan	14	7	0
Germany	13	8	0
United Kingdom	11	8	0
France	12	8	1
Other Countries	175	122	0
Total	316	205	9

[b] Each case may consist of multiple named countries and multiple NAICS6 industries, the combination of one country and one industry is considered as one count.

Table 3.2: Antidumping Cases in Canada by the Named Country's Economic Status 1990-2004

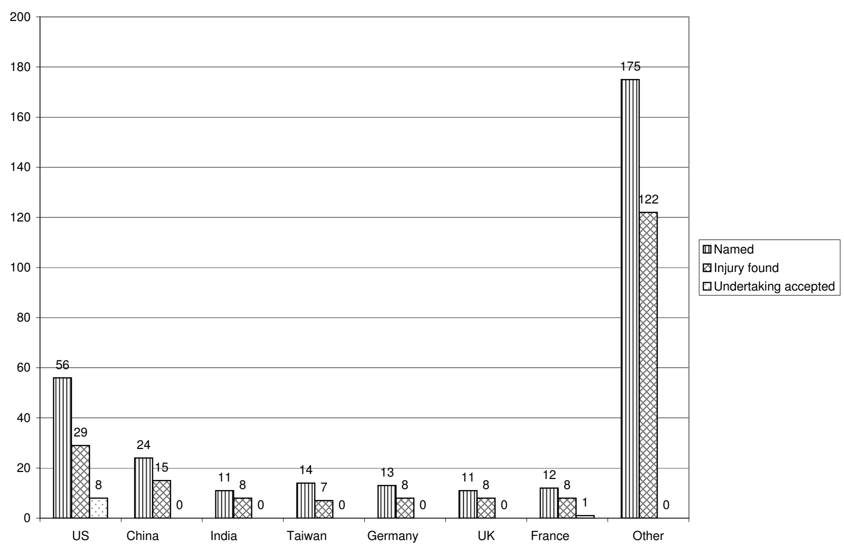
Initiation Year	**Advanced Economies**[c]	**Developing Countries**
1990	6	9
1991	12	0
1992	39	17
1993	18	6
1994	3	0
1995	36	1
1996	3	7
1997	8	5
1998	5	6
1999	11	18
2000	8	16
2001	9	16
2002	1	4
2003	7	15
2004	6	5
Total	172	125

[c]Classification comes from International Monetary Fund's World Economic Outlook 2007.

Canada's antidumping legislation process is quite different from that in the United States. First, no ex-ante duties are collected, and the named countries are allowed to raise export prices and accept undertaking before any final decisions are made. Second, named countries with dumping margins less than a threshold set by CBSA are excluded from injury determination.[134] Thus, not all named countries will have duties imposed if the determination is affirmative. However, once an affirmative decision is made, Canada tends to impose a heavier duty to eliminate the dumping margin.

[134]U.S. calculates its dumping margin using a practice called "zeroing" which eliminates any negative dumping margins and includes all named countries, thus possibly overestimating the margin.

Figure 3.1: Antidumping Cases in Canada by the Named Countries 1990-2006



In Canada, the Lobbyists Registration Act became effective in 1995 and required all lobbyists to register with Industry Canada. They must also list which company they represent, what purpose they have and what actions they plan to take. Actions usually include meetings with legislators and attending committee meetings where the politicians who have the power to influence policies attend. Table 3.3 shows the number of active lobbyist registrations in Canada from 1996 to 2005, and it can be seen that the total number of active lobbyists that registered with Industry Canada has doubled since 1996. Unlike direct political contributions, there is no restriction on lobbying expenditure. Thus, industries can spend as much on lobbying as they prefer to reach their goals and may hire as many lobbyists as they wish to represent them.

Table 3.3: Active Lobbyist Registrations in Canada 1996-2005

Year	**Consultant**	**In-house (Corporate)**	**In-house (Organisation)**[d]
1996-1997	1774	380	295
1997-1998	2012	367	327
1998-1999	2060	352	362
1999-2000	2401	336	382
2000-2001	2682	300	363
2001-2002	3003	234	357
2002-2003	3095	296	316
2003-2004	3287	298	330
2004-2005	3417	192	271

[d] Data from Office of Registrar of Lobbyists, recorded as of March 31st in the year

In Canada, firms and industries that petition for antidumping are observed hiring lobbyists to lobby CITT for their cases. Table 3.4 shows the percentage of Canadian lobbyists between 1996-2003 who had indicated they planned to lobby the CITT. 18.7% of all lobbyists on average showed intention to lobby the CITT. The percentage in manufacturing is higher, with

23.8% of all lobbyists on average planned to lobby the CITT.[135]

Table 3.4: Percentage of Lobbyists that Lobbied Canadian International Trade Tribunal 1996-2003

	Year	**Lobbies CITT**	**Lobbies CITT & Foreign**[e]
All	1996	15.5%	0.3%
	1997	17.5%	0.2%
	1998	18.1%	0.3%
	1999	20.2%	0.7%
	2000	20.5%	0.9%
	2001	19.0%	0.9%
	2002	18.8%	1.0%
	2003	19.8%	1.1%
Manufacturing Only	1996	18.9%	0.6%
	1997	21.4%	0.5%
	1998	22.4%	0.8%
	1999	26.3%	2.2%
	2000	26.4%	2.7%
	2001	24.5%	2.3%
	2002	24.6%	2.7%
	2003	25.5%	3.3%

[e] Author's own recoding, each registration is counted as one lobbyist, raw data from Public Registry of Lobbyists, Industry Canada

[135] Blonigen and Prusa (2003) suggested that directly unproductive profit-seeking activity like lobbying is more explicit in administered protection like antidumping duties than in traditional protection like tariffs.

3.3 Empirical Analysis

In this section, we analyse the factors influencing antidumping case determinations in Canada during 1996-2003. The economic and political determinants that can affect an affirmative determination are drawn from previous empirical analyses of antidumping case determinations. A key assumption underlying our work is that firms only file based on their likelihood of success in getting an affirmative decision.[136]

We assume that the relation between affirmative determinations and the independent variables can be described by

$$n_i = F(p_i, c_i, e_i, d_i) \tag{3.1}$$

where n_i is the dependent variable representing number of antidumping cases by industry i that are determined affirmative, p_i represents the political variables, c_i represents the determinants CITT uses for injury determination, e_i represents the additional economic determinants and d_i represents dumping indicators.

The dependent variable is constructed as the number of antidumping petitions that were determined affirmative. Data on petitions are taken from the Historical Listing of Antidumping Cases in the Canada Border Services Agency website. Cases that had been filed, investigated and ruled on in Canada are listed in the data base with the Harmonised System (HS) 10 digits product code of dumped products, the initiation dates of the investigation, the specific accusation (dumping or subsidised), the countries named, the disposition, the dumping margins and the final rulings. To construct this variable at industry level, each HS 10 digits product is matched with its corresponding North America Industry Classification System 6 digits code (NAICS6) using a concordance provided by Statistics Canada. Each petition may have more than one exporting country named and more than one

[136]This assumption means industries self-select into filing antidumping petitions given the expected likelihood of success in affirmative decision.

product identified as dumped. In the construction of the dependent variable, each named country in each complaint is to be treated as an individual petition. For example, the complaint initiated on March 1, 1996 named two products, HS codes 4823.51.00.00 and 4820.10.00.00; and named two countries, Indonesia and Brazil. The equivalent NAICS6 industry codes for these products are respectively, 323119 and 323116. Therefore, the number of petitions would be two for each of the two industries. By the same logic, and excluding complaints that were terminated before decision or complaints filed by non-manufacturing industries, there were 163 petitions filed by 50 industries, among which 127 cases were determined affirmative or had undergone price undertakings. Hansen and Prusa (1997) suggested that cases that were settled (went through price undertakings) should also be included because political pressure plays heavily in explaining these cases.

3.3.1 Economic and Political Determinants

According to the CITT mandate, all determinations of injury must be made purely based on evidence that the imports are dumped. Reasons that are unrelated to the discrepancy of import prices relative to prices in the exporter countries should not be considered.[137]

Profits, capacity utilisation[138] and capital investment[139] are included in the analysis as industry-specific CITT economic injury determinants. Instead of the total number of employees, the annual growth rate in employment is used for analysis, as it is a better indication of industry injury than the total employment. Average labour earnings growth and output growth

[137]Industry specifics such as profits, employment, capacity utilisation and investment can be considered for determinations of injury as they are indirectly affected by imports dumped. However, changes in domestic demand, technology, export performance of Canadian firms, volume and prices of non-dumped imports, trade restrictiveness and performance of firms should not be included.

[138]A capital utilisation rate that is less than 100 percent would indicate the industry has excess capacity available to increase production for replacing any displaced imports.

[139]Capital investment data are only readily available in subcategories of NAICS, thus requires re-weighing by the industry's proportion in total output of the subgroup to determine an approximate amount of capital investments.

are also included as additional economic determinants.

Industry export intensity is used to proxy the economic interdependence described by Finger et al. (1982). Export intensity is calculated as the ratio of domestic exports to manufacturing shipments. Therefore, a high export intensity indicates an industry is highly dependent on exports and will probably experience less injury in case of dumping.

Knetter and Prusa (2003) and Feinberg (2005) both found that macroeconomic indicators such as currency depreciation can be influential in antidumping cases. Thus a year dummy each for 1997 and 2001 is included to indicate a depreciation in Canadian dollar relative to the year before. The former is the year of Asian financial crisis and the latter is the year terrorists attacked the U.S. Both years saw overall deterioration in world economy and weakened Canadian dollars. [140]

The "interest group" theory assumes that interest groups influence politicians for desirable policy outcome. The channel of influence is not specific. It can be contributions, lobbying or some other type of political influence. In earlier empirical studies, political influence was often represented by variables that are not exactly political in nature. However, as suggested by Baldwin (1989), better measures are needed to illustrate the extent of political pressures exerted by economies than indirect measures such as industry concentration ratio or sales growth. To address this, in this analysis, a political variable is constructed using the Canadian Lobbyists Registration database from 1996 to 2003. The Lobbyists Registration database discloses details of all active lobbyists including what particular concerns the lobbyists have and which government agencies they plan to lobby. Thus for this analysis, lobbyists who have listed their lobbying concerns as "Special Import Measures Act (SIMA)", "antidumping regime" or those who planned

[140]Knetter and Prusa (2003) also showed that real GDP growth increase antidumping cases in Canada but real GDP growth of the Canadian economy has been very steady over the sample period. It would be obsolete to include as macroeconomic determinant.

to lobby CITT are selected. Out of the 163 antidumping cases initiated in the sample period, about one-quarter of them had lobbyists that lobbied CITT or had SIMA concern. Each of these lobbying firms is manually matched with its NAICS6 industry code by searching through the Canadian Companies Capability Database.[141]

Drope and Hansen (2004) suggest that lobbyists data should be complemented by political contributions data to identify how much industries spent in seeking protection. Therefore, a second political variable formed by the amount of lagged political contributions is included in the analysis. The total amount of political contributions by each industry is matched with the corresponding NAICS6 code as in the case of the lobbyists data.[142] Political contributions may not directly influence the antidumping case determinations as they differed from direct lobbying in nature. However, recent literature, like Austen-Smith (1995) has suggested that political contributions and lobbying are complementary, i.e. the hard-money contributions are used as access fee for future lobbying. All values of the political contributions are transformed into logarithms for easier interpretation. As CITT mandate is assumed to be independent of political pressure, therefore, any political determinants should not be significant in determination. In other words, if the antidumping legislation is correctly implemented, the effects of both lobbying and contributions variables should be zero.

Many previous empirical studies (such as Finger et al. (1982) and Hansen and Prusa (1997)) included variables that reflected the collective action hypothesis (Olson (1965)). The hypothesis says a more concentrated industry is able to organise more easily, and that organised industries fare better in

[141] If a firm is not found in the Canadian Companies Capability database, other online sources such as Lexis-Nexis Academic and Manta will be searched. If the industry code is still unfound after these sources are exhausted, information listed on the company websites will be checked and an appropriate code will then be assigned.

[142] Political contributions data are taken from Election Canada website. However, unlike the lobbyists data, political contributions by businesses and trade unions cannot be identified by what the donations were for, since each contribution will only be associated with the donor's name and the intended party.

obtaining affirmative determinations than the non-organised ones. While these studies did not find strong support on the collective action theory, an industry concentration ratio is included in this analysis to test the collective action hypothesis in Canadian antidumping case determinations. A Herfindahl-Hirschman index would be the best indicator of concentration of an industry as it is weighted by the market share. However, due to limited availability of data, we use a four-firm industry concentration instead.

In addition to the CITT economic injury determinants and other economic determinants and political determinants, import price growths and import penetration ratios are included as dumping indicators. Import unit value, calculated by dividing the total import value with total import volume, is used as a proxy for import prices.[143] Import penetration ratio is calculated as the imports of goods as a ratio to the domestic consumption, i.e. how much of domestic demand is satisfied by imports. [144] Industries that have high import penetration ratio are hypothesized to be able to obtain protections more easily than those that have low import penetration.

Bown, Hoekman and Ozden (2003) showed that developing countries were named more frequently than developed countries in antidumping petitions in the U.S. However, as shown in Table 3.2, developing countries are not named more often than the advanced economies in Canadian antidumping cases. The economic natures of the named countries are therefore irrelevant in Canada. A possible reason is that Canada trades mostly with the U.S. and European countries, and less so with developing countries.

There is a possibility of endogeneity issue that needs to be addressed before moving on to our main analysis. If increased lobbying can generate more affirmative determinations in antidumping cases, then it is possible that increased affirmative determinations encourage more lobbying in the future.

[143] Import values and volumes are reported in HS code, these are recoded into NAICS6 using the Statistics Canada concordance.

[144] Domestic consumption equals the sum of domestic output and imports less exports.

We examine this possibility as follows. Assume that the number of lobbyists hired to represent an industry can be loosely taken as the amount of lobbying effort exerted by an industry and that the lobbying expenditure by an industry is positively correlated to the number of lobbyists representing the industry. Thus, an increased number of lobbyists hired would indicate a larger amount of effort. We show in the following analysis that lobbying efforts are influenced by industry-specific characteristics by regressing the number of lobbyists hired by each industry on three types of characteristics. We also include two variables to account for the influence of past affirmative determination in antidumping cases, a variable that represents the cumulative number of affirmative determinations and a dummy that indicates there was ever an affirmative determination.

There are three types of industry-specific characteristics: political factors, market-related factors and production-related factors. The political factors include variables that represent whether there is counter-lobbying in the industry, whether there is previous experience in lobbying and whether the industry had contributed politically before. They are included to examine how these political involvements affect the industry lobbying efforts. The market-related factors are the import elasticities the industry faces, the import penetration ratio the industry experiences, the amount the industry sells to the government, the amount of subsidy the industry receives from government and the number of complaints the industry files with government agencies. They are included to examine how the market environment affects the amount of lobbying efforts. Finally, the production-related factors are the industry concentration, the amount of industry output and value-added, the number of employees and establishments in the industry, the amount of capital investment of the industry, the capital-labour ratio, the cost of energy and R&D expenses and the industry's export propensity. These are included to examine the effects of industry production characteristics on lobbying efforts.

Note that there are some industries that have never lobbied, which yields some zeros in the data for the number of lobbyists. To deal with overdispersion caused by the excessive zeros, unobserved heterogeneity and serial dependence, a random effects negative binomial regression is used to reduce the possibility of biased estimates.

The results of the regression of lobbying efforts are presented in Table 3.5.

Table 3.5: Regression of Lobbying Efforts

Independent Variables[f] Models	1	2	3	4
Cumulate affirmative	0.025♮ (0.005)	1.680♮ (0.525)	0.025♮ (0.005)	1.636♮ (0.506)
Ever affirmative	−0.059 (0.080)	−1.525♮ (0.543)	0.099 (0.072)	−1.830♮ (0.526)
Lagged counter-lobbying	0.073 (0.052)			0.070 (0.069)
Experience in lobbying	0.036♮ (0.006)			0.035♮ (0.013)
Lagged contribution	0.056♮ (0.016)			0.055♯ (0.022)
Import elasticities		0.502 (1.224)		1.603 (1.019)
Import penetration		0.356† (0.190)		0.511 (0.331)
Sales to government		0.215♮ (0.049)		0.116♯ (0.054)
Government subsidy		0.003 (0.026)		0.020 (0.027)
Complaints		0.012 (0.010)		0.007 (0.009)
Industry concentration			−0.006♮ (0.002)	0.001 (0.003)
Output			0.466† (0.250)	0.404 (0.284)
Employees			0.002 (0.005)	−0.009 (0.008)
Establishments			0.051 (0.041)	−0.073 (0.070)
Capital investment			0.034 (0.160)	0.005 (0.199)
Capital labour ratio			−0.001 (0.004)	−0.004 (0.006)
Cost of energy			0.001♮ (0.000)	−0.000 (0.001)
Value-added			−0.090 (0.102)	0.006 (0.117)
Export propensity			−0.075 (0.120)	−0.004 (0.342)
R&D expenses			0.051 (0.042)	0.061 (0.060)
Concentration*export propensity			0.004♯ (0.002)	−0.004 (0.005)
Log-likelihood ratio	−2452.628	−1461.565	−3242.040	−1091.282
Number of observations	n=1310	n=761	n=2055	n=500

[f] Standard errors are in parentheses, ♮, ♯ and † represent the significance levels of 1%, 5% and 10%.

The first three specifications are regressions of the number of lobbyists on each of the three sets of characteristics plus the two variables accounting for past affirmative determinations. The results show that the cumulative number of affirmative determinations is always significant and positive, while the dummy that indicates if there was ever an affirmative determination is not. Note that in each specification, a few additional variables are significant, such as lobbying experience and lagged contributions in the political factors; import penetration ratio and sales to government in the market-related factors; and industry concentration ratio, industry output and cost of energy in the production-related factors.

The final specification includes all three sets of factors and an interaction term of industry concentration and export propensity. The interaction term is used to capture the resultant effect of the opposing effects of industry concentration and export propensity. The two variables that represent influences of past affirmative determinations are significant but with opposite effects. The cumulative number of affirmative determinations increases the lobbying effort. However, if there was ever an affirmative determination, the industry will lower the number of lobbyists they hire. It will be difficult to say whether the opposing effects will net out. But as both factors are significant, endogeneity between affirmative determination and lobbying seems to exist. We will take this into account in the empirical work below.

Almost all other factors, except for the political factors, become insignificant when regressed together. Both the lobbying experience and political contributions increase lobbying effort. Thus, industries that are experienced in lobbying and have contributed will exert more effort. The existence of counter-lobbyists does not seem to have significant effect on lobbying effort. The only other significant factor is the sales to government. Overall, the above results show that in Canada, the amount of lobbying efforts exerted by the industries is highly motivated by the previous success in obtaining determinations and what previous political involvements they had. Lastly, the overdispersion test results show that the choice of negative binomial regression is appropriate in all of the specifications.

Next we describe the econometric model used for analysing the historical cases.

3.3.2 Econometric Analysis

A negative binomial model that can utilise the count data nature is used to study the effect of the determinants on the number of occurrences of an event (affirmative determinations). The model assumes the mean and the variance are unequal (as opposed to equal mean and variance in Poisson regression) which can be used to overcome the problem of overdispersion that is common in count data. Moreover, data in trade and political economics typically have large variations and excess zeroes.[145] The structure of a negative binomial is in the form of

$$y_i \sim \text{Poisson}(\mu_i *) \tag{3.2}$$

$$\mu_i * = \exp(x_i \beta + u_i) \tag{3.3}$$

$$e^{u_i} \sim \text{gamma}\left(\frac{1}{\alpha}, \frac{1}{\alpha}\right) \tag{3.4}$$

where u_i represents an omitted variable such that e^{u_i} follows a gamma distribution, α is the overdispersion parameter.

Another advantage of using a negative binomial model is that it allows for unobserved heterogeneity between events through u_i. A likelihood ratio test will be performed to justify the use of negative binomial regression. If the null hypothesis of non-unity dispersion factor cannot be rejected, then the model reduces to a simple Poisson.

[145] Examples of excess zeroes in this analysis would be there are some industries that have never filed for antidumping, which creates a skew in the distribution. The mean and variance would undoubtedly be unequal.

The data for all cases initiated from 1996 to 2003 are pooled for analysis and all variable values are deflated to 1997 constant dollars using industrial product price index. There are a total of 127 affirmative determinations out of 163 cases among 258 manufacturing industries. The countervailing cases contributed to less than 1% of all cases, and thus will be excluded from the analysis. Although lobbying is often done at firm level, most antidumping cases are raised at industry level. Analyses are therefore performed at industry level. Furthermore, the lack of detailed data for characteristics at firm level made it difficult to carry out analyses at firm level.

Table 3.6 shows the averages of the determinants and their expected signs as regression coefficients in the negative binomial analysis.

Table 3.6: Expected Signs of Determinants

Determinant	**Average**[g]	**Expected Sign**
Lobbyist	1.3	+
Political contributions (dollars)	9317	+
Industry concentration ratio	52.6	+
Profit (bil. dollars)	-1.4	−
Employment growth	-3.1%	−
Capacity utilisation rate	82.9	−
Capital investments (bil. dollars)	12.1	+
Growth in average earnings	1.9%	−
Output growth	4.7%	−
Import price change	6.6%	−
Import penetration ratio	0.5	+
Export intensity	47%	−

[g] Several industries do not have information on import prices.

We tried several specifications of the model and the estimation results are shown in Tables 3.7 and 3.8. The first three specifications each regresses on a different set of variables that represents the political variables, the CITT economic injury determinants and the additional economic determinants.

The fourth specification regresses on all determinants with an addition variable, the interaction between industry concentration and export intensity. In order to account for possible endogeneity between lobbying and affirmative determinations, we include an independent variable that is equal to the lagged percentage of affirmative cases in terms of all successful antidumping petitions in the fifth to eighth specifications which are repeats of the first four specifications.

Table 3.7: Negative Binomial Regression on Antidumping Case Determinations

Independent Variables [h] **Models**	**1**	**2**	**3**	**4**
Lobbyist	$0.050^{\natural}$ (0.018)			$0.053^{\natural}$ (0.019)
Industry concentration ratio	0.001 (0.007)			−0.003 (0.012)
Lagged contributions	$0.249^{\sharp}$ (0.116)			$0.247^{\sharp}$ (0.118)
Profit (bil. dollars)		0.093 (0.155)		0.003 (0.023)
Employment growth		0.018 (0.012)		$0.028^{\dagger}$ (0.015)
Capacity utilisation rate		0.032 (0.033)		0.031 (0.038)
Capital investments		0.001 (0.010)		−0.006 (0.010)
Growth in average earnings			−0.014 (0.020)	−0.026 (0.019)
Output growth			−0.002 (0.011)	0.008 (0.015)
Import price change			−0.002 (0.005)	−0.002 (0.005)
Lagged import penetration			0.003 (0.031)	0.004 (0.033)
Export intensity			$-0.009^{\dagger}$ (0.005)	−0.010 (0.015)
Concentration*Intensity				0.000 (0.001)
Year dummy	No	No	No	Yes
Log-likelihood	−147.534	−186.800	−179.736	−136.456
Number of observations	n=1465	n=2048	n=1857	n=1307

[h] Standard errors are in parentheses, ♮, ♯ and † represent the significance levels of 1%, 5% and 10%.

Table 3.8: Negative Binomial Regression on Antidumping Case Determinations (Cont'd)

Independent Variables [i] **Models**	**5**	**6**	**7**	**8**
% of affirmative cases	0.855 (0.904)	1.908♮ (0.667)	1.747♮ (0.667)	0.675 (0.941)
Lobbyist	0.047♯ (0.019)			0.048♯ (0.019)
Industry concentration ratio	0.008 (0.010)			0.002 (0.013)
Lagged contributions	0.255♯ (0.126)			0.274♯ (0.124)
Profit (bil. dollars)		0.084 (0.155)		0.004 (0.024)
Employment growth		0.020 (0.013)		0.028 (0.016)
Capacity utilisation rate		0.060† (0.034)		0.057 (0.040)
Capital investments		0.001 (0.010)		−0.001 (0.010)
Growth in average earnings			−0.017 (0.019)	-0.026 (0.020)
Output growth			−0.005 (0.012)	0.003 (0.015)
Import price change				
Lagged import penetration			0.005 (0.030)	0.005 (0.031)
Export intensity			−0.010 (0.006)	−0.008 (0.016)
Concentration*Intensity				−0.000 (0.000)
Year dummy	No	No	No	Yes
Log-likelihood	−127.527	−162.330	−163.517	−121.992
Number of observations	n=1274	n=1794	n=1750	n=1233

[i] Standard errors are in parentheses, ♮, ♯ and † represent the significance levels of 1%, 5% and 10%.

The result from the first specification shows that the number of affirmative determinations increases when the industries that filed the petition also hired lobbyists to lobby CITT and when they had contributed monetarily before. Thus, political involvement is positively associated with administered protection in Canada. Both lobbyists and lagged contributions are significant though the industry concentration does not seem to influence administered protection. The next two specifications show some surprising results. Of all the economic determinants, only export intensity is found to be significant and of expected sign. This is surprising because the economical determinants are the only determinants that are supposed to be used in determinations. The results indicate that being economically independent (as suggested in Finger et al. (1982)) can lower the number of affirmative determinations. The fourth specification includes all determinants as regressors. Both lobbyists and lagged contributions continue to be significant. Employment growth is the only economic determinant that turns out to be significant except that the sign is not as expected.

Thus, if we ignore the endogeneity between affirmative determinations and lobbying, increased amount of political involvements of industries increases the number of affirmative determinations. The insignificance of economic determinants is quite unanticipated, especially the ones used by CITT. However, this is similar to what Hansen and Prusa (1997) found: that is, increasing economic injury may not improve the chance of protection. The growth in employment is expected to have a negative effect on determination because if dumping injures an industry, one would expect a decline in employment to follow. The estimation result shows otherwise. A possible explanation is that growth in employment represents increase in the size of an industry that needs protection. If that is the case, the results of the positive relation can be justified and can be interpreted as the size effect overpowering the economic effect.

Widely accepted dumping indicators like import price change and lagged import penetration are not significant even though they are of expected signs. There is a possibility that on average, import prices did not fluctuate a lot in the sample period even though import prices for some commodities such as machinery had decreased quite significantly. Similarly, the average import penetration ratio is only 0.5, showing that the Canadian economy overall does not face a high import penetration. The lack of significance in economic determinants also shows that antidumping cases may not be determined based on the proof of unfair trade practices by the foreign exporters (such as lower import prices), but rather on other determinants. The year dummies do not seem to have any effect, which can be easily explained by the fact that Canadian economy remained rather steady in the sample period. Therefore, the economic setbacks in 1997 and 2001 were not sufficient to affect antidumping case determinations in Canada.

Overall, when ignoring the endogeneity issue, the empirical results indicate that antidumping case determinations may have been influenced by factors other than those stated in the CITT mandate.

The next four specifications take into account the endogeneity between affirmative determinations and lobbying (note that in the seventh and eighth specifications, import price growth is removed to maintain the concavity assumption). We find that, when the number of affirmative determinations is regressed on the lagged percentage of affirmative determinations and the political variables, only the number of lobbyists and lagged contributions are significant. However, when the regression is carried out on economic determinants, the lagged percentage of affirmative determinations became significant. This shows that if cases are determined only on economic determinants, the affirmative rate of past antidumping cases can influence the number of future affirmative determinations.

In the eighth specification, when all regressors are included, the lagged percentage of affirmative determinations returns to being insignificant. Both the number of lobbyists and lagged contributions are significant while other economic determinants are not. Thus, the result here does not support there is an endogeneity between lobbying and determinations. Political involvement is much more important in terms of affecting determinations.

The results from the last four specifications are intriguing because they indicate that if the mandate is truly apolitical, the determinations of antidumping cases is influenced by the rate of affirmative determination in the past. Yet when firms are lobbying to the CITT, the influence is switched to the political strategies. Summarising the results of all specifications, we have evidence that political factors have influences on the number of affirmative case determinations in Canada.

One question that remains is whether lobbying leads to industries obtaining affirmative determinations or whether it also leads to more antidumping petitions. We tried the same analysis on the number of successful antidumping petitions. A successful petition is one that had been filed, investigated and determined but not necessarily affirmative. The results are shown in Table 3.9.

Table 3.9: Negative Binomial Regression on Antidumping Petitions

Independent Variables [j] / **Models**	**1**	**2**	**3**	**4**
Lobbyist	$0.064^{\dagger}$ (0.037)			$0.072^{\sharp}$ (0.039)
Industry concentration ratio	$0.025^{\natural}$ (0.009)			0.009 (0.021)
Lagged contributions	$0.419^{\natural}$ (0.136)			$0.361^{\sharp}$ (0.152)
Profit (bil. dollars)		0.009 (0.072)		0.005 (0.029)
Employment growth		0.001 (0.000)		$0.077^{\natural}$ (0.030)
Capacity utilisation rate		$0.133^{\natural}$ (0.043)		0.042 (0.049)
Capital investments		0.001 (0.010)		0.001 (0.010)
Growth in average earnings			−0.026 (0.033)	$-0.075^{\dagger}$ (0.042)
Output growth			$-0.043^{\dagger}$ (0.023)	0.029 (0.030)
Import price change			−0.035 (0.025)	−0.018 (0.015)
Lagged import penetration			0.354 (0.618)	0.006 (0.075)
Export intensity			−0.022 (0.014)	0.001 (0.022)
Concentration*Intensity				−0.000 (0.000)
Year dummy	No	No	No	Yes
Log-likelihood	−203.244	−256.832	−247.607	−185.678
Number of observations	n=1465	n=2048	n=1857	n=1307

[j] Standard errors are in parentheses, $\natural$, $\sharp$ and $\dagger$ represent the significance levels of 1%, 5% and 10%.

Comparing the results in Table 3.7 and Table 3.9, it can be seen that the estimates are quite close. The determinants that are significant in Table 3.7 are also significant in Table 3.9. There are a few exceptions such as industry concentration ratio is significant in the first specification, the growth in output is significant in the third specification, and the growth in average earnings is significant and of expected sign in the fourth specification. There are two possible explanations to why the results are similar. First, it is possibly an indication that the number of successful petitions and the number of affirmative determinations are driven by similar determinants. Thus if political involvements like lobbying promotes affirmative determinations, it also promotes the successful petitions. Second, the affirmative determination rate is moderately high relative to the number of successful petitions. In fact, the percentage of affirmative determinations relative to successful petitions is almost 70% over the sample period. Nonetheless, both analyses provide evidence that in Canada, antidumping cases are not independent of political influences.

3.4 Concluding Remarks

Using the Canadian Lobbyists Registration data and the historical antidumping cases in Canada, this paper attempts to determine to what extent the economic and political factors are affecting administered protection.

In the above empirical analyses, the number of CITT lobbyists is always significant and positive. Economic determinants on the other hand do not affect determinations as much. Similar studies on U.S. antidumping case determinations found rather different results. Economic determinants are often found equally important as political determinants, if not more so. The difference is most probably driven by the fact that Canada and the U.S. are very different in terms of their economic structures and antidumping legislations. First, Canada is very export dependent compared to the U.S. This means Canadian industries may be more economically independent in the Finger et al. sense and thus may endure lower amount of injuries in case of dumping.

Second, Canada's antidumping legislation is very straightforward, using a prospective system that publishes "undumped" prices that are sufficient to eliminate the need to pay dumping duties. Therefore, importers can simply follow these guidelines in setting prices. By contrast, the U.S. antidumping legislation is very complicated. It applies a retrospective system that collects an ex-ante dumping duties. Adjustments in duties such as collecting more from the importers or refunding them only occur in regular reviews after determination. Some of the U.S. practices may lead to importers being fined more (the zeroing practice in calculation of margin) and industries filing more antidumping petitions than needed (motivated by incentive such as the Bryd Amendment). The U.S. Department of Commerce also uses many different rules in its reviews than the original investigation, many of which are rules that could result easier in affirmative determinations. Furthermore, importers are allowed to lower their home prices instead of raising the U.S. import prices to avoid dumping duties which does not relieve any dumping injuries that domestic industries experience. The complexity in the U.S. antidumping legislation made it possible for industries to manipulate their levels of injury for affirmative determinations. In other words, Canada's simple antidumping legislation made manipulation of injuries almost impossible. These two important differences combined increases the importance of using political strategies to influence determination. Another finding from the empirical analyses is that the determinants that are significant in influencing affirmative determinations are also significant in influencing successful petitions. This suggests political strategies such as lobbying the CITT affect both stages of antidumping cases.

Lack of appropriate data has made it difficult to empirically analyse the relation of political strategies with policy outcomes. This paper, like many of its predecessors, reflects the same difficulty. Although the Lobbyists Registration data has provided a suitable set of detailed data to construct a political variable, an ideal political variable should be constructed using lobbying expenditure. Fortunately, one can still isolate the lobbyists who are interested in influencing particular outcomes in order to conduct more focussed studies. In this case, only lobbyists who lobbied CITT were selected to study whether the antidumping case determinations are independent of influences other than those allowed as stated in the mandate. Nonetheless, use of the Lobbyists Registration data allows the study of political strategies to go beyond the traditional use of industry concentration or political contributions. For the economic determinants, there are also many situations where less detailed measures must be used. The measure of capital investments is one of the determinants CITT is allowed to consider regarding injury and has been shown to be an influential determinant in previous studies. However, capital investment data by industry are often not released due to information protection. In this case, this variable has to be constructed by weighing the aggregate level of capital investments using industry output, which greatly reduces its accuracy. Other variables such as the industry concentration ratio and the capacity utilisation rate are also only available at NAICS 3 digit level instead of the NAICS 6 digit level needed for the analysis. Furthermore, much of the data transformation requires applications of concordance or manual matching, either of which could translate into sources of error.

Another weakness of our analysis is that only a short time series of data is available. The antidumping cases that were initiated during this period amount to only a small portion of the total number of antidumping cases in Canada. If data were available for a longer time series, the estimates would be more reliable. Further research may need to consider problems such as identifying individual firms' intents to lobby CITT (whether it is for or against protection) and whether the firms that lobby are also the petitioners of the cases. Other considerations may include incorporating the institutional structure of the agencies responsible for antidumping investigation and injury determination, and developing ways to quantify the benefits and costs associated with antidumping cases.

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