
Appendix F: The Changing Composition of the Canadian Workforce, 1961-95

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F.1 Introduction

THIS APPENDIX PRESENTS THE METHODOLOGY for estimating labour inputs in the aggregate business sector and each industrial sector over the 1961-95 period. Unlike the simple measure of hours worked, the labour input measure in this study takes into account the compositional or quality change of the workforce (relatively more educated and older workers). The estimates incorporate individual data from the Census of Population. They also use data from the annual Survey of Consumer Finance (SCF) and the monthly Labour Force Survey (LFS).

Hours of work (or employment) would be a valid measure of labour inputs for productivity analysis if workers were homogeneous. However, they differ by sex, age, education, and class of employment (paid vs. self-employed) and their composition changes over time. But the number of hours worked is relatively easy to estimate and is used extensively in productivity analysis. Statistics Canada uses hours worked in productivity estimates at the detailed industry level (Statistics Canada, 1994b). As another example, until the publication of the Bureau of Labor Statistics (BLS, 1993) study on labour composition in the United States, all official productivity estimates made by that agency used hours of work as a measure of labour inputs.

Jorgenson, Gollop and Fraumeni (1987) constructed labour input data for 51 industries and the aggregate civilian U.S. economy over the 1947-79 period. Their measure takes into account the compositional changes of workers by age, sex, education, class of employment, and occupation. Ho and Jorgenson (1999) extended the analysis and estimated labour inputs in the U.S. civilian economy over 1948-95 period. The BLS (1993) estimated labour inputs in the U.S. private business sector, incorporating demographic changes in the workforce such as the rising educational attainment, the baby boom and baby bust, and the rising female labour force participation.

The aggregate labour input was also constructed for Canada by Dougherty (1992), and Jorgenson and Yip (1999). The indices of labour inputs in Dougherty

(1992) were aggregated from data on workers by educational attainment and employment class. Jorgenson and Yip (1999) extended the analysis and constructed labour inputs for the Canadian economy over the 1960-95 period.

Section F.2 below presents the methodology for constructing labour input indices. The data sources used in constructing labour inputs are described in Section F.3, along with the methodology for generating annual time series of hours worked and labour compensation, cross-classified by sex, age, education, class, and industry of employment. Section F.4 presents the estimates of labour inputs and examines the contribution to the composition of labour of demographic changes such as rising educational attainment, the baby boom and baby bust, and rising female labour force participation. Section F.5 concludes.

F.2 Methodology for Constructing Indices of Labour Inputs¹

THE INDICES OF LABOUR INPUTS are constructed from data on hours of work and labour compensation per hour by worker type. To construct an index of labour inputs, we assume that the aggregate labour input (L) can be expressed as a translog function of its individual components. The growth rate of the aggregate labour input is therefore a weighted average of the growth rates of its components $\{L_i\}$:

$$(1) \quad \Delta \ln L = \sum_i \bar{v}_i \Delta \ln L_i,$$

where Δ denotes a first difference, or change between two consecutive periods, for example:

$$(2) \quad \Delta \ln L = \ln L(t) - \ln L(t-1).$$

The weights are given by the average share of the components in the value of labour compensation:

$$(3) \quad \bar{v}_i = \frac{1}{2} [v_i(t) + v_i(t-1)], \quad v_i = \frac{p_i^L L_i}{\sum_i p_i^L L_i},$$

where $\{p_i^L\}$ is the hourly compensation of all types of workers. At market equilibrium, the hourly compensation of a worker is equal to its marginal

product. Therefore, aggregating labour inputs by means of compensation rates effectively accounts for the differences in the productive contribution of various types of workers.

For each type of workers, we assume that labour input $\{L_i\}$ is proportional to hours worked $\{H_i\}$:

$$(4) \quad L_i(t) = Q_i H_i(t),$$

where the constants of proportionality $\{Q_i\}$ transform hours worked into flows of labour services.

Using Equation (4), we can rewrite Equation (1) and express the growth rate of labour inputs in terms of the components of hours worked $\{H_i\}$:

$$(5) \quad \Delta \ln L = \sum_i \bar{v}_i \Delta \ln L_i = \sum_i \bar{v}_i \Delta \ln H_i.$$

The compositional or quality change of labour inputs is defined as the difference between the growth of labour inputs and the unweighted sum of hours worked:

$$(6) \quad \Delta \ln Q^L = \Delta \ln L - \Delta \ln H,$$

where $H = \sum_i H_i$ is the unweighted sum of hours worked. This quality index measures the contribution to labour inputs from substitution among its components. In terms of its components, the growth rate of labour quality can be written as:

$$(7) \quad \Delta \ln Q^L = \sum_i \bar{v}_i \Delta H_i - \Delta \ln H.$$

An examination of Equation (7) shows that labour quality remains unchanged if all components of hours worked grow at the same rate. Labour quality increases if the share of workers with relatively higher earnings (more educated and older workers) increases. Labour quality falls if the share of those workers declines.

To identify the contribution to labour inputs from worker characteristics such as gender, age, education, and employment class separately, we construct the partial indices of labour inputs corresponding to these worker characteristics. For this purpose, we denote H_{saec} the components of hours worked, classified by sex s , age a , education e , and employment class c . We also consider shares of these components in the value of labour compensation v_{saec} . A partial index of labour inputs corresponding to, for example, sex, is defined as follows:

$$(8) \quad \Delta \ln L^{sex} = \sum_s \bar{v}_s \Delta \ln H_s, \\ = \sum_s \bar{v}_s \Delta \ln \left(\sum_a \sum_e \sum_c H_{saec} \right),$$

where:

$$\bar{v}_s = \frac{1}{2} [v_s(t) + v_s(t-1)], \\ v_s = \sum_a \sum_e \sum_c v_{saec}.$$

The partial index of labour inputs corresponding to sex captures substitution between the two sexes alone. Similarly, the partial labour input indices for age, education or employment class measure substitution between age groups, educational attainment levels, or employment classes.

The growth rate of the partial labour quality index is the difference between the growth rates of the partial labour input index and hours worked. These partial quality indices measure the contribution to labour quality from gender, age, education, and employment class separately.

F.3 Data Sources and Data Construction

THE TWO DATA COMPONENTS for the construction of labour inputs are the matrices of annual hours worked and annual worker earnings. To ensure the comparability of labour input measures between Canada and the United States, we employed a classification scheme similar to the one used for the United States by Ho and Jorgenson (1999). We have 2 sexes, 7 age groups, 4 educational levels, and 3 classes of employment, as shown in Table F.1. Thus, the classification involves a total of $2 \times 7 \times 4 \times 3 = 168$ types of workers and 123 industries in the business sector.

Table F.1		
Classification of the Canadian Workforce		
Worker Characteristics	Number of Categories	Description
Sex	2	Male; Female
Employment Class	3	Paid Employees; Self-employed; Unpaid Family Workers
Age	7	15-17; 18-24; 25-34; 35-44; 45-54; 55-64; 65+
Education	4	0-8 Years of Grade School; Some or Completed High School; Some or Completed Post-secondary; University or Above

The task is to generate annual estimates of hours worked and worker earnings for the 20,664 cells of the cross-classification between 168 worker types and 123 industrial sectors over the 1961-95 period. The main features of our methodology are as follows. The methodology begins with the Census of Population for 1961, 1971, 1981, 1986, 1991, and 1996. We use the Census micro-data files to construct the benchmark matrices of annual hours worked and earnings for the Census reference years (the year prior to the Census).² We then employ data from the Labour Force Survey (LFS) and the Survey of Consumer Finance to estimate the hours and earnings matrices for years between the Census benchmarks. For this purpose, we employ the method of iterative proportional fitting (for details, see Jorgenson, Gollop and Fraumeni, 1987). A weighted average of the two neighbouring benchmark matrices is used to initialize the method of proportional fitting. The data on annual hours worked and earnings from the LFS and SCF are used to control the marginal distribution of hours worked and worker earnings by sex, age, education, and employment class. All matrices of hours worked and worker earnings are then adjusted to annual hours worked and earnings by industry and class of employment in Statistics Canada's productivity account.

F.3.1 Matrices of Annual Hours Worked

F.3.1.1 Benchmark Matrices from the Census

The Census provides benchmark matrices of annual hours worked for the Census reference years 1960, 1970, 1980, 1985, 1990, and 1995. For each member of the household surveyed, the Census micro-data files provide data on sex, age, education, industry and class of employment, and hours worked

during the week prior to the Census (reference week). The files also provide data on weeks worked and income from paid employment and self-employment during the year prior to the Census (reference year). Using these Census micro-data files, we have constructed matrices of annual hours worked for the 20,664 cells of the cross-classification between 168 worker types and 123 industrial sectors. Annual hours worked for an employed person during a reference year is calculated as the number of weeks worked in the reference year multiplied by the number of hours worked in the reference week.³

As of the 1981 Census, self-employed workers were subdivided into those with and those without an incorporated business. We include in the paid-employment category both paid workers and self-employed workers with an incorporated business. The self-employment category only includes those who have not incorporated their business.

In the 1971 Census, a person was simply asked whether he or she was self-employed or a paid employee. No distinction was made between the self-employed who incorporated their business and those who did not. However, a distinction was made between self-employment income from an unincorporated business and the income from an incorporated business. The income received from an unincorporated business was reported as self-employment income, while the income received from an incorporated business was reported as wages and salaries. We have used that distinction to reclassify a worker between paid employment and self-employment. A worker was classified as a paid worker if his wage and salary income exceeded his self-employment income. On the other hand, a worker was classified as self-employed if his self-employment income was greater than his wage and salary income.

The class of employment in the Census refers to whether the worker is a paid, self-employed, or unpaid family worker in the reference week. However, a worker's employment status in the reference week does not necessarily reflect his status in the reference year. We have thus reclassified a worker between paid employment and self-employment by comparing his paid employment and self-employment income in the reference year.

Micro-data files are not available for the 1961 Census. But existing publications on the 1961 Census provide us with considerable detailed information on one-way, two-way, and sometimes three-way tabulations of employment including: (1) number of paid workers by gender and industry; (2) number of

workers by sex, age, education, and employment status; (3) number of workers by sex, age, and employment status; (4) number of workers by sex, age and industry; and (5) number of workers with university education and number of workers with post-secondary education. We have used these cross-tabulations to generate the full employment matrix — six-way tabulations of employment by sex, age, education, and class and industry of employment. The value of each cell in the 1961 employment matrix is first initialized at its value in 1970. All available cross-classifications for 1961 are then used in the method of iterative proportional fitting to control the distribution of employment among cells. To obtain the hours worked matrix for 1961, we multiply the estimated employment in 1961 by the average annual hours of work in 1970 for each type of worker.

F.3.1.2 Estimating Hours Worked Matrices in the Inter-censal Years from the LFS

For the 1976-95 period, we used micro-data files from the LFS to obtain one-way tabulations of annual hours worked by sex, age, education and employment class. These tabulations are then used as control marginals in the method of iterative fitting to estimate the hours worked matrices between the censuses for that period. For the 1961-75 period, we estimate the hours worked matrix as a weighted average of the two neighbouring hours worked matrices and then adjust the resulting matrix to hours worked by industry and class of employment in Statistics Canada's productivity account.

The monthly LFS provides data for each worker type on usual hours worked, sex, age, education, and employment class during the reference week (usually the week containing the 15th day of the month). For each worker type, annual hours worked is calculated as the average weekly hours worked in a year times the number of working weeks in a year (which is set at 52 weeks). For multiple jobholders, hours worked on the second job are aggregated to the employment class of the second job.

In January 1990, the LFS revised the questions used to measure the educational attainment of respondents. From 1976 to 1989, education reflected the number of years of primary and secondary education completed. Post-secondary education was limited to education that normally requires high-school graduation. Since January 1990, education reflects the highest grade completed. Post-secondary education now includes any education that could be counted towards a degree, certificate or diploma from an educational institution.

The high-school graduation requirement is dropped in this new definition of post-secondary education. These changes in the questions on educational attainment caused a reallocation of respondents from secondary to post-secondary education in 1990, which is evident in Figure F.3.

F.3.2 Matrices of Annual Worker Earnings

F.3.2.1 Benchmark Matrices from the Census

To construct time series on annual worker earnings by worker type, we again proceed in two steps. First, we construct benchmark matrices of worker earnings for the Census reference years. We then employ earnings data from the SCF to estimate matrices of annual worker earnings between censuses.

The Census provides data on wage and salary income of paid workers.⁴ Supplementary income such as employers' contribution to pension plans and unemployment insurance is not included in the wage and salary income. But it should be included in labour compensation since it reflects the cost of labour inputs from the viewpoint of an employer. To address the issue, we have adjusted the earnings matrices from the Census to total sectoral compensation of paid workers in Statistics Canada's productivity account. Essentially, we distribute the sectoral compensation among types of paid workers in proportion to their wage and salary income.

A second issue relates to the estimation of earnings of self-employed workers. Self-employment income as reported in the Census includes both labour and property income. But self-employment earnings should only include labour income. To estimate earnings from self-employment, we made two adjustments to self-employment income as reported in the Census. First, self-employment income is set to zero for those workers who reported negative self-employment income. A negative self-employment income is almost surely attributed to the use of capital. Second, Statistics Canada imputed earnings of self-employed workers in an industry on the basis that the hourly earnings is the same between paid and self-employed workers. We have used these sectoral earnings from self-employment to adjust the earnings matrices.

A third issue is the treatment of unpaid family workers. Unpaid family workers are persons who work without pay on a farm or in a business or professional practice owned and operated by another family member. In this

study, we set earnings of unpaid family workers to zero.⁵ To the extent that unpaid family workers contribute to industry output, our measure of labour inputs is underestimated. But any bias is likely to be negligible since the share of unpaid family workers in total employment is very small.

Due to the absence of micro-data files in the 1961 Census, we used the method of iterative fitting to estimate the earnings matrix for 1961. We first multiply the hourly earnings of a worker in 1970 by his annual hours of work in 1961. The resulting matrix is used to initialize our method of iterative fitting. The control marginals for the method of iterative fitting include annual income by industry for male and female paid workers and annual income by sex, age and education.

F.3.2.2 Estimating Earnings Matrices in Inter-censal Years from the SCF

For the 1976-95 period, we used earnings data from the SCF to estimate the earnings matrices between censuses. First, we estimated from the SCF micro-data files hourly earnings by gender, age, education, and employment status. The earnings per hour was then multiplied by hours worked from the LFS to obtain one-way tabulation of annual earnings by gender, age, education, and employment status. These one-way tabulations are used as control marginals in our method of iterative fitting to estimate the earnings matrices between the Census benchmarks.⁶ For the 1961-75 period, we calculated the earnings matrix as a weighted average of the two neighbouring earnings matrices and then adjusted the resulting matrix to total sectoral compensation.

F.4 Empirical Results

IN THIS SECTION, WE PRESENT THE INDICES OF LABOUR INPUTS over the 1961-95 period. These indices are aggregated from data on 168 types of workers by gender, age, education, and employment class.

F.4.1 Trends in Hours Worked

The change in the composition of hours worked contributes either positively or negatively to labour inputs. The compositional change contributes positively to labour inputs if there is an increase in the share of workers with relatively higher earnings, such as relatively more educated workers, workers of

prime working age, paid relative to self-employed workers, or male relative to female workers.

Figure F.1 shows that the share of hours worked represented by men declined steadily over the 1961-95 period in the business sector. The share of women almost doubled during that period — from about 20 percent in 1961 to about 40 percent in 1995 .

Figure F.2 presents the share of total hours worked by age group from 1961 to 1995. For the 1961-80 period, the share of hours worked represented by young workers aged 15-24 showed a steady increase as the baby boomers entered the workforce. The share of the prime working age group (35-54) declined from 45 to 35 percent during that period. However, the trend reversed in the early 1980s as the baby boomers reached their prime working age. During the 1980-95 period, the share of the 15-24 age group declined sharply, from 24 to 13 percent. The share of the prime working age group increased from 37 to 50 percent during the same period. These shifts in the age composition of hours worked are the major determinant of labour quality change in the business sector.

Figure F.3 shows the share of hours worked by education level in the aggregate business sector. The share of workers with post-secondary education or above shows a more than fivefold increase, from 9 percent in 1961 to 57 percent in 1995. The rising educational attainment is the ongoing source of the increase in the quality of the Canadian workforce. The change in the definition of education introduced in the LFS in 1990 resulted in a noticeable re-allocation of hours worked from secondary to post-secondary education.

The share of hours worked by paid workers is presented in Figure F.4. The share of paid workers increased steadily from 1961 to the late 80s. The increase was particularly strong before the mid-70s. After the late 80s, the share of paid workers declined and the share of self-employed workers increased.

Figure F.1
Share of Hours Worked by Male Workers in the Business Sector (%)

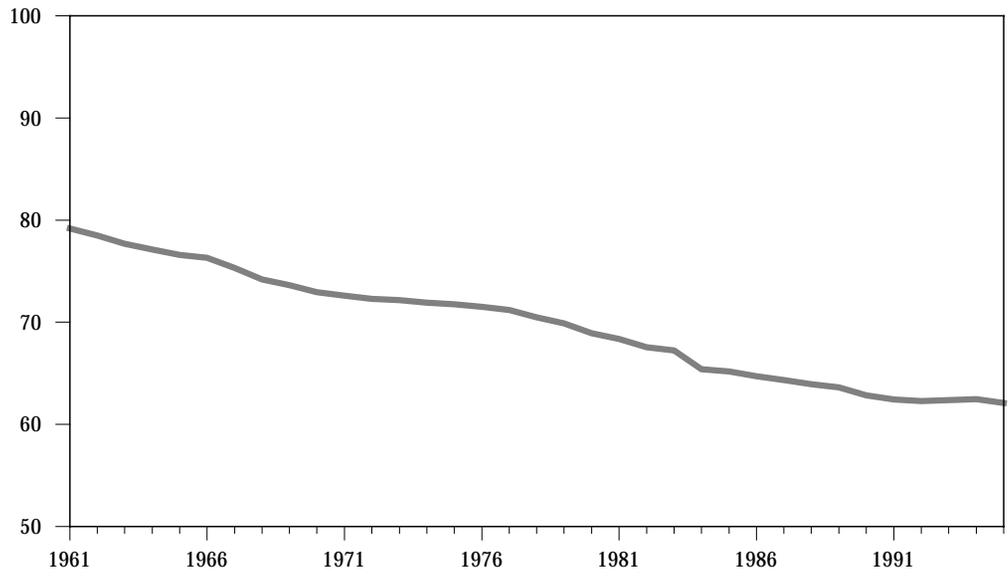


Figure F.2
Share of Hours Worked by Age Group in the Business Sector (%)

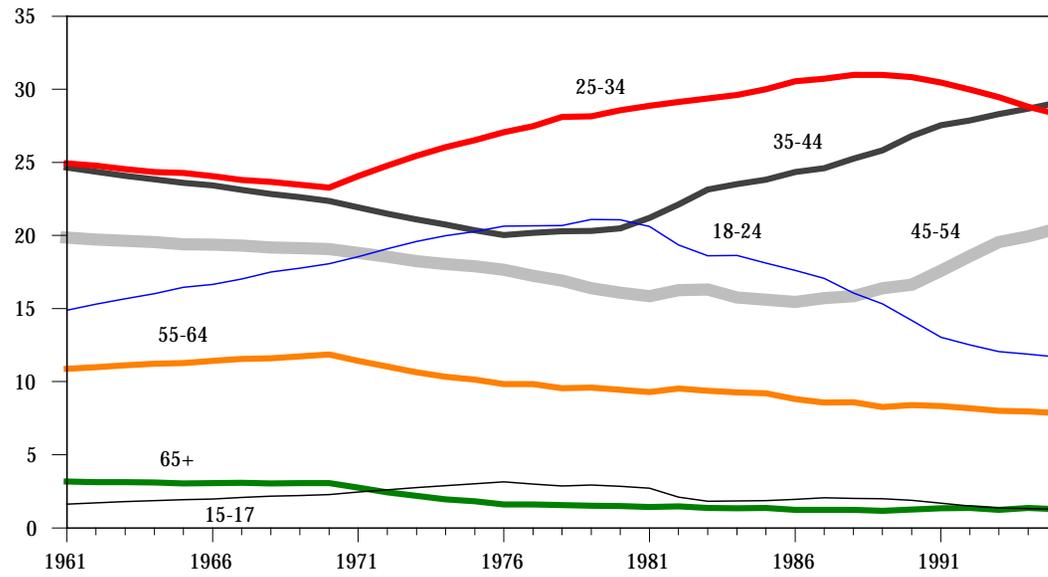
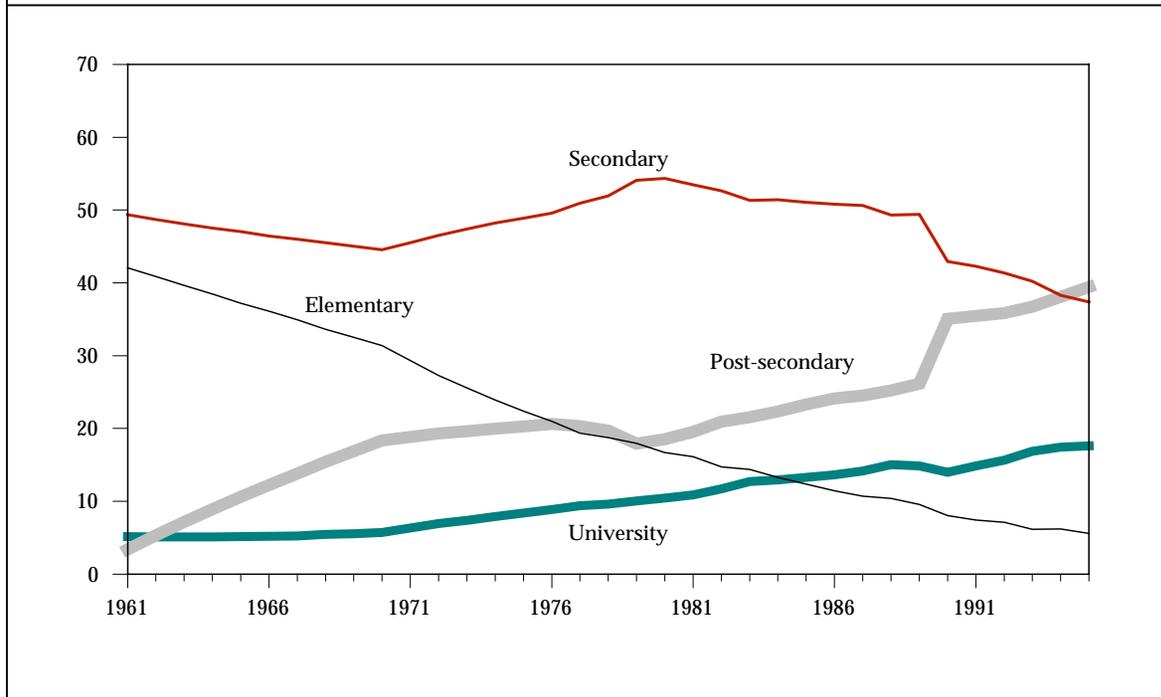
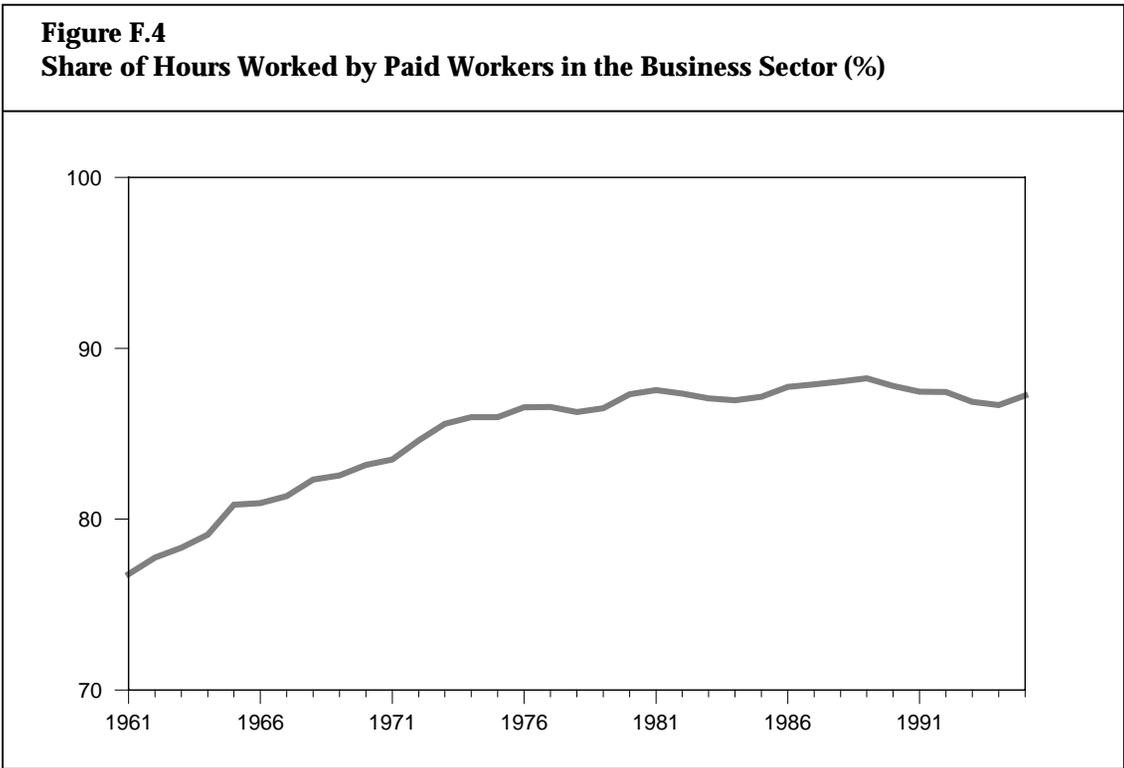


Figure F.3
Share of Hours Worked by Educational Attainment in the Business Sector (%)





F.4.2 Indices of Labour Inputs and Labour Quality

Table F.2 presents the growth rates of labour inputs, labour quality and hours worked in the business sector for the 1961-95 period and three sub-periods: 1961-73, 1973-85 and 1985-95 (also shown in Figure F.5). For the 1961-95 period, the annual growth rate of labour quality was 0.61 percent. It accounted for a quarter of the growth in labour inputs over that period. The annual growth in labour quality was highest over the 1961-73 period (0.86 percent), accounting for about 30 percent of the growth in labour inputs. The growth of labour quality slowed down during the 1973-85 period (0.37 percent), and then recovered in the 1985-95 period (0.59 percent).

	1961-95	1961-73	1973-85	1985-95
Growth of Labour Inputs	2.47	3.08	2.15	2.11
Growth of Hours Worked	1.86	2.22	1.78	1.51
Growth of Labour Quality	0.61	0.86	0.37	0.59
First-order Quality Indices				
Sex	-0.15	-0.22	-0.15	-0.07
Age	0.04	-0.15	0.04	0.25
Education	0.53	0.86	0.33	0.36
Class of Employment	0.15	0.27	0.13	0.04

Table F.2 also presents the growth in the first-order contributions to labour quality by gender, age, education and employment class (also shown in Figure F.6). As a result of the rising educational attainment of the workforce, the education contribution had an average annual growth of 0.53 percent from 1961 to 1995. The contribution of employment class was positive for most of the period as the share of paid workers increased. But that contribution declined sharply after the mid-1980s as the growth of self-employed increased. The increasing share of female workers contributed to a decline of 0.15 percent per year in labour input over the period.⁷ The contribution of age was positive and amounted to 0.04 percent for the 1961-95 period. However, it was negative for the 1961-73 period as young workers from the postwar baby boom entered the workforce. After the mid-1980s, as the baby boomers entered their prime working age, the age contribution increased.

Figure F.5
Indices of Labour Inputs, Labour Quality and Hours Worked in the Business Sector

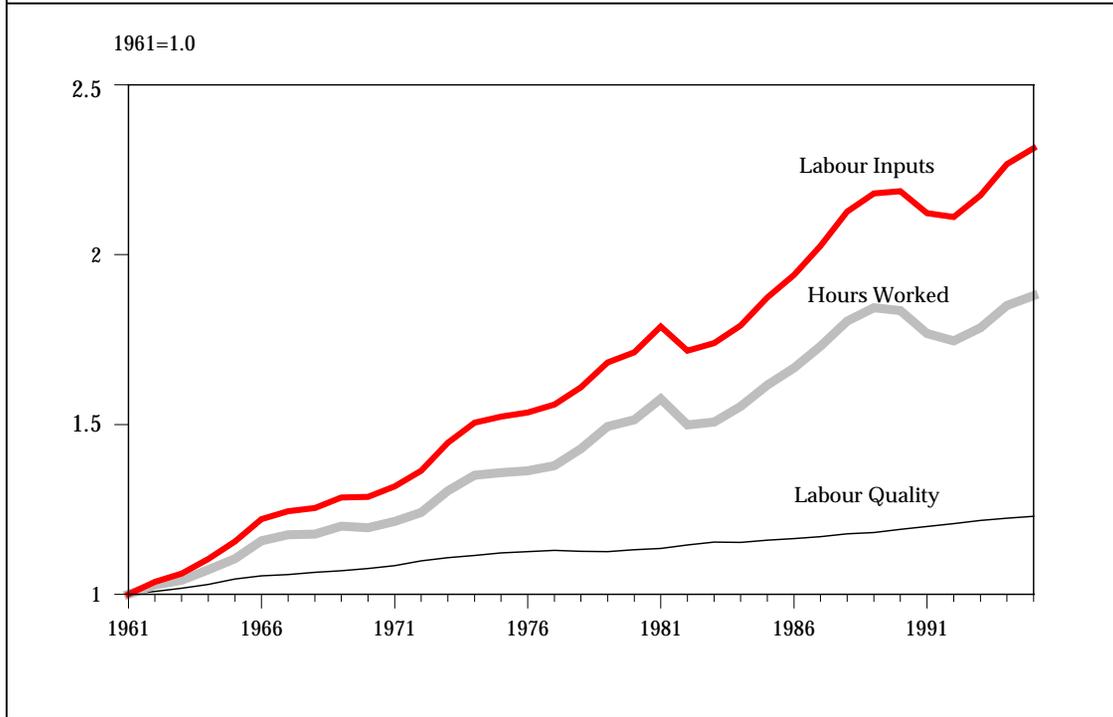
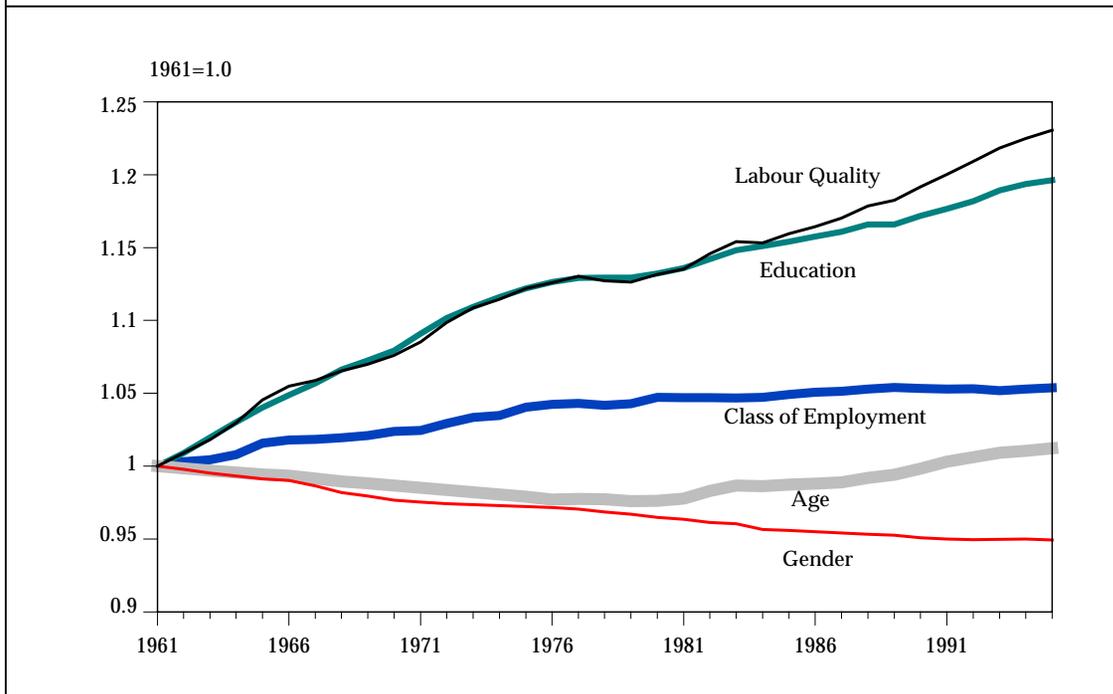


Figure F.6
First-order Indices of Labour Quality in the Business Sector



Nearly all of the trend in labour quality improvement over the 1961-95 period can be attributed to the increase in the level of educational attainment. However, this is a consequence of offsetting trends in gender, age, and employment class. The slowdown in the growth of labour quality over the 1973-85 period was primarily due to the entry of young and less-educated workers in the workforce.

We have also constructed labour input, hours worked, and labour quality measures for each of the 123 industrial sectors over the 1961-95 period. The results show that labour quality increased in almost all industries over this period.

F.5 Conclusion

THIS APPENDIX PRESENTS THE METHODOLOGY for constructing the composition-adjusted labour input measures for Canada. Over the 1961-95 period, the compositional or quality change contributed 0.61 percentage points or a quarter of the labour input growth in the business sector. The growth of labour quality was highest in the 1961-73 period (0.86 percent per year), accounting for about 30 percent of the growth in labour inputs. The 1973-85 period witnessed a slow growth in labour quality, primarily a result of the entry of baby boomers in the workforce. After the mid-1980s, the growth of labour quality increased as baby boomers reached their prime working age.

The share of more educated workers showed a steady increase from 1961 to 1995. This shift towards relatively more-educated workers contributed to the increase in the labour inputs in the business sector at a rate of 0.53 percent per year from 1961 to 1995. The rise in educational attainment explains almost all the trend in labour quality over that period. However, as indicated earlier, this is a consequence of offsetting trends in contributions from gender, age, and employment class.

Notes

- 1 This section follows Ho and Jorgenson (1999).
- 2 The micro-data files for the 1961 Census are not available. However, very detailed information on employment and earnings cross-classified by one, two, and three characteristics of labour inputs are published by Statistics Canada. We thus employed the method of iterative proportional fitting to estimate the matrices of hours worked and compensation for 1961.
- 3 The number of hours worked is set at 75 for a worker who reported more than 75 hours of work during the reference week.
- 4 Consistent with our definition of paid employees that includes self-employed workers with an incorporated business, income received from businesses which have corporate status is reported as wages and salaries income.
- 5 Ho and Jorgenson (1999) assumed that unpaid family workers and self-employed workers are in the same employment class.
- 6 The annual Survey of Consumer Finance is not used for estimating hourly earnings for the 1971-75 period since the corresponding micro-data files from the Labour Force Survey, used to estimate hours by worker characteristics, are not available.
- 7 This is partly due to the fact that women are traditionally concentrated in low paying industries and low paying occupations.

