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Investment in Human Capital and the Output of the Education Sector in Canada

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Abstract

The paper constructs two experimental measures of education services for Canada using income-based and cost-based approaches. The two approaches both start with the notion that education services represent the effect of education on knowledge, skills and competencies or human capital stock embodied in individuals. The task of measuring education output is therefore essentially the one of measuring investments in education. The income-based approach measures the investment in education using future stream of earnings that education can be expected to provide. The cost-based approach is based on the costs of that investment.

The paper finds that two approaches yield similar estimates of the growth in real education output, but produce very different estimates of the level of nominal education output. The difference in the level of nominal education output between the two approaches mainly reflects the difference in the coverage of the education sector as defined by the two approaches. The education services sector in the income-based approach includes the inputs of non-market activities, while the cost-based approach does not.

The paper presents a hedonic method that can be used to capture quality changes in education output. It finds that the hedonic adjustment for education quality raised the growth rate of real education output by 0.2 percentage points per year over the period 1976 to 2005.

1 Introduction

Education is an important economic activity in Canada. Education expenditures, at 15 percent of consolidated government expenditures, are the third largest expenditure item following health (19%) and social services (30%) in 2009 (Statistics Canada, CANSIM, table 385-0001).

However, the output of the educational sector has been measured by the costs of inputs (teachers' salaries and materials) used to produce education services in Canada. The objective of this paper is to develop new experimental measures of the output of the educational sector for Canada.[1]

Over the last couple of years, several statistical agencies in OECD countries have undertaken research to develop output-based measures of educational services and other non-market services sector such as health services. The research has led to the development of improved methods for the measurement of education services. By 2006, nine OECD countries have implemented the output-based measures of education services: Australia, Finland, France, Germany, Italy, Netherlands, New Zealand, Spain, and United Kingdom. A number of other OECD countries are expected to implement the output-based measures for education output (Schreyer, 2009). More recently, the Bureau of Economic Analysis has developed new output-based measures for the U.S. primary and secondary education (Fraumeni, et. al., 2008).

It is useful to start with the definition of education services. Schreyer (2009) and Fraumeni, et. al. (2008) define education services as the effect of education on the level of knowledge, skills and competencies of students. As the level of knowledge, skills and competencies represent the stock of human capital embodied in students (OECD, 2010), the output of the education sector also represents the impact of education on human capital or investment in human capital. The characterization of educational services as investment in human capital dates back to Becker (1964), Mincer (1974) and Schultz (1961) and is further developed and implemented in series of papers by Jorgenson and Fraumeni (1989, 1992a, 1992b).

The characterization of education services as investment in human capital makes it clear that the task of measuring education services is essentially the one of measuring investment in human capital. The empirical literature has developed two competing approaches to measure the value of investments in human capital. In one strand of the literature, perhaps best exemplified by Kendrick (1976), investment in human capital is estimated based on the costs of that investment; in the second strand of the literature, developed most notably in an important series of papers by Jorgenson and Fraumeni (1989, 1992a, 1992b), the same investment is measured as the effect of education on an

[1] The public education sector includes (1) GS2100, Universities; (2) GS2210, Government Elementary and Secondary Schools; (3) GS2220, Government Community Colleges; and (4) GS2230, Other Govt Education Services.

individual's lifetime income. Abraham (2010) described and critiqued the cost-based and income-based approaches to the measurement of investment in human capital

A major challenge for the measurement of education services is to capture changes in the quality of education that students receive. There have been numerous attempts to take into account quality changes in the measure of the education output (see Schreyer, 2008 and Abraham, 2010 for a review). A contribution of this paper is to recognize that the quality adjustment for education services is similar to the one that have been made for the output of computer and other information and communication products that underwent dramatic improvement in their quality. This paper then proceeds to describe and implement the hedonic technique for quality-adjusting the output of education sector.

The rest of the paper is organized as follows. Section 2 presents the cost-based and income-based estimates of education services for Canada. Section 3 presents quality-adjusted education output. Section 4 concludes the paper.

2 Measuring the Output of the Education Sector

In this section, we first present two approaches to measuring the output of educational sector. The one is based on the costs of education and the other is based on information on the future stream of earnings that education can be expected to provide. We then use the two approaches to produce estimates of the output of the Canadian education sector.

2.1 Income-based Approach to the Measurement of Education Services

The income-based approach or the human capital approach is developed in a series of papers by Jorgenson and Fraumeni (1989, 1992a, 1992b). The approach measures the value of education services as the effect of education on an individual's lifetime income. As the value of education depends on the student's age, sex and education level, the approach disaggregate students by their age, sex and education levels.

We denote $h^t_{s,e,a}$ the discounted lifetime income (or human capital stock) of individuals with sex s, educational attainment e, and age a in year t; and $N^t_{s,e,a}$ the number of students with sex s, age a who are enrolled in education level e. We assume that individuals enrol in school to attain higher education level. That is, the individuals who are enrolled in education level e have already achieved education level e-1.

The nominal value of education services (V) is estimated as increments in lifetime incomes arising from increases in education for all students:

$$(1) \qquad V^t = \sum_{s,e,a} (h^t_{s,e+1,a+m}(1+g)^m / (1+r)^m sr_{a,a+m} - h^t_{s,e-1,a}) N^t_{s,e,a} = \sum_{s,e,a} I^t_{s,e,a} N^t_{s,e,a} \ ,$$

We assume that individuals with education level e-1 who are enrolled in school need to spend an average of additional m years in school to obtain higher education level e. g in the equation is the expected growth in real income and r is the discount rate used to estimate the present value of future lifetime labour income. $sr_{a,a+m}$ is the probability that an individual aged a will survive for m more years. $I^{t}_{s,e,a}$ is investments in human capital for a student and $N^{t}_{s,e,a}$ is the number of students.

The nominal value of education output in Equation (1) can be divided into volume and price components. The volume index of education output (denoted by *Q*) is an index number using Tornqvist aggregation, based on school enrolments. It is calculated as a weighted sum of student enrolments using as weights the increment in lifetime labour incomes due to education, cross-classified by age, sex, and education level:

$$(2) \qquad \ln Q^{t} - \ln Q^{t-1} = \sum_{s,e,a} \overline{v}_{s,e,a} (\ln N^{t}_{s,e,a} - \ln N^{t-1}_{s,e,a}) ,$$

$$\text{where } \overline{v}_{s,e,a} = 1/2 \left(\frac{I^{t}_{s,e,a} N^{t}_{s,e,a}}{P^{t} Q^{t}} + \frac{I^{t-1}_{s,e,a} N^{t-1}_{s,e,a}}{P^{t-1} Q^{t-1}} \right) .$$

$\overline{v}$ is the share of individuals with s, e, a in the total value of investment in education, average over year t-1 and t.[2]

The price index of education services (*P*) is estimated by dividing the nominal value of education services by the volume index of education services.

$$(3) \qquad P_{t} = V_{t} / Q_{t} .$$

The estimates of education output in (1), (2) and (3) are based on the numbers of pupils enrolled at different levels of education. Alternatively, the estimates of education output can be based on the number of graduates who obtain a particular educational qualification in a year and leave school systems. The output of education sector based on the number of graduates is estimated as the sum of lifetime incomes embodied in those graduates. It can be shown that the estimates of education output based on the number of enrolments and those based on the number of graduates are identical.

In practice, data on enrolments are more readily available. In addition, estimates based on school enrolments allow us to estimate education output for different levels of education institutions such as primary education, secondary education and post-secondary education. The estimate based on graduates attaining a qualification reflects the sum of

[2] O'Mahony and Stevens (2009) used the increments in earnings from increases in education to weigh student enrolments to derive a volume index of education output. Their measure will be similar to the income-based measures if persons do not purpose further education once they leave schools and the number of remaining working years for workers with different education levels.

the contribution of all education institutions leading up to the qualification. For those various reasons, we will use data on student enrolments to estimate education output.

2.2 Cost-based Approach to the Measurement of Education Services

In contrast to the income-based approach, the cost-based approach measures the output of education services using the cost of inputs to education. The approach typically disaggregates students by different education levels (e.g., elementary, secondary or post-secondary), as students enrolled various education levels require different amounts of those inputs. In addition, as discussed by Fraumeni, et. al. (2008), it may be important to differentiate along the lines of other student characteristics such as regular versus special education or native versus non-native English speaker.

The nominal value of education services V using the cost-based approach is:

$$(4) \qquad V^t = \sum_i C_i^t N_i^t \ ,$$

where N_i^t is the number of students enrolled in a specific education level (primary, secondary or post-secondary) or specific education program (regular vs. special education), and C_i^t is the costs of inputs per student.

Once again, the nominal value of education services can be divided into the price and volume components. The volume index of education services is a weighted sum of student enrolments across different education levels using their share of input costs as weights. The price index of education services is the ratio of the nominal value of education services to the volume index.

A number of OECD countries have implemented this cost-based approach to the measurement of education services.[3] Schreyer (2008) recommends the use of cost-based approach over the income-based approach. Diewert (2008) shows that valuing output at average costs in measuring output and productivity growth is a second best option while the best option would be to use final demand prices to value output. The use of the final demand prices should correspond to the income-based approach in the context of education services.

The nominal value of education services using the income-based approach is much larger that the one estimated using the cost-based approach. Abraham (2010) provides a number of explanations for this large difference between the two approaches. The discount rate used to calculate the present value of future lifetime income may be too low. The costs of time spent by students in studying are not included in the cost estimates. The earning

[3] Fraumeni et al. (2008) and Schreyer (2009) provide an extensive review of approaches a number of countries adopted to measure education services.

differences between more educated and less educated may reflect a host of factors other than education such as student ability, family background and difference in on the job training.

While those two approaches produce very different estimates of the nominal value of education services, they produce similar estimates of the price and volume indices of education, as shown in this paper.

2.3 Data

Data required for estimating education output starts with enrolment data. In addition, the income-based approach requires data on the impact of education on human capital stock or investment in education, and the cost-based approach requires the data on education expenditures at different levels of education.

Data on Student Enrolments

The data on enrolment are taken from various surveys on enrolments of Statistics Canada. Using those surveys, we have prepared time series data on the number of pupils enrolled in school, cross-classified by gender, 5 education levels, 69 ages (6 to 74). The five education levels are defined as 0-8 years of schooling; some or completed high school; some or completed post-secondary school below Bachelors degree; Bachelors degree; and Masters degree or above. The data covers the period from 1972 to 2005. There appears to be a break in enrolment data for education level 3 (some or completed post-secondary education below Bachelors) in 1976. We will therefore use the data for the period from 1976 to 2005 in this paper.

The enrolment data for elementary and secondary education are obtained from The Elementary-Secondary Education Statistics Project (ESESP) for the years after 1997. For the years before 1997, they are obtained from the Elementary/Secondary School Enrolment (ESSE) survey.

ESESP is an annual survey that collects aggregate data from each provincial/territorial Ministry or Department of Education. Specifically, the information on enrolments pertains to the following two programs: regular and minority and second languages education. The information on regular programs is collected by type of programs (regular, upgrading and professional), education sector (youth or adult), grade and sex. The one on minority and second language programs is collected by type of program (immersion, as language of instruction, as a subject thought) and by grade.

For the years before 1997, the data on enrolment are obtained from ESSE. The survey collects data on enrolment by type of school (public, private, schools for the visually and hearing impaired, federal schools and for the Department of National Defence). The data are broken down by age and gender and by grade and gender. Data on public schools are

provided to Statistics Canada by the provinces and territories. For private schools, survey methods vary. Some provinces supply both private and public schools, while in others Statistics Canada surveys the institutions directly.

The enrolment statistics for primary and secondary education from the ESESP provides information on the grades in which students are enrolled (grade one to grade 13), but does not have information the ages of the pupils. We will infer the age of pupils from the fact that pupils start grade 1 at age 6 in Canada. The pupils enrolled in grade 1 are set to be 6 years old, and those enrolled in grade 2 are set to be 7 years old, and so forth.

The enrolment data for post-secondary education are obtained from the Postsecondary Student Information System (PSIS) for the years after 1992. For the years before 1992, the data are obtained from three separate surveys: University Student Information System (USIS), the Community College Student Information System (CCSIS) and the Trade/Vocational Enrolment Survey (TVOC).

The Postsecondary Student Information System (PSIS) is a national survey that provides detailed information on enrolments and graduates of Canadian postsecondary education institutions. PSIS collects information pertaining to the programs and courses offered at an institution, as well as information regarding the students themselves and the program(s) and courses in which they were registered, or from which they have graduated.

In the year 2001, PSIS began to replace the University Student Information System (USIS), the Community College Student Information System (CCSIS) and the Trade/Vocational Enrolment Survey (TVOC) with a single survey offering common variables for all levels of postsecondary education. Historical enrolment and graduate data from previous surveys have been converted using PSIS variable definitions and code sets to maintain the historical continuity of the statistical series.

Data on Investments in Human Capital

Data in the impact of education on human capital stock are obtained from Gu and Wong (2010). The estimates of human capital stock and investment are estimated for all individuals of the Canadian working-age population, cross-classified by 2 genders, 5 education levels, and 60 ages (from 15 to 74).

The human capital estimates from Gu and Wong (2010) includes all individuals of the Canadian working-age population aged 15 to 74. To estimate the output of the education sector from the enrolment data, we also need to estimate human capital stock for the individuals aged 6 to 14. For the purpose of this paper, we will extend the human capital estimates from Gu and Wong (2010) to include individuals aged 6 to 14.

The individuals aged 6 are assumed to be enrolled in grade 1 and are expected to complete grade 8 when they are 15 years old. Those individuals will get the life time

income of individuals aged 15 with education level 1 in 8 years. The individuals aged 7 are assumed to be enrolled in grade 2 and are expected to complete grade 8 when they are 15 years old. Those individuals will get the life time income of individuals aged 15 with education level 1 in 7 years. Similarly, we can estimate the lifetime labour income of those individuals aged 8 to 14.

The above assumptions imply that the discounted lifetime labour income of individuals of age a can be estimated as:

(5) $$h^t_{s,e,a} = h^t_{s,e,15}(1+g)^{15-a} / (1+r)^{15-a} sr_{s,a,15}\,,$$ for a < 15,

where $sr_{a,15}$ is the probability that an individual with sex s and age a will survive to age 15, g and r are the real income growth and the discount rate used to discount future income.

Investment in education is the increase in the discounted lifetime labour income from spending additional year in schools. For students enrolled in education level 2 or above, the estimate of investment in education is based on the difference in human capital stock between individuals enrolled in that education level and individuals in lower education level, and with the same age and sex:

(6) $$I^t_{s,e,a} = h^t_{s,e+1,a+m}(1+g)^m / (1+r)^m sr_{a,a+m} - h^t_{s,e-1,a}\,,$$ for $e \geq 2$.

For the students enrolled in education level 1 (0-8 years of schooling), their investment in education is the increase in the lifetime labour income compared with those individuals who do not have education. However, we do not have estimates of human capital stock for those individuals with no education. The individuals are not coded as having no education in the household surveys or the Census of Population in Canada. As the primary education is mandatory in Canada, most individuals in Canada have some levels of education.

To estimate investment in education for those pupils enrolled in education level 1 (0-8 years of schooling), we use the fact that individuals start grade one at the age of 6 and the primary level education are mandatory in Canada. For the individuals enrolled in grade 8 with age 14, investment in human capital is the difference between the lifetime income of those individuals and the lifetime income of the individuals who are enrolled in lower grade (grade 7) with the same age. As the individuals who are enrolled in grade 7 are all 13 year olds, the lifetime income of the individuals who are enrolled in grade 7 with age 14 is not observed. We will assume the individuals who are enrolled in grade 7 with age 14 will obtain the lifetime income of individuals enrolled in grade 7 with 13, with one year lag. Investment in human capital for the 14 year old is estimated as:

(7) $$I^t_{s,1,14} = h^t_{s,1,14} - h^t_{s,1,13}(1+g) / (1+r)\ sr_{s,13,14}\,.$$

In general, investment in education for students enrolled in education level 1 with age a ($6 \le a \le 14$) can be estimated as:

(8) $$I^{t}_{s,1,a} = h^{t}_{s,1,a} - h^{t}_{s,1,a-1}(1+g) \ / (1+r) \ sr_{s,a-1,a} .$$

Data on Expenditures by Education Levels

We will disaggregate education by education levels when we construct the cost-based estimates of education services. The cost of education includes labour cost (salaries of teachers), capital cost and intermediate inputs. The data are obtained from the Canadian Input/Output Tables for three levels of education: primary and secondary education, college education, and university education.

Data on the costs of education are not available at individual education levels before 1997. To calculate the income-based estimates of education services, we assume the relative differences in unit costs across three education levels did not change for the period before 1997 and are set to be equal to those in year 1997.

2.4 Estimates of the output of the education sector

In this section, we first present the income-based and cost-based estimates of the output of the education sector. We then compare the two estimates.

The Income-Based Estimate of Education Output

Figure 1 plots trends in school enrolments by education level over the period 1976 to 2005. Enrolments in the primary education and secondary education fell from 1976 to the mid-1980s as the baby boomers left the grade one to thirteen education. Enrolments in grade 1-8 then gradually increased after the mid-1980s and fell again after the mid-1990s as the school-aged population shrinks. Enrolments in the secondary school (grade 9 to 13) increased after the mid-1980s and flattened after the mid-1980s.

Figure 2 plots school enrolments by gender over the period 1976 to 2005. Enrolments increased faster for women than men, as a result of large increases in their participation in colleges and universities. After the mid-1980s, enrolment by women exceeded enrolment by men. Women now accounted for more than half of pupils enrolled in schools.

Table 1 presents annual growth rates of student enrolments. The most notable is the large increases in enrolments in colleges and universities over time. It increased at 2.6% per year from 1976 to 2005. While some of the increase was due to the demographics of baby boom, the most of the increase was due to increases in participation in college and university education among Canadians aged 18 to 26 (Emery, 2004).

Table 2 presents the income-based estimates of investment in education in current dollars for the period 1976 to 2005. The nominal value of education services in Canada, as measured by the impact of education on the lifetime labour income of the students, is large. In 2005, investment in education was estimated at 469.9 billion dollars representing about 34 percent of GDP for that year.

The nominal value of education services is divided into the price and quantity components in Tables 3, 4 and 5. The quantity index of the education output (weighted sum of enrolments) increased at a rate of 0.8% per year for the period 1976 to 2005, while the un-weighted enrolments increased at a rate of 0.4% per year over the period. The difference between the weighted and un-weighted measures reflects the rising enrolments in secondary and higher education over the period.

The price index of the education output rose at 2.4% per year for the period 1976 to 2005. It increased at a much slower rate after the mid-1990s. It grew at an annual rate of 0.9% over the period 1996 to 2005.

The growth of the price and volume indices of education output is slower than the growth of the price and volume index of gross domestic product (GDP). Real GDP increased at 2.9% per year over the period 1976 to 2005. The price index of GDP increased at 3.9% per year during the period.

The price change of education services is greater than the quantity change in Canada. The rate of growth in the prices accounts for about two-thirds of the rate of growth of nominal education output. In contrast, the rate of growth of the GDP price index accounts for a lower portion (60%) of the rate of growth in nominal GDP.

The level of investment in education for men exceeded that for women, as shown in Table 1. The difference between them narrowed before the mid-1990s due to increased enrolments by women over that period. After the mid-1980s, the difference in investment in education between women and men was virtually unchanged.

The growth rate of investment in education in constant prices was much faster for women than for men before the mid-1980s, and was similar afterwards (as shown in Table 4). For the period 1976 to 1986, investment in education for women increased at 1.3% per year, while investment in education for men remained unchanged over the period. After the mid-1980s, investment in education for men started to grow at a rate similar to that for women.

Investment in education in post-secondary education (colleges and universities) increased the most (as shown in Table 4). It increased at 2.7% per year during the period 1976 to 2005. In contrast, investment in education in primary and secondary education changed little over the period.

Tables 6 and 7 present the underlying data on investment per student in current and constant dollars that are used to produce the income-based estimates of the education output . Those estimates are also plotted in Figures 4 and 5.

The nominal value of investment in education per student was greater for men than for men. The difference between women and men decreased slowly over time. In 2005 investment in education per student for women was about 84% of that for men.

The value of investment in education per student in colleges and universities was similar to that in the secondary education (grade 9 to 13) before the mid-1990s. After the mid-1990s, it was higher. The value of investment per student in primary education (grade 1 to 8) was the lowest. In 2005, the value of investment in education for a student enrolled in colleges and universities was 109 thousand dollars a year, while investment in education for a student in primary education was 50 thousand dollars a year and was 93 thousand for a student in high school.

Investment per student in constant prices rose steadily over time for both men and women. This reflects the rising enrolments in the secondary and post-secondary education. Investment per student in constant prices for primary, secondary and post-secondary education was relatively constant throughout the period.

The Cost-Based Estimate of Education Output

Table 8 presents annual growth of the cost-estimates of education services in Canada. For a comparison, the table also present the income-based estimates of education services.

The cost-based and income-based approaches yield similar estimates of the growth rates of the real education output. The cost-based estimate increased at 0.6% per year over the period 1976 to 2005, while the income-based estimates rose at 0.8% per year over the period.

While the two approaches yield similar estimates of the growth in real education output, they produce very different estimates of the level of education output (Figure 6). The income-based estimate of the nominal value of education service was about 6.8 times as large as the cost-based estimate in 2005. The difference in the level of education services mainly reflects the difference in the coverage of the education sector as defined by the two approaches. The education services in the income-based approach include the inputs of non-market activities: opportunities of student times, while the cost-based approach does not.

Figure 6 shows that the ratio of the benefits of education (as measured by the impact of education on lifetime labour income) to costs of education declined from 1976 to the mid-1980s. It then remained virtually unchanged from the mid-1980s to 2000, and declined again after 2000. This suggests that the return to education declined between 1976 to mid-1980s and it declined again after 2000 after a period of little change from the mid-1980s to 2000. This is consistent with the findings on the trends in the rate of return

to education in Canada (Emery, 2004). Emery examined the rate of return to the undergraduate university education for the period 1960 to 2000, and found that there appear to have been some reductions in returns to university education in the late 1970s and early 1980s, but by 1985, the returns to education resumed their high levels in the 1960s and early 1970s.

Figure 7 compares the two new estimates of real education output with the input-based estimate of the real education output. The input-based estimate is currently produced by the System of National Accounts in Canada. The results show that the two new estimates of education output increased at a slower rate than the input-based measure of education output. For the period 1976 to 2005, the input-based measure of the education output increased at 1.2% per year.

Figure 8 presents the underlying data on the cost of education per student that are used to produce cost-based estimate of education output. The unit cost was the highest for university education, lowest for primary and secondary education, and in between for college education. The unit cost increased for university education and primary & secondary education from 1997 to 2005, while it changed little for college education.

Figure 9 plots trends in labour productivity of the Canadian education sector based on three alternative measures of education output (two output-based measures of education services and one input-based measure). All three measures of labour productivity show that labour productivity declined in the Canadian education sector before 1990 and increased after 1990. Labour productivity based on income-based estimates of education output declined at 1.6% per year in the education sector for the period 1976 to 1990. For the period 1990 to 2005, it increased at 0.4% per year.

3 Accounting for Quality Changes in Education Services

A significant challenge for measuring the output of the education sector is adjusting for changes in the quality of education services over time. To the extent the income and cost estimates of the real education output do not capture quality improvements, the changes in real education output will be under-estimated and price changes over-estimated.

Looking at changes in the quantity or quality of the inputs used to educate students is one way to account for quality changes in education quality (Fraumeni et. al., 2008; Abraham, 2010). The inputs that impact education quality include class size and teacher qualifications such as degrees earned, whether the teacher has been trained in the subject being taught and years of teaching experience (see Christian and Fraumeni 2005, Fraumeni, et al. 2009).

As an alternative to looking at the inputs to education and attempting to adjust for changes in the quality of those inputs, one might instead look at outcome measures such as average test scores or the share of students who are promoted to the next grade level or who graduate (Abraham, 2010).

The greatest challenge here involves the estimation of the precise value of the change in output resulting from a given change in inputs and outcomes. For example; if class sizes drop by 10 percent, does the quality of education services increase by 10 percent?

In this paper, we address the issue of estimating the effect of various factors (quality and quantity of inputs and outcomes) on education output. The key for doing so is to recognize that the quality adjustment in education output is akin to quality adjustment in the output of computers, semiconductors, and telecommunications equipment.

The hedonic methods are widely used to construct quality-constant price index for computers, semiconductors, and telecommunications equipment. Triplett (2006) has provided an extensive survey of the research on the construction of hedonic price indexes for computers and other information and communication products. The hedonic methods can be also used to capture quality improvement in education output.

The two component data that are used to estimate education output are the price and quantity data associated with student enrolments disaggregated by education levels, gender and age. The quantity component is the number of students or the number of student hours. The corresponding price component is the impact of education on lifetime labour income for the income-based approach and it is unit expenditures for the cost-based approach.

The hedonic methods consist of two essential steps. First, we collect data on various factors that may affect the quality of education that students receive. As discussed above, they include the quality and quantity of inputs to student education (class size or the number of experienced teachers) and the outcomes of education (test scores).

The next step is to estimate a hedonic function that relates the indicators of education quality (class size, exam scores, the number of inexperienced teachers) to the price component of education output, which is investment in education per student for the income-based approach and education expenditures per student for the cost-based approach. The coefficients on the indicators of education quality are called the implicit prices of the indicators of education quality (Triplet, 2006). This second step is often missing in previous empirical studies.

Once we have the indicators of education quality and estimated implicit prices associated with those indicators from hedonic regressions, we can estimate changes in the price index of education output that can be attributed to the changes in education quality. The imputed changes in the price index of the education output due to the changes in education quality is then included in the change in the quality-adjusted volume index of the education output.

In this paper, we will focus on the hedonic adjustment for the income-based estimates of education services. The data for the adjustment can be obtained from the International Adult Literacy and Skills Survey (IALSS 2003) (Statistics Canada and OECD, 2005).[4]

3.1 Test Scores

For this paper, we will use time-series data on test scores in literacy and related cognitive skills for individuals that obtained their highest level of education in different years. The data are constructed from the Canadian data from IALSS 2003 (Statistics Canada and OECD, 2005).

The IALSS 2003 includes standard questions on demographics, labour force status and earnings, but it also attempts to measure literacy and related cognitive skills in four broad areas: Prose, Document, Numeracy, and Problem Solving. We will use test scores in those four broad areas of literacy and cognitive skills to capture the quality of education. Hanushek and Zhang (2006) also used the literacy scores from the IALSS 2003 to measure the quality of education.

The Prose questions in the surveys assess skills ranging from items such as identifying recommended dosages of aspirin from the instructions on an aspirin bottle to using an announcement from a personnel department to answer a question that uses different phrasing from that used in the text. The Document questions, which are intended to assess capabilities to locate and use information in various forms, range from identifying percentages in categories in a pictorial graph to assessing an average price by combining several pieces of information. The Numeracy component ranges from simple addition of pieces of information on an order form to calculating the percentage of calories coming from fat in a Big Mac based on a table.

The IALSS 2003 asks the respondents about their age at the time of the survey (2003), and the age when they completed the highest level of education. The information is then used to infer the years when the respondents completed the highest level of education. We then estimate the average test scores for individuals who completed a education level in a year as indicators of education quality at the education level in that year.

The individuals may lose and gain skills as a result of ageing process or on the job training. If individuals tend to lose skills over time due to aging, exam scores for early cohorts of graduate will underestimate the quality of education for those cohorts. On the other hand, if individuals tend to gain skills over time due to on the job training, exam scores for early cohorts will overestimate the quality of education for those cohorts. Therefore, we will control for the effect of aging and on the on the job training for the text scores for various cohorts of graduates to provide an unbiased estimates of changes in education quality.

[4] OECD Program for International Student Assessment (PISA) survey may provide better data sources for capturing changes in education quality over time.

Literacy scores of cohorts of graduates may also reflect the effect of student ability and family background in addition to the effect of education. Therefore we need to control for the effect of student ability and family background. We will proxy for ability using three variables from the IALSS 2003. We include a dummy variable equalling one if the person agreed or strongly agreed with the statement that they got good grades in math when they were in school, a dummy variable equalling one if the respondent agreed or strongly agreed with the statement that teachers often went too fast and the person often got lost, and a dummy variable equalling one if the person responded that he or she received remedial help or special classes with reading at school. To control for the effect of family background on test scores, we add variables on parental education and immigrant status.

Since our objective is to examine the education sector in Canada, we exclude from our sample anyone born outside of Canada or educated outside of Canada from our samples. We also drop the over-sampled First Nations observations from the 2003 survey. The survey cover individuals over age 16 but we exclude individuals who list their main activity as student in order to highlight the effect of completed schooling and what happens to literacy afterwards. We will exclude those individual who completed the highest level of education before 1976 as we are interested the changes in the education quality for the period after 1976 in this paper.

In sum, to estimate the test scores for the cohorts of graduates at each education level, we estimate the following regression on literacy scores using the Canadian data in the IALSS 2003:

(9)

$$\ln(score)_{it} = \alpha_o + \alpha_2 E2_{it} + \alpha_3 E3_{it} + \alpha_4 E4_{it} + \alpha_5 E5_{it} + \beta_1 (t * E1_{it}) + \beta_2 (t * E2_{it}) + \beta_3 (t * E3_{it}) + \beta_4 (t * E4_{it}) + \beta_5 (t * E5_{it}) + \gamma Z_{it} + \varepsilon_{it}$$

The dependent variable is the literacy scores of the individual i who obtained the highest level of education in year t. The variables *E1* to $E5$ are the dummy variables indicating the highest level of education that the individual obtained. For example E1 is set to equal to one if the highest level of education for that individual is level 1(0-8 years of schooling). t is the year that the individual obtained the highest level of education, and set equal to 1 for year 1976, 2 for year 1977, and so forth. The vector Z is the set of control variables including gender, age of the individuals, age squared, proxies for student variables, and variables for family background.

The estimated coefficients β_1 to β_5 measure the percent changes in literacy scores of graduates at each education level over time and will be used to capture the changes in quality in education services at each education level.

We use population weights throughout in order to present results that are representative of the Canadian population. The regression results are presented in Table 8. The results

show that test scores increased over time for graduates at education levels one and two (primary, and secondary school). But there are no statistically significant changes in test scores for graduates at post-secondary education (educations level 3 to 5). Literacy scores increased at 1% per year at the primary education level and increased at 0.2% per year at the secondary school level.

The results on the effects of the ability and family background variables on literacy scores are consistent those in Green and Riddell (2003). Student ability and parental education levels both have positive effects on literacy scores. The immigration status of parents does not appear to have significant effects on literacy scores. Controlling for the effects of student ability and family background does not lead to significant changes in the estimated changes in education quality.

3.2 Hedonic Regression

To estimate the hedonic function for education output, we will again use the Canadian data from the International Adult Literacy and Skills Survey (IALSS 2003). The IALSS 2003 includes questions on demographics, labour force status, earnings, and education attainment. The Canadian data from the IALSS 2003 can be used to estimate the hedonic function that relates test scores to increments in lifetime incomes. Ideally, we would like to construct increments in lifetime incomes for all individuals in the sample and estimate a hedonic function that relates test scores to gains in lifetime incomes. In this paper, we will use marginal gains in current labour income from education as a proxy for gains in lifetime labour incomes.

The hedonic regression for the output of education services we will estimate is a standard Mince human capital earnings function:

(10)

$$\begin{aligned}\ln(earnings)_{it} = {} & \alpha_o + (\alpha_2 + \beta \ln(score_{it}))A2_{it} + (\alpha_2 + \beta \ln(score_{it}))A3_{it} \\ & + (\alpha_2 + \beta \ln(score_{it}))A4_{it} + (\alpha_2 + \beta \ln(score_{it}))_5 A5_{it} \\ & + \gamma Z_{it} + \varepsilon_{it}\end{aligned}$$

The earnings represent annual earnings. The dummy variables A2 to A3 are the dummy variables that represent the levels of education achieved. We assume that the individuals who obtained a higher education level also received the lower ones. For an individual whose highest level of education is level five, dummy variables A2 to A5 are all set to equal to 1. For an individual whose highest level of education is level 4, dummy variables A2 to E4 are all set to equal to 1 and dummy variable A5 is set to equal to 0. The vector Z is the set of control variables including gender, the experience of the individuals, experience squared, proxies for student variables. We do not include the variables for family background in the estimation as the variables have no effect on individuals' earnings.

The coefficients on the variables A2 to A5 represent the marginal wage gains of achieving that education level over the previous level of education. The estimated marginal gains are used as a proxy for investment in education at that level. In the regression, we allow those marginal gains to change as a result of test scores. The coefficients on the log of literacy scores represent the implicit prices associated with literacy scores that can be used to estimate the quality-adjusted price index of the education output.

The sample used for estimating the hedonic regression is similar to the one used for estimating the literacy scores, except we have eliminated those individuals that are self-employed for the hedonic regression. We have also eliminated from our sample those individuals whose annual earnings are less than $2,000 and over $1,000,000. The latter restriction eliminates retired people, the unemployed and others who are not in the labour force. It also cuts out a small number of individuals with earnings that are substantial outliers relative to the rest of the sample. We drop the self employed because we wish to examine the remuneration of skills in the labour market, and self employed earnings reflect both that remuneration and returns to capital.

The parameter estimates from the hedonic regression are presented in Table 10. The estimated β is 0.57 and statistically significant. This suggests that one percent increase in test scores are associated with 0.57 percent increase in marginal gains from obtaining a higher level of education.

3.3 Quality-adjusted Price and Volume Indices of Education Output

Denote $score_e^t$ the literacy scores for individuals that obtained education levels e in year t, and β the estimated coefficient on the log of test scores from the hedonic regression that relates the log of test scores to returns to education.

The quality adjusted price index for student enrolments disaggregated by sex, education levels and age is estimated as:

(11) $$adjI_{s,e,a}^t = I_{s,e,a}^t / (hedonic\ quality\ adjustment),$$

where $(hedonic\ quality\ adjustment) = (score_e^t)^{\beta}$

Those quality-adjusted price indices are then aggregated to obtain quality-adjusted price index of education services. The quality-adjusted quantity index of education services is calculated by dividing the nominal value of education output by the quality-adjusted price index.

Table 11 presents the quality-adjusted output of the education sector. The quality adjustment raised the growth of the education output by 0.2 percentage points per year and lowered the growth of the corresponding price index by 0.2 percentage points per

year. The 0.2 percentage point quality adjustment factor for Canada is similar to the 0.25% quality-adjustment factor per year that is utilized in the U.K. official estimates of the volume index of education services.

4 Conclusions

Recently, several statistical agencies in OECD countries have undertaken research to develop output-based measures of educational services and other non-market services sector such as health services. This paper argues that various approaches can be classified into two broad groups. The first is the income-based approach, or human capital approach, developed in a series of papers by Jorgenson and Fraumeni (1989, 1992a, 1992b). The second approach is the cost-based approach that can be traced back to the estimates of investment in education based on expenditures by Kendrick (1976).

The paper then adopts the two approaches to estimate the output of the Canadian education sector. It finds that two approaches yield similar estimates of the growth in education output. Over the period 1976 to 2005, the income-based estimate of the real output of the education sector increased at 0.8% per year, while the cost-based estimate rose at 0.6% per year.

However, the two approaches produce very different estimates of the level of education output. In 2005, the income-based estimate of the nominal education output is about 6.8 times as large as the cost-based estimate of education output. The large difference in the level of education between the two approaches mainly reflects the difference in the coverage of the education sector as defined by the two approaches. The education services sector in the income-based approach includes the inputs of non-market activities: opportunity costs of student times, while the cost-based approach does not.

The paper also contributes to the methodologies for the measurement of education output. While the previous papers attempted to capture quality changes in education output, they often lacked precise methodologies to do so. This paper points out that quality adjustment for education output is no different from quality for computer output. The hedonic methods that are used to construct quality-constant price index for computers can be also used to capture quality improvement in education output.

The paper finds that the hedonic adjustment for the quality changes in education services raised the growth of education output by 0.2 percentage points per year over the period 1976 to 2005.

While the appropriate approach for such adjustment is the hedonic methods that have been used by statistical agencies for quality adjustment for computer prices, the challenge facing statistical agencies is to collect time consistent data on the various indicators of education quality (such as class size, test scores, and teacher qualities), and conduct surveys that can be used to estimate hedonic regressions that link the indicators of education quality to the price of education output.

References

Abraham, Katherine. 2010. "Accounting for Investments in Formal Education." paper presented to the Bureau of Economic Analysis Advisory Committee.

Becker, Gary S. 1964. *Human Capital. 2nd Edition.* New York: Columbia University Press.

Card, David. 1999. "The Causal Effect of Education on Earnings." in *Handbook of Labor Economics*, vol. 3A, Edited by O. Ashenfelter and D. Card, Amsterdam: Elsevier Science.

Christian, Michael and Barbara M. Fraumeni. 2005. "Measuring the Education Function of Government." Unpublished. Bureau of Economic Analysis.

Christian, M.S. 2010. "Human Capital Accounting in the United States." *Survey of Current Business,* BEA.

Collesi, D., D. Guerrucci, D. Versace, and S. Zannoni. 2007. "The Use of Class Size and the Italian Method." paper presented at the OECD workshop on "*Measuring Education and Health Volume*", Paris.

Diewert, Erwin. 2008. "The Measurement of Nonmarket Sector Outputs and Inputs Using Cost Weights." Discussion Paper 08-03, Department of Economics, University of British Columbia, Vancouver, B.C. Canada.

Emery, Herd. 2004. "Total and Private Returns to University Education in Canada: 1960 - 2030 and in Comparison to other Post-Secondary Training." Department of Economics, University of Calgary.

Green, D.A., and W.C. Riddell. 2007. "Literacy and the Labour Market: The Generation of Literacy and Its Impact on Earnings for Native Born Canadians." Statistics Canada catalogue no. 89-552-MIE, no. 18.

Griliches, Zvi. 1970. "Notes on the Role of Education and Production Functions and Growth Accounting." in W.L. Hansen (ed.), *Education, Income and Human Capital*, Studies in Income and Wealth, vol. 35.

Griliches, Zvi, and William Mason. 1972. "Education, Income, and Ability." *Journal of Political Economy*, 80(3) part 2, pp. S64-S103.

Gu, W. and A. Wong. 2010. "Estimates of Human Capital in Canada: The Lifetime Income Approach." Economic Analysis Research Paper no. 062. Statistics Canada.

Fraumeni, B.M., M.B. Reinsdorf, B.B. Robinson, and M.P. Williams. 2008. "Price and Real Output Measures of the Function of Government: Exploratory Estimates for Primary and Secondary Education." NBER Working Paper 14099.

Heikkinen, Jani and Sami Hautakangas. 2007. "The Use of Credits and Fields of Education in Tertiary Education – the Finnish Method." paper presented at the OECD workshop on "*Measuring Education and Health Volume*", Paris.

Hanushek, E.A., and L. Zhang. 2006. "Quality-Consistent Estimates of International Returns to Skill." NBER Working Paper, 12664.

Hanushek, Eric A, and L. Woessmann. 2008. "The Role of Cognitive Skills in Economic Development." *Journal of Economic Literature*, 46(3): 607-668.

Hanushek, Eric A., and D. D. Kimko. 2000. " Schooling, Labor-force Quality, and The Growth of Nations." *American Economic Review*, 90(5): 1184-1208.

Harlot S., A. Borland, and A. Forslund. 1997. "The Output of the Swedish Education Sector." *Review of Income and Wealth*. 43(1): 89-104.

Kendrick, John W. 1976. T*he Formation and Stocks of Total Capital*. New York: Columbia University Press.

Jorgenson, D. W. and B.M. Fraumeni. 1989. "The Accumulation of Human and Nonhuman Capital." In *The Measurement of Saving, Investment and Wealth*, eds. Robert E. Lipsey and Helen Stone Tice. Chicago: University of Chicago Press, 227-281.

Jorgenson, D. W. and B.M. Fraumeni. 1996a. "Investment in Education and U.S. Economic Growth" in Jorgenson, D. W., Productivity, Volume 1: Postwar Economic Growth, The MIT Press.

Jorgenson, D. W. and B.M. Fraumeni. 1992b. "The Output of the Education Sector." In *Output Measurement in the Service Sector*, Zvi Griliches, ed. Chicago: University of Chicago Press, 303-338.

Kendrick, John W. 1976. *The Formation and Stocks of Total Capital*. New York: Columbia University Press.

Magnusson, Birgitta. 2006. "Volume Calculations of Individual Government Production in the National Accounts of Sweden." paper presented at the OECD/ONS/Government of Norway Workshop on "Measurement of non-Market Output n Education and Health", London, 2006.

Miner, Jacob. 1974. *Schooling, Experience and Earnings*. New York: Columbia University.

Murray, Richard. 2007. "Developing Quality-adjusted Output Measure for the Scottish Education System." paper presented at the OECD workshop on "*Measuring Education and Health Volume*", Paris.

OECD. 2010. "The OECD Human Capital Project: Progress Report." Paris.

O'Mahony, M. and P.A. Stevens. 2009. "Output and Productivity Growth in the Education Sector: Comparisons for the US and UK," *Journal of Productivity Analysis*, 31:177-194.

Schreyer, Paul. 2008. "Output and Outcomes – Measuring the Productivity of Non-market Services." paper presented at the 2009 Productivity Workshop, Bank of Canada, Ottawa, Canada.

Schreyer, Paul. 2009. *Towards Measuring the Volume of Health and Education Services, Draft Handbook.* Paris: OECD.

Schultz, T.W. 1961. "Investment in Human Capital." *American Economic Review*. 51(1): 1-17.

Statistics Canada and OECD. 2005. *Learning a Living, First Results of Adult Literacy and Life Skills Survey*. Ottawa and Paris.

Triplet, Jack. 2006. *Handbook on Hedonic Indexes and Quality Adjustments in Price Indexes*. OECD, Paris

Wei, H. 2004. "Measuring the Stock of Human Capital for Australia: a Lifetime Labour Income Approach."Australian Bureau of Statistics Research Paper.

Wei, H. 2007. "Measuring Australia's Human Capital Development: The Role of Post-School Education and the Impact of Population Ageing." *Statistical Journal of the IAOS* 24, 183-191.

Table 1. Annual growth in school enrolments, 1976 to 2005

	1976 to 2005	1976 to 1986	1986 to 1996	1996 to 2005
Total	0.4	-0.6	1.1	0.6
Male	0.2	-0.8	1.1	0.4
Female	0.5	-0.3	1.2	0.7
Grade 0-8	-0.3	-1.7	1.2	-0.3
High school	0.0	-1.4	1.0	0.5
College or above	2.6	4.1	1.0	2.6

Table 2. Investment in education by gender and education level, 1976 – 2005, (billions of current dollars)

Year	Total	Male	Female	Grade 0-8	High school	College or above
1976	187.4	102.1	85.2	46.7	94.5	46.2
1977	196.7	107.7	89.0	47.6	101.1	47.9
1978	196.9	108.1	88.8	47.9	99.3	49.7
1979	197.4	110.5	86.9	49.0	98.5	49.9
1980	205.8	111.6	94.3	51.7	103.4	50.6
1981	242.5	130.4	112.1	60.8	118.7	63.1
1982	264.2	139.2	125.0	64.4	124.1	75.6
1983	251.4	131.2	120.2	64.8	106.4	80.2
1984	266.8	145.8	121.0	68.9	110.5	87.4
1985	262.1	145.5	116.6	72.4	103.1	86.6
1986	281.4	151.0	130.4	74.0	113.1	94.3
1987	302.6	160.5	142.1	81.5	124.4	96.8
1988	301.6	158.1	143.5	87.3	118.9	95.4
1989	335.9	183.1	152.7	94.7	135.7	105.4
1990	440.9	242.4	198.5	109.1	173.5	158.3
1991	461.9	245.0	216.9	116.1	166.9	178.8
1992	443.0	235.4	207.6	117.0	165.4	160.6
1993	408.8	228.2	180.6	115.0	150.9	142.9
1994	399.2	217.6	181.7	113.3	145.9	140.0
1995	416.4	217.5	198.9	115.9	153.8	146.7
1996	407.6	224.4	183.2	118.0	145.4	144.3
1997	410.5	230.4	180.1	124.7	143.8	142.0
1998	415.7	232.7	183.0	128.1	142.4	145.1
1999	423.8	234.3	189.6	131.2	147.7	145.0
2000	445.4	238.0	207.4	132.7	160.9	151.8
2001	454.6	241.0	213.6	138.3	153.7	162.6
2002	476.9	265.9	211.0	138.7	171.7	166.5
2003	483.6	259.9	223.7	136.7	178.0	168.9
2004	472.7	246.9	225.8	140.9	152.4	179.4
2005	469.9	251.6	218.4	144.8	145.4	179.8

Table 3. Investment in education by gender and education level, 1976 – 2005, (billions of 2002 dollars)

Year	Total	Male	Female	Grade 0-8	High school	College or above
1976	368.7	221.2	149.7	143.5	147.5	83.4
1977	366.4	219.6	148.8	139.1	146.9	84.5
1978	364.4	216.5	149.7	133.8	145.6	87.5
1979	361.2	213.3	149.5	129.7	143.9	89.2
1980	361.4	213.3	149.7	127.1	142.9	92.5
1981	365.4	215.2	151.7	129.5	141.1	97.2
1982	371.0	218.7	153.9	128.3	140.5	104.4
1983	391.3	225.1	166.7	126.9	141.7	123.2
1984	390.6	224.2	166.8	125.8	138.2	127.4
1985	392.5	223.7	169.1	124.7	138.2	130.1
1986	391.4	221.0	170.5	120.0	141.2	129.7
1987	404.7	227.8	177.0	125.6	146.6	132.2
1988	410.2	229.8	180.3	127.1	147.9	134.9
1989	413.5	231.5	181.9	129.5	147.5	136.6
1990	418.2	234.3	183.8	131.4	146.6	140.7
1991	439.4	247.2	192.1	132.5	155.7	150.7
1992	446.1	252.8	193.5	133.5	163.5	148.9
1993	448.6	254.6	194.3	133.9	166.7	147.9
1994	446.2	252.8	193.6	134.2	164.9	147.0
1995	450.0	253.9	196.1	135.3	166.7	147.9
1996	442.2	250.5	191.8	136.1	160.6	145.6
1997	453.3	256.7	196.8	139.5	167.1	147.2
1998	455.2	256.9	198.5	138.9	169.0	147.9
1999	456.7	257.0	199.9	138.7	171.9	146.9
2000	464.8	260.1	204.7	138.5	171.9	154.9
2001	471.7	263.0	208.7	139.1	172.3	160.6
2002	476.9	265.9	211.0	138.7	171.7	166.5
2003	471.8	264.3	207.5	137.4	159.8	175.1
2004	469.5	262.7	206.8	135.1	157.0	178.7
2005	469.9	262.0	207.8	132.6	158.8	180.1

Table 4. Annual growth in the volume index of investment in education, 1976 to 2005

	1976 to 2005	1976 to 1986	1986 to 1996	1996 to 2005
Total	0.8	0.6	1.2	0.7
Male	0.6	0.0	1.3	0.5
Female	1.1	1.3	1.2	0.9
Grade 0-8	-0.3	-1.8	1.3	-0.3
High school	0.3	-0.4	1.3	-0.1
College or above	2.7	4.5	1.2	2.4

Table 5. Annual growth in the price index of investment in education, 1976 to 2005

	1976 to 2005	1976 to 1986	1986 to 1996	1996 to 2005
Total	2.4	3.5	2.5	0.9
Male	2.6	4.0	2.7	0.8
Female	2.1	3.0	2.2	1.1
Grade 0-8	4.3	6.6	3.5	2.6
High school	1.2	2.3	1.2	0.1
College or above	2.1	2.8	3.1	0.1

Table 6. Investment in education per student by gender and education level, 1976 – 2005, (thousands of current dollars)

Year	Total	Male	Female	Grade 0-8	High school	College or above
1976	33.9	36.0	31.6	14.7	60.2	58.2
1977	36.1	38.7	33.3	15.5	65.1	57.9
1978	36.9	39.8	34.0	16.2	64.5	59.6
1979	37.7	41.5	33.8	17.1	65.3	58.5
1980	39.8	42.5	37.0	18.4	70.7	57.0
1981	46.5	49.2	43.8	21.2	83.7	68.0
1982	50.6	52.4	48.7	22.7	89.0	76.5
1983	47.0	48.4	45.7	23.0	76.3	70.4
1984	50.1	54.1	46.1	24.7	80.5	75.3
1985	49.2	54.2	44.2	26.2	75.1	73.2
1986	53.9	57.8	50.0	27.7	83.2	79.3
1987	56.2	59.6	52.7	29.2	89.8	79.8
1988	55.4	58.4	52.5	30.9	86.2	77.0
1989	60.9	66.8	55.0	32.9	98.0	83.8
1990	78.6	87.0	70.4	37.4	124.0	122.6
1991	80.5	85.8	75.2	39.5	115.9	131.8
1992	76.4	81.3	71.4	39.5	111.5	118.4
1993	70.3	78.6	62.0	38.7	100.3	106.4
1994	68.7	75.1	62.3	38.1	96.8	105.3
1995	71.2	74.7	67.7	38.7	100.9	110.7
1996	69.9	77.2	62.6	39.1	97.0	109.8
1997	69.1	77.8	60.5	40.3	93.9	108.1
1998	69.8	78.6	61.2	41.6	92.0	109.8
1999	70.8	78.9	62.9	42.6	94.6	107.8
2000	74.1	80.1	68.3	43.2	103.6	109.5
2001	74.9	80.4	69.5	44.9	99.3	113.0
2002	78.1	88.2	68.2	45.2	111.1	111.3
2003	78.7	85.9	71.7	45.1	117.1	106.3
2004	76.9	81.7	72.2	47.2	98.7	110.6
2005	76.6	83.5	69.9	49.5	93.0	109.0

Table 7. Investment in education per student by gender and education level, 1976 – 2005, (thousands of 2002 dollars)

Year	Total	Male	Female	Grade 0-8	High school	College or above
1976	66.7	78.1	55.5	45.3	93.9	105.2
1977	67.2	78.9	55.7	45.2	94.6	102.2
1978	68.3	79.7	57.2	45.2	94.6	104.9
1979	69.0	80.2	58.1	45.1	95.3	104.5
1980	69.9	81.2	58.8	45.1	97.6	104.1
1981	70.1	81.1	59.2	45.2	99.5	104.8
1982	71.0	82.3	60.0	45.2	100.8	105.7
1983	73.2	83.0	63.3	45.1	101.6	108.1
1984	73.4	83.2	63.5	45.1	100.6	109.8
1985	73.7	83.3	64.1	45.1	100.6	110.0
1986	75.0	84.6	65.4	45.0	103.8	109.2
1987	75.1	84.6	65.6	45.0	105.9	109.0
1988	75.3	84.8	65.9	45.0	107.2	108.8
1989	74.9	84.4	65.5	45.0	106.5	108.6
1990	74.6	84.1	65.1	45.0	104.8	109.0
1991	76.6	86.6	66.6	45.0	108.1	111.1
1992	76.9	87.3	66.6	45.1	110.3	109.8
1993	77.1	87.7	66.7	45.1	110.8	110.2
1994	76.8	87.3	66.4	45.1	109.4	110.6
1995	76.9	87.2	66.7	45.1	109.3	111.6
1996	75.8	86.2	65.6	45.1	107.1	110.8
1997	76.3	86.7	66.1	45.1	109.0	112.1
1998	76.5	86.7	66.4	45.1	109.2	112.0
1999	76.3	86.5	66.3	45.1	110.1	109.3
2000	77.4	87.5	67.5	45.1	110.7	111.7
2001	77.7	87.8	67.9	45.2	111.2	111.7
2002	78.1	88.2	68.2	45.2	111.1	111.3
2003	76.8	87.4	66.6	45.3	105.2	110.3
2004	76.4	86.9	66.2	45.3	101.7	110.1
2005	76.6	87.0	66.5	45.3	101.6	109.2

Table 8. Annual growth in cost-based and income-based estimates of education services

	1976-2005	1976 to 1986	1986-1996	1996 to 2005
Cost-based estimates				
Nominal value	5.8	8.7	5.0	3.5
Quantity index	0.6	0.0	1.1	0.9
Price index	5.2	8.8	4.0	2.6
Income based estimates				
Nominal value	3.2	4.2	3.8	1.6
Quantity index	0.8	0.6	1.2	0.7
Price index	2.4	3.6	2.5	0.9

Table 9. Regression results for the log of literacy scores

	(1)		(2)		(3)	
Variable	Coeff.	t-stat	Coeff.	t-stat	Coeff.	t-stat
Constant	5.3040	106.75	5.1631	63.97	5.0467	43.36
E2	0.3118	6.24	0.4170	5.11	0.4259	3.91
E3	0.3774	7.55	0.5110	6.27	0.5273	4.85
E4	0.4426	8.86	0.5657	6.95	0.5665	5.21
E5	0.4872	9.69	0.6077	7.35	0.6168	5.66
t*E1			0.0086	2.24	0.0099	1.93
t*E2			0.0021	3.42	0.0017	1.75
t*E3			0.0005	0.70	-0.0008	-1.07
t*E4			0.0011	1.76	-0.0006	-0.78
t*E5			0.0012	1.35	-0.0008	-1.09
Female					-0.0102	-1.74
Age					0.0080	4.44
Age squared					-0.0001	-5.82
Good math grades					0.0473	8.20
Teachers too fast					-0.0258	-2.01
Reading difficulties					-0.0637	-5.21
Mother post-secondary education					0.0360	5.69
Father post-secondary education					0.0338	5.74
Mother Canadian					-0.0143	-1.37
Father Canadian					0.0051	0.53

Table 10. Hedonic regression results for the price of education output

Parameters	Estimates	t-statistics
alpha	8.5386	68.9
alpha2	-2.3987	-6.95
alpha3	-2.8526	-8.49
alpha4	-2.9765	-8.74
alpha5	-3.1603	-8.81
beta	0.5657	9.74
gamma0 (female)	-0.3227	-10.99
gamma1 (experience)	0.0930	19.69
gamma2 (experience squared)	-0.0019	-14.53
Gamma3 (Good math grades)	0.0948	2.82
Gamma3 (Teachers too fast)	-0.0812	-1.29
Gamma4 (Reading difficulties)	-0.0829	-1.46

Table 11. Annual growth in the quality-adjusted education output based on the income approach

	1976 to 2005	1976 to 1986	1986 to 1996	1996 to 2005
Without quality adjustment				
Volume index	0.8	0.6	1.2	0.7
Price index	2.4	3.5	2.5	0.9
With quality adjustment				
Volume index	1.0	0.8	1.4	0.9
Price index	2.2	3.3	2.3	0.7

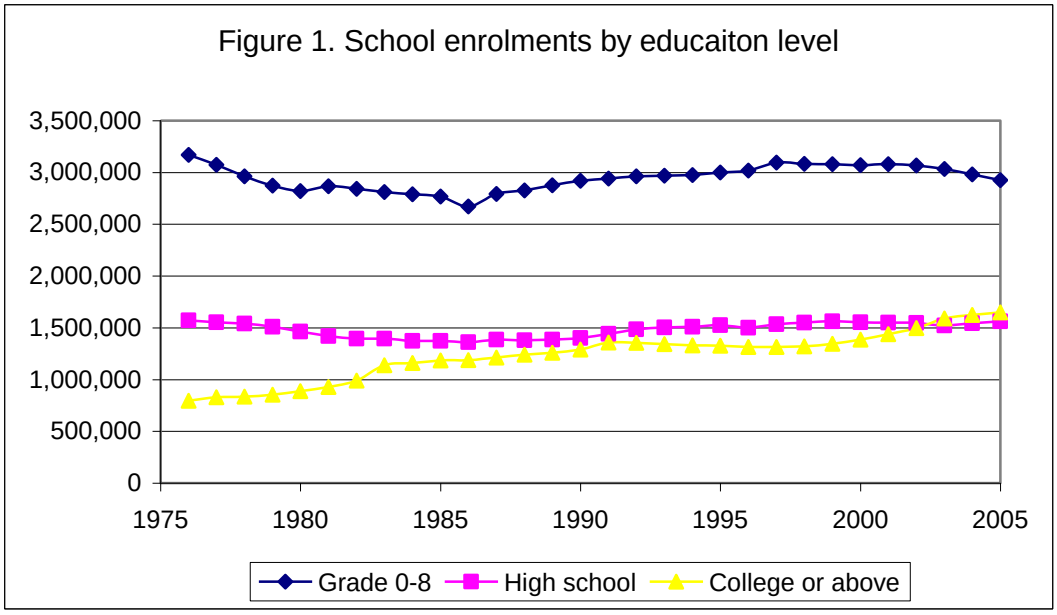
Figure 1. School enrolments by educaiton level
3,500,000
3,000,000
2,500,000
2,000,000
1,500,000
1,000,000
500,000
0
1975
1980
1985
1990
1995
2000
2005
Grade 0-8
High school
College or above

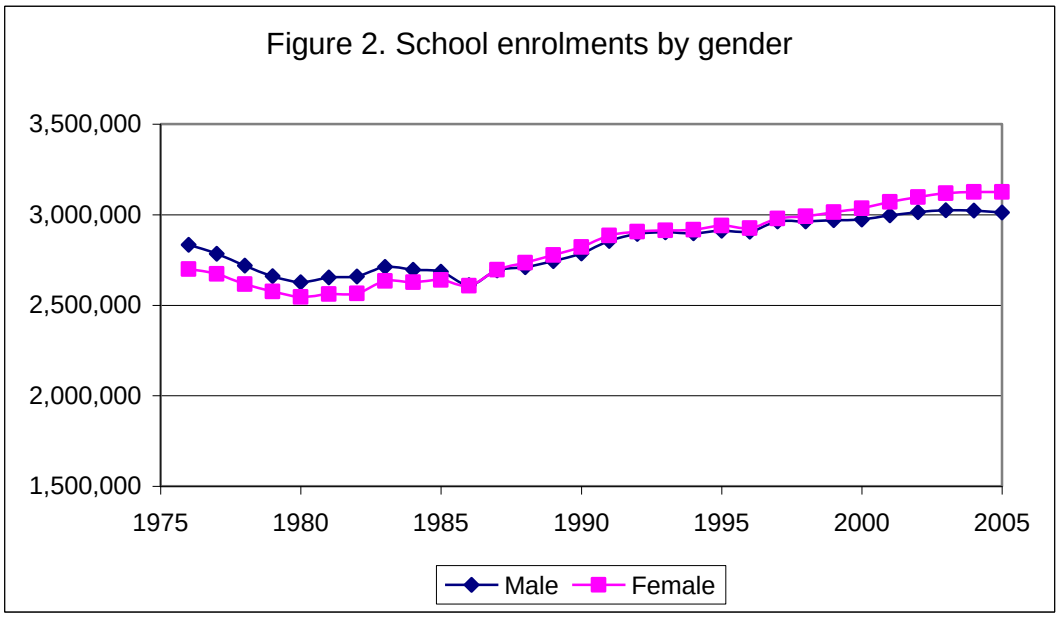
Figure 2. School enrolments by gender
3,500,000
3,000,000
2,500,000
2,000,000
1,500,000
1975
1980
1985
1990
1995
2000
2005
Male
Female

Figure 3. Investment in education by education level, 1976 - 2005, (billions of 2002 dollars)

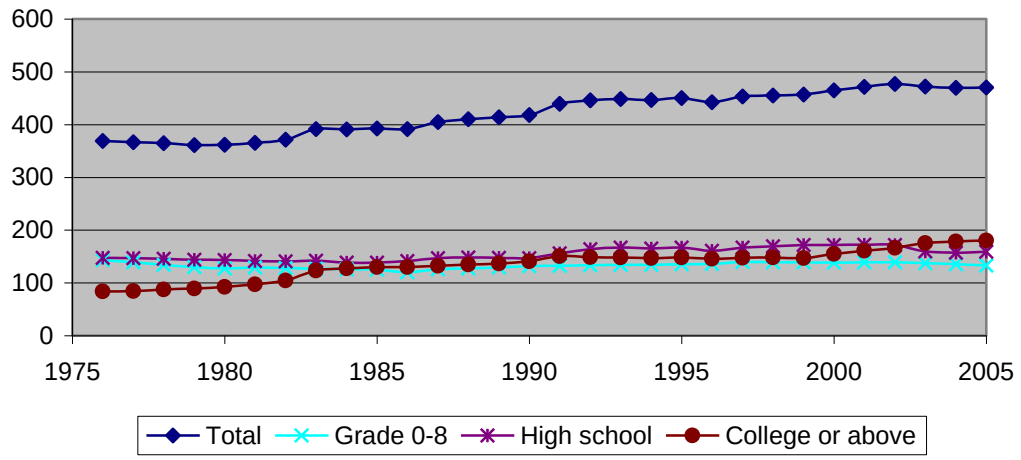

Figure 4. Investment in education per student by gender, 1976-2005 (thousands of 2002 dollars)

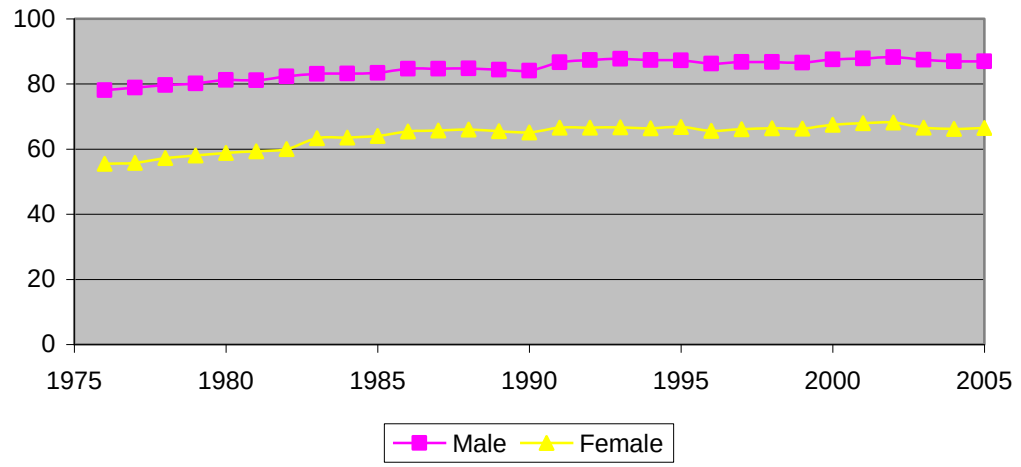

Figure 5. Investment in education per student by education level, 1976-2005 (thousands of 2002 dollars)

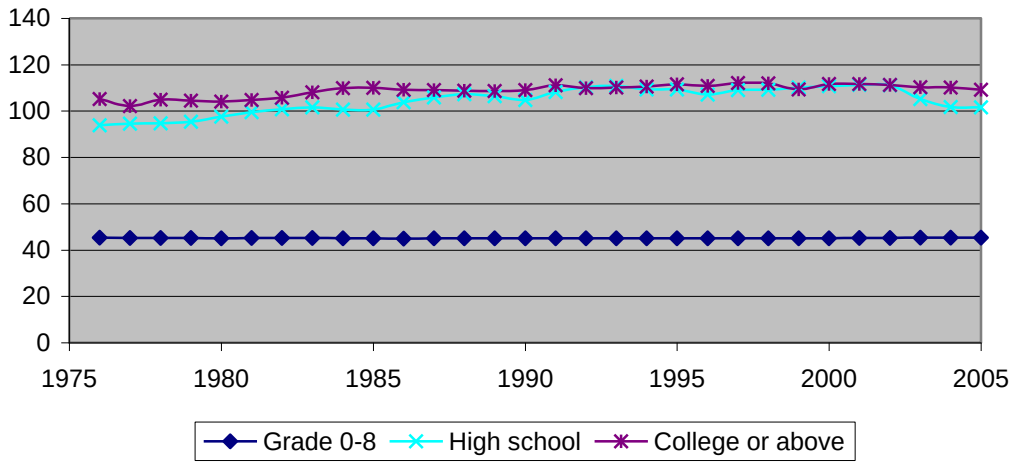

Figure 6. The income-based estimate over cost-based estimate of education service

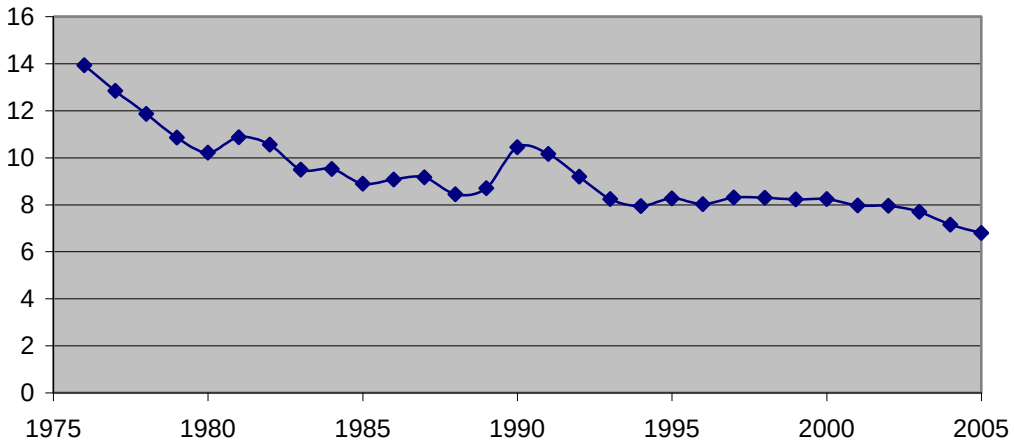

Figure 7. Alternative measure of education output

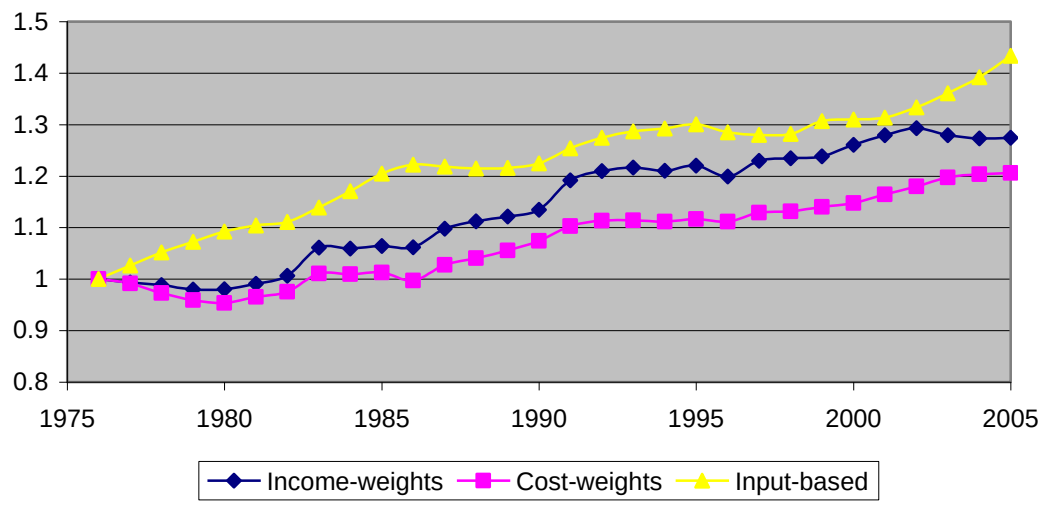

Figure 8. Cost of education per student (000s)

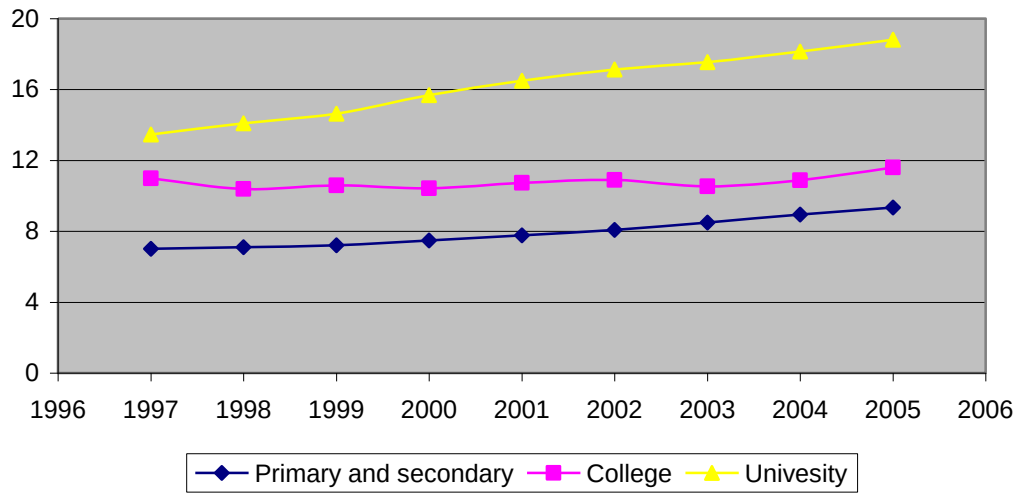

Figure 9. Labour productivity in the education sector