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Methodology for Measuring Education Output Using a Human Capital Approach

Barbara M. Fraumeni
Muskie School of Public Service, University of Southern Maine
and the National Bureau of Economic Research, USA

For additional information, please contact:

Author name: Barbara M. Fraumeni
Author address: Muskie School of Public Service, University of Southern Maine, PO Box 9300, 606 Law Building, Portland, Maine, USA 04104-9300, USA
Author E-mail: Barbara.Fraumeni@maine.edu
Author fax: 001 (207)780-4417
Author Telephone: 001 (207) 228-8245

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Methodology for Measuring Education Output Using a Human Capital Approach

by
Barbara M. Fraumeni
Muskie School of Public Service, University of Southern Maine
and the National Bureau of Economic Research, USA[1]

This note describes the methodology underlying a research project to extend the Jorgenson-Fraumeni (J-F) research on investment in education (1992a, 1992b). The current project, undertaken by Jorgenson, Fraumeni, and Christian (J-F-C), differs from the earlier efforts in several respects. The most obvious is that results will be provided from 1960-2003 or 2004 instead of from 1948-1986. Of most interest to the participants in this workshop is that the basic project will be the launching pad for several subprojects. One of these will focus on how to isolate the impact of public education on lifetime earnings in order to measure government education output. The workshop presentation will briefly touch on a couple of important modifications to the basic J-F-C results that are needed to make the transformation from measuring the output of all formal education activities to those undertaken by the government.

The original J-F project was a massive project which took some 5-10 years to complete. A number of investigators were involved in preparing inputs to the estimates, most notably Chinloy, Gollop and Ho who constructed a labor data base on wages, hours worked, and employees for age and education categories. The J-F human capital estimates were constructed by single year of age and education. Realistically such an effort cannot be supported on an on-going basis. Accordingly, the J-F-C project is asking the question: Can robust estimates be constructed with a blend of categorical data from the labor data base maintained by Ho and information on enrollment and population by single year of age and grade enrolled or highest education level completed? Even this less ambitious project entails producing a large data set; the largest data base has over 120,000 observations spread out over 45 years with about 25 variables associated with each observation. Accordingly even though it was hoped results would be ready for this conference, there was not sufficient time to construct the estimates and to subject them to the type of quality checking that any data intensive work requires.

The J-F methodology estimates investment in education (the output of education) as the impact of education on lifetime income. Lifetime income is both market and nonmarket income. The value of nonmarket labor is estimated as well as the value of market labor. Time spent in sleep and maintenance activities, which was assumed to be 10 hours per day in J-F, is not valued. Investment in education occurs when individuals are enrolled in school. The expected future lifetime income of someone enrolled in school is compared to the expected future lifetime income of someone who has one less year of formal schooling. Expected future income is discounted and a real rate of growth of labor

[1]For the current project, Mun Ho of Resources for the Future provided the labor data base (compensation, wages, hours and employees by category). Michael Christian of the Bureau of Economic Analysis provided the other data to update the J-F estimates to the present, with the exception of the tax rates which came from Jon Samuels of Harvard University. Marc Hitchcock, a graduate assistant of the Muskie School of Public Service, helped by aggregating data and putting data into appropriate formats.

income is assumed based on historical trends and expected future trends. Expected future income depends on the lifetime income of older individuals in the year for which estimates are being constructed. Specifically, the expected future income of a male aged 22 with an undergraduate college degree in 1980 depends on the expected future lifetime income of males living in 1980 who are 22 years of age or older and have an undergraduate college degree or at least one year towards a graduate degree. Finally, lifetime incomes are calculated by a backwards recursion, starting with age 74, which is the oldest age before retirement.

The following text describes in more detail the methodology being employed for the estimates being developed. The format of the description is similar to the format of the appendix to Jorgenson-Fraumeni (1992).

Dimensions of the Data

Years: 1960-2003 or 2004
By Sex: Male and Female

Categories:

Age

1 16-17
2 18-24
3 25-34
4 35-44
5 45-54
6 55-64
7 65-74
8 75+

Education (1960-1992) based on years of school

1 Less than HS
2 Some high school
3 High school grad
4 Some college
5 College grad
6 More than college

Education (1992-2000) based on highest level achieved

1 8th grade or less
2 grades 9-12 no diploma
3 high school grad
4 some college no degree, associate degree
5 BA, BS
6 More than BA or BS

When the variable is enrollment or investment in education, the education categories refer to level of enrollment instead of years enrolled or highest level achieved.

Level of enrollment for all years

1 Grade 1-8
2 High school years 1-3
3 High school year 4
4 College year 1-3
5 College year 4
6 Graduate school

In the following equations, when the variables are categorical as opposed to by single year of age and education, capital letters are used. For example, a variable with an "A" dimension is an age category variable; a variable with an "a" dimension is a by single year of age variable. Enrollment is referred to as "ENR" when it is an enrollment category variable; it is referred to as "enr" when it is a by single year of education level enrolled variable. Otherwise education is referred to by "E" (categorical) or "e" by single number of years in school or by single year of highest level of education achieved.

The single years of age are for a = 0,1,2,…75, 75+. The single years of education are:

Education = e	Enrollment or Investment in Education
1	Not enrolled
2	Grade 1
3	Grade 2
4	Grade 3
5	Grade 4
6	Grade 5
7	Grade 6
8	Grade 7
9	Grade 8
10	High school 1
11	High school 2
12	High school 3
13	High school 4
14	College 1
15	College 2
16	College 3
17	College 4
18	College 5+

Variables

The input variables required for estimates of the output of the educational sector by year, unless otherwise indicated, are denoted as follows. Variables are in current (nominal) dollars, are per person in the population unless otherwise noted, and are categorical unless otherwise noted by small letter dimensions and description.

Cmp(s,A,E) – hourly compensation, gross of taxes on labor income.
Emp(s,A,E) – number of employees.
Hrs(s,A,E) – hours worked per week.
Pop(s,a,e) – population by single year of age and education.
R – (1 + real rate of growth on labor income)/(1 + discount rate)
Senr(s,a,enr) – enrollments by single year of age and single year of level enrolled.
Sr(birthyear, s,a) – probability of survival, specific to the year of birth
Tax – Average tax rate on labor income
Taxam – Average marginal tax rate on labor income

Intermediate stage variables estimated from the above variables include:
Hrstot(s,A,E) – hours worked per week summed across all employees in the category.
Pop(s,A,E) – population.
Senr(s,A,ENR) – enrollments.
Ymi(s,a,e) – yearly market income by single year of age and education.
Ymi(s,A,E) – yearly market income.
Ymitot(s,A,E) – yearly market income summed across all employees in the category.
Ynmi(s,a.e) – yearly nonmarket income by single year of age and education.
Ynmi(s,A,E) – yearly nonmarket income.

Output variables include:
Life(s,a,e) – lifetime income by single year of age and education.
Mi(s,a,e) – market lifetime income by single year of age and education.
Nmi(s,a,e) – nonmarket lifetime income by single year of age and education
Si(s,a,enr) – Investment in education by single year of age and single year of level enrolled.

Life Stages Equations

There are five stages of life in the J-F human capital model of investment in education. Since calculations proceed by starting with those aged 75, the stages of life are being listed in reverse.

Stage 5: retirement, age 75+
ymi(s,a,e)=ynmi(s,a,e)=mi(s,a,e)=nmi(s,a,e) = 0

Stage 4: work only, age 35-74
ymi(s,a,e)=ymitot(s,A,E)/pop(s,A,E)*(1-tax)

ynmi(s,a,e)=[14*7*52-hrstot(s,A,E))/pop(s,A,E)]
cmp(s,A,E)(1-taxam)
mi(s,a,e)=ymi(s,a,e)+sr(s,older)*mi(s,older,e)*R
nmi(s,a,e)=ynmi(s,a,e)+sr(s,older)*nmi(s,older,e)*R

Stage 3: work and school, age 16-34
ymi(s,a,e)=ymitot(s,A,E)/pop(s,A,E)*(1-tax)
ynmi(s,a,e)=[14*7*52-hrstot(s,A,E)/pop(s,A,E)-1300*senr(s,A,ENR)]*cmp(s,A,E)
*(1-taxam)
mi(s,a,e)=ymi(s,a,e)+[senr(s,a,enr)*sr(s,older)*mi(s,older,school)
+(1-senr(s,a,enr))*sr(s,older)*mi(s,older,e)]*R
nmi(s,a,e)=ynmi(s,a,e)+[senr(s,a,enr)*sr(s,older)*nmi(s,older,school)
+(1-senr(s,a,enr))*sr(s,older)*nmi(s,older,e)]*R

Stage 2: school only, age 5-15
ymi(s,a,e)=ynmi(s,a,e)=0
mi(s,a,e)=[senr(s,a,enr)*sr(s,older)*mi(s,older,school)+(1-
senr(s,a,enr))*sr(s,older)*mi(s,older,e)]*R
nmi(s,a,e)=[senr(s,a,enr)*sr(s,older)*nmi(s,older,school)+(1-
senr(s,a,enr))*sr(s,older)*nmi(s,older,e)]*R

Stage 1: no school or work, age 0-4
ymi(s,a,e)=ynmi(s,a,e)=0
mi(s,a,e)= sr(s,older)*mi(s,older,e)*R
nmi(s,a,e)= sr(s,older)*nmi(s,older,e)*R

Summary Estimates

life(s,a,e)=mi(s,a,e)+nmi(s,a,e), where life is lifetime income, both market and nonmarket, per capital, total population
si(s,a,e)=senr(s,a,enr)*(life(s,older,e)-life(s,older,e-1))
If you are enrolled in a particular grade, and complete it when you are one year older, you get the lifetime income of someone who is one year older and who has completed that grade.

Volume (constant$) variables for each of the output variables are estimated with a translog (Divisia/Tornqvist) index.

Weights in nominal $s	Quantities
Si	Enrolled students
Mi	Population
Nmi	Population
Life	Population

A variety of other volume (constant$) indexes could be constructed, such as for yearly market income and depreciation of human capital.

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