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THE OUTPUT OF THE SWEDISH EDUCATION SECTOR

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THE OUTPUT OF THE SWEDISH EDUCATION SECTOR[1]

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Abstract

The output of the Swedish education sector is defined as the addition to lifetime incomes that is generated by the schooling system. Using cross-sectional information on wage-profiles by years of schooling, employment rates, working hours, school-participation and leisure time, we compute new output-based measures of the education sector. Measures that include and exclude leisure, and that are counted before and after taxes are computed for the years 1967, 1973, 1980 and 1990.

Our most important conclusion is that the output-based measure differs so markedly from conventional input-based ones that a replacement of the latter with the former would change the picture of the overall performance of the Swedish economy over the period.

1. Introduction

In traditional national accounts, the contribution of the education sector (ES) is measured by direct costs in the form of teachers' salaries, books, equipment, etc. It is commonplace to recognise that this procedure gives rise to problems, e.g. connected with difficulties of measuring productivity in the absence of a market valuation of the output of the sector. This, of course, is a problem pertaining to many other kinds of activities performed in the public sector. There is, however, a more specific problem when this method is applied to the ES: the input of time on part of the students is neglected. As this input by no means is of negligible size, this is a serious shortcoming of the method.

In a series of papers, Dale Jorgenson and Barbara Fraumeni (1992a, 1992b and 1992c) have developed a method to estimate the output of the ES and also applied this method on US data. The purpose of this study is to apply their method on Swedish data. The point of departure is to view education as investment in human capital. The output of the ES, consequently, should be measured by its contribution to the amount of investment in human capital undertaken over a specified time interval. The measure of investment in human capital employed in this paper, is the effect of education on an individual's lifetime income. The valuation, thus, is imputed from the market valuation of the productivity increase due to additional education. It goes without saying that the accuracy of the method depends critically upon the extent to which productivity gains due to schooling actually are reflected in market wages.

The measure both accounts for changes in the value of time spent outside the labour market (parenting, enjoyment of leisure time etc.) and values market activities. However, insofar as schooling per se has an important part of consumption to it, this is not reflected in our measures.

The approach also fails to take account of possible externalities from education in that education might produce not only individually appropriable knowledge (human capital) but also disembodied knowledge that extends beyond the individual in the sense of e.g. Romer (1990). The externalities arising from this kind of non-rival knowledge play a key role in modern theories of endogenous growth.

For a typical individual, then, we project the expected change in lifetime income of an additional year of schooling by applying the age and education structure of earnings in a given cross-section of individuals, properly discounting future incomes back to present value and applying an assumption of real income growth over time. This gives a measure of the change in life-time market income. Given the number of hours worked in the labour market and the individual's after-tax hourly wage rate, we can value non-market activities on the assumption that an optimising individual chooses to work up to the point where the marginal benefit of work equals the marginal benefit of leisure. The value of leisure is, thus, given by the marginal after-tax wage rate times the number of leisure hours. The contribution to investment in human capital in a given year, due to the education system, is the sum across all individuals engaged in education and across the changes in market and non-market life-time incomes.

Two limitations of the analysis may be appropriate to mention already at this moment: First, we look only at education undertaken in formal schooling, whereas on-the-job training, which also is an important determinant of the development of an individual's productivity over time, is neglected. Second, we measure formal schooling in calendar years, thus formally equalising the returns to all kinds of educations of the same length. While we still may capture the average returns correctly, our results will have no bearing on, e.g., the question whether to allocate resources to the training of nurses or of engineers.

In principle, our problem of estimating life-time incomes is straightforward to solve, given sufficient data on educational levels, ages, wage rates, tax rates, working hours etc. Of course, one has to make more or less well informed guesses about real income growth rates and discount rates, but the real problem is the lack of annual surveys of the whole population providing information on key variables. We have therefore had to use surveys of representative samples of about 6000 individuals for the years 1968, 1974, 1981 and 1991 (the Swedish Level of Living Surveys, LNU). As described more in detail below, raw data from these surveys have been used to estimate the key inputs to our model, a number of matrices with information on incomes, market hours and the like, where a typical element pertains to an individual of age a, sex s and with educational level e.

Section 2 presents the variables appearing in the calculations and the algorithm mapping input matrices to the outputs in the form of investment in human capital. *Section 3* describes our basic data and gives some summary sample statistics of the variables used, whereas *Section 4* gives the details of how the matrices used in the algorithm have been extracted from the raw data. In *Section 5,* results and some sensitivity analysis are presented and *Section 6* concludes the study.

2. Variables and computations

In this section we present the variables used and the computations linking the input variables to the output. We start by defining the variables and introducing our notation, which is the same as in Jorgenson and Fraumeni:

y - calendar year

s - sex

a=0, 1, ..., 74, 75, 75+, - age

e=6, 7, ..., 18+, - educational attainment in years

com - hourly compensation in the labour market, net of income tax

empr - employment rate

life - lifetime labour (market plus nonmarket) income per capita

whrs - conditional market labour time, the number of working hours, conditional on being employed

mhrs - market labour time per capita

mi - lifetime market labour income per capita

nmhrs - nonmarket labour time per capita

nmi - lifetime nonmarket labour income per capita

senr - school enrollment rate, the probability that an individual with educational attainment e is enrolled in educational level e+1.

cshrs - conditional school hours per capita, the number of school hours per capita, conditional on enrollment in education.

shrs - school hours per capita

si - investment in education per capita

sr - probability of survival

tax - average labour income tax rate in a specified income bracket

taxam - average marginal labour income tax rate in a specified income bracket

ymi - annual market income per capita, net of labour income tax

ynmi - annual nonmarket income per capita

r - discount rate

g - projected real income growth rate

(i) The individual's time allocation

In the calculations, we assume that the individual allocates her total available time between four activities: work in the labour market (*mhrs*), nonmarket activities (*nmhrs*), schooling (*shrs*) and maintenance. Maintenance per capita is assumed to amount to 10 hours a day, leaving 14 hours per day to be allocated to the other three activities. We will check how sensitive our results are to this assumption. The number of market hours, *mhrs*, is derived as the product of the employment rate (*empr*) and the number of working hours conditional on employment (*whrs*). In an analogous fashion, the number of school hours (*shrs*) is given by the school enrollment rate (*senr*) times the number of school hours conditional on enrollment in education (*cshrs*).

Given estimates of *mhrs* and *shrs*, *nmhrs* thus is given by

$$nmhrs(y,s,a,e)=14*7*52-shrs(y,s,a,e)-mhrs(y,s,a,e)$$

(ii) Market and nonmarket annual labour income per capita

Given the number of hours spent in the labour market, annual labour market income is given by

$$ymi(y,s,a,e)=mhrs(y,s,a,e)*com(y,s,a,e).$$

Nonmarket labour income is derived on the assumption that an optimising individual on the margin equates the remunerations in different activities. On the further assumption that intramarginal units of nonmarket time are valued just as much as the marginal one, annual nonmarket labour income is given by

$$ynmi(y,s,a,e)=nmhrs(y,s,a,e)*com(y,s,a,e)*(1-taxam(y,ymi))/(1-tax(y, ymi)).$$

(iii) Lifetime income and investment in schooling per capita

Lifetime income per capita (*life*) is measured by projecting future incomes using the age, sex and educational structure of labour incomes in a given year, increasing these incomes by an assumed real income growth rate, discounting them back to a present value and weighing them with probabilities of survival. Total lifetime income is the sum of lifetime market income and lifetime nonmarket income.

The incomes are calculated by a backward recursion: first the lifetime income of an individual with the highest educational attainment (which we take to be 18 years) is computed, working backwards from age 74, which we take to be the oldest age before retirement. The next step in the recursion involves computing lifetime income for an individual with 17 years of formal schooling. This, in turn, consists of the lifetime income connected with 18 years of schooling times the probability of enrolling in the 18th year, given enrollment in the 17th year. In addition, it includes the discounted value of incomes for a person with 17 years of education times one minus the probability of enrolling in the 18th year. Thus, we have for market lifetime income per capita *(mi)*

$$\begin{aligned} mi(y,s,a,e) &= ymi(y,s,a,e) + \\ &(senr(y,s,a,e)*sr(y,s,a+1)*mi(y,s,a+1,e+1) \\ &+(1-senr(y,s,a,e))*sr(y,s,a+1)*mi(y,s,a+1,e))*(1+g)/(1+r). \end{aligned}$$

Note that this recursion is well defined, since mi(y,s,75,e)=0. In an analogous fashion we have the following expression for nonmarket lifetime income *(nmi)*:

$$\begin{aligned} nmi(y,s,a,e) &= ynmi(y,s,a,e) + \\ &(senr(y,s,a,e)*sr(y,s,a+1)*nmi(y,s,a+1,e+1) \\ &+(1-senr(y,s,a,e))*sr(y,s,a+1)*nmi(y,s,a+1,e))*(1+g)/(1+r). \end{aligned}$$

Total lifetime income *(life)* is given by

$$life(y,s,a,e)=mi(y,s,a,e)+nmi(y,s,a,e).$$

Finally, investment in education per capita in the population *(si)* is

$$si(y,s,a,e)=senr(y,s,a,e)*(life(y,s,a,e+1)-life(y,s,a,e)).$$

3. The data

Our basic data set comes from the Swedish Level of Living Surveys (see Robert Erikson and Rune Åberg, 1987) performed in 1968, 1974, 1981 and 1991, and consisting of personal interviews with around 6000 individuals, randomly selected from the Swedish population. Most of the interviews were done during the first half of each year.

The hourly wage rate is constructed from questions about earnings and weekly working hours. The respondents are first asked about the compensation scheme: whether they are paid by the hour, by piece-rate, by the week, by the month or by some other scheme. Then the respondent reports the actual level of compensation per period; those paid by piece-rate or according to some other scheme report monthly earnings. Dividing by normal working hours per week gives the hourly wage rate.

The wage variable is only available for employed persons, which means that we will apply the wage-age-schooling structure for employed persons on self-employed persons too. According to available information[2], this procedure is not likely to create any considerable bias.

[2]Anders Björklund and Christian Kjellström (1993) estimated human capital income equations on both employed persons and employed plus self-employed using (log) income from tax registers as the dependent variable. The schooling coefficient did at the most differ by 0.012 (0.040 for employed only vs. 0.052 for employed plus self-employed in 1981) for men and by 0.005 (0.075 for employed vs. 0.080 for employed plus self-employed in 1974) for women.

Another section of the questionnaire asks about labour market activities during the whole preceding year, i.e. 1967, 1973, 1980 and 1990. The respondent is asked to report the number of weeks spent working full-time, working part-time, at school and with household work during the year. For every activity the respondent also reports the average number of hours per week in that activity. These questions form the basis for the variables: employment rate, working hours, school enrollment rate and conditional school hours. Since we compute annual labour market income by multiplying the hourly wage rate and annual working hours, it is important to note the exact definitions of these variables. Both vacations and spells of sickness are included in working hours, which means that we apply the hourly wage rate on these hours too. Given the rules for vacation and sickness pay in Sweden, this is a reasonable approximation. Hence it is also natural to exclude the payroll taxes for sickness and vacation pays from the hourly wage rate.

Table 1 reports sample statistics for the variables picked from the Level of Living Surveys. The table describes the marked changes in the Swedish labour market that took place from the late 1960s until the early 1990s. Wage dispersion declined from 1967 to 1980, employment rates and working hours reveal large increases for women and slight decreases for men, school enrollment rates and educational levels have gone up.

Table 1 *Sample characteristics: means and standard deviations (within parentheses)*

	1967	1973	1980	1990
Log hourly wages				
Men	4,15 (0,42) (#1777)	4,39 (0,32) (# 1699	4,42 (0,32) (# 1754)	4,44 (0,31) (#1650)
Women	3,83 (0,43 (#1123)	4,12 (0,35) (# 1303)	4,23 (0,28) (# 1587)	4,24 (0,24) (#1650)
Employment rate (*empr*)				
Men	0,87 (0,33) (#2710)	0,85 (0,36) (# 2636)	0,84 (0,37) (# 2686)	0,83 (0,37) (#2620)
Women	0,58 (0,49) (#2676)	0,65 (0,47) (# 2645)	0,72 (0,45) (# 2660)	0,75 (0,43) (#2581)
Annual working hours (*whrs*)				
Men	2132,35 (714,70) (# 2374)	1992,03 (687,47) (# 2233)	1943,47 (709,60) (# 2251)	1953,68 (719,43) (#2183)
Women	1406,01 (811,83) (# 1563)	1370,25 745,33 (# 1730)	1432,34 (673,28) (# 1921)	1619,76 (638,02) (#1939)
School enrollment rate (*senr*)				
Men	0,10 (0,30) (# 2710)	0,12 (0,33) (# 2636)	0,12 (0,33) (# 2686)	0,12 (0,33) (#2620)
Women	0,07 (0,26) (# 2676)	0,11 (0,31) (# 2645)	0,13 (0,34) (# 2660)	0,14 (0,35) (#2581)
Conditional school hours (*shrs*)				
Men	1367,04 (787,55) (# 264)	1210,96 (694,89) (# 321)	1041,67 (695,64) (# 337)	1200,35 (697,85) (#325)
Women	1325,13 (808,10) (# 195)	1336,65 (792,28) (# 281)	974,21 (670,05) (# 345)	1116,50 (690,54) (#369)
Years of education (*e*)				
Men	8,44 (2,88) (# 2710)	9,34 (3,29) (# 2636)	10,12 (3,66) (# 2686)	11,05 (3,52) (#2620)
Women	8,18 (2,56) (# 2676)	8,88 (2,88) (# 2645)	9,61 (3,23) (# 2660)	10,70 (3,26) (#2581)
(# = number of observations)				

Note: The figures in the table pertain to samples of the same age groups for all four years. The wage rates have been transformed to 1990 SEK using the CPI.

4. Filling in the blanks - from raw data to input matrices

Distinguishing between 18 different levels of education for what in practice amounts to 61 age groups and two sexes, we need observations on 2196 groups per year. The sample size in the Level of Living Surveys is in the order of magnitude of 6000. This means that for quite a large number of groups we have only one or no observation at all. The general methodology employed has been to use regression techniques to predict the values of the elements in our matrices, conditional on sex, age and level of education. The presentation below is a more detailed account, by variable, of how this has been done.

The hourly compensation in the labour market is derived by regressing the logarithm of hourly wage rates for the sub-sample with observed positive wage rates on a, a^2, e, e^2, ae, $(ae)^2$ and a dummy for sex (both for intercept and slopes). The regression equation is used to predict the hourly compensation levels for all combinations of age and educational levels for both sexes. In the same fashion, conditional labour market time, *whrs*, and conditional school hours, *cshrs*, are estimated. The predicted values of the logarithm of wages and the annual working hours are displayed in *Figures 1 and 2*, respectively.

The employment rate, *empr*, and the school enrollment rate, *senr*, are both predicted by means of logit estimations on the same set of regressors as the three previous variables. The predicted employment and school enrollment rates are reproduced in *Figures 3 and 4*.

The income tax rates, both average (*tax*) and marginal (*taxam*) are calculated using numbers of taxes actually paid in relation to income for different income brackets, based on tax reports collected by Statistics Sweden. The probabilities of survival, (*sr*), are taken from sex-specific tables from Statistics Sweden, whereas the projected

Figure 1. Predicted log of hourly wages. 9 and 15 years of education

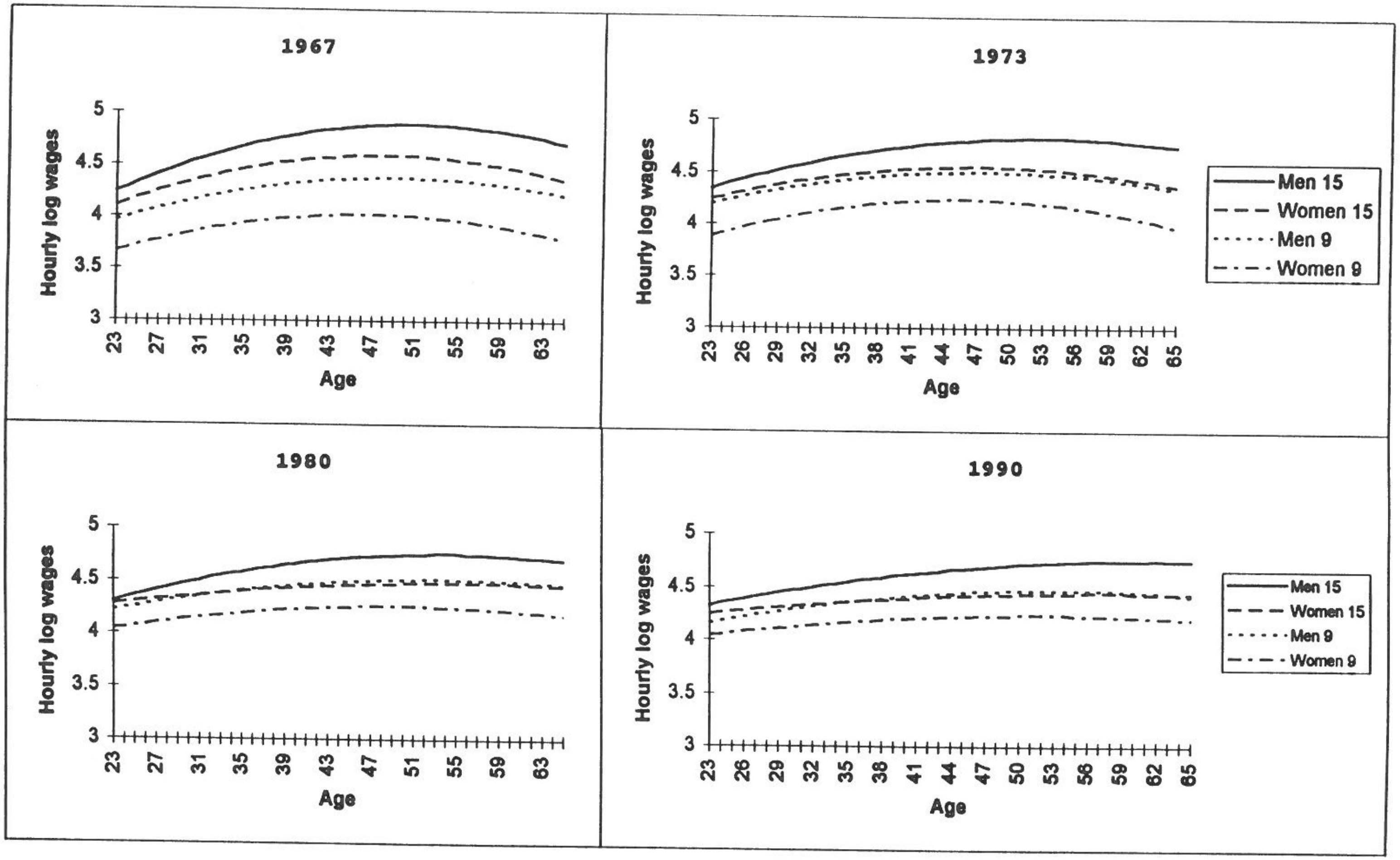


Figure 2. Predicted annual working hours. 9 and 15 years of education

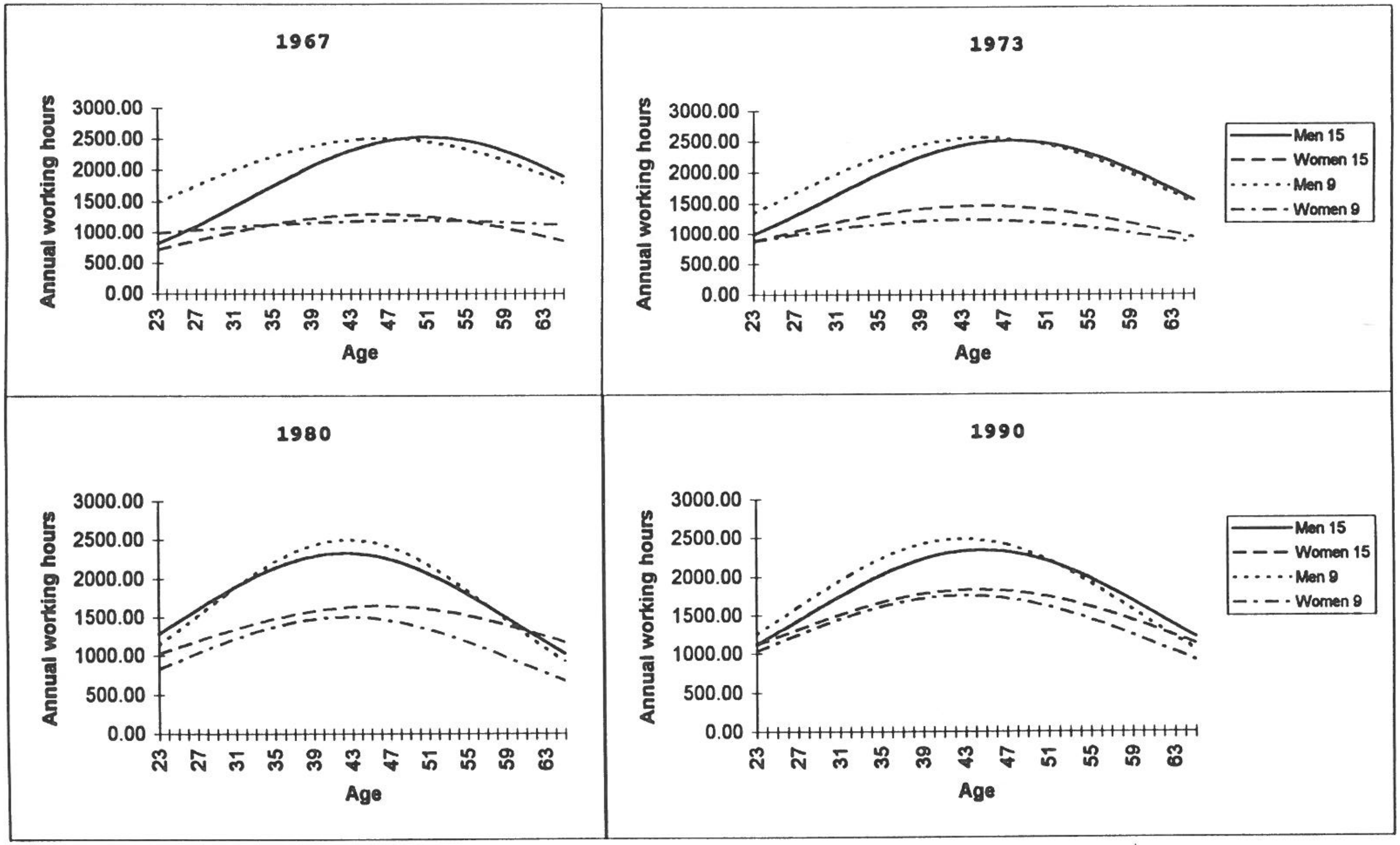


Figure 3. Predicted employment rates. 9 and 15 years of education

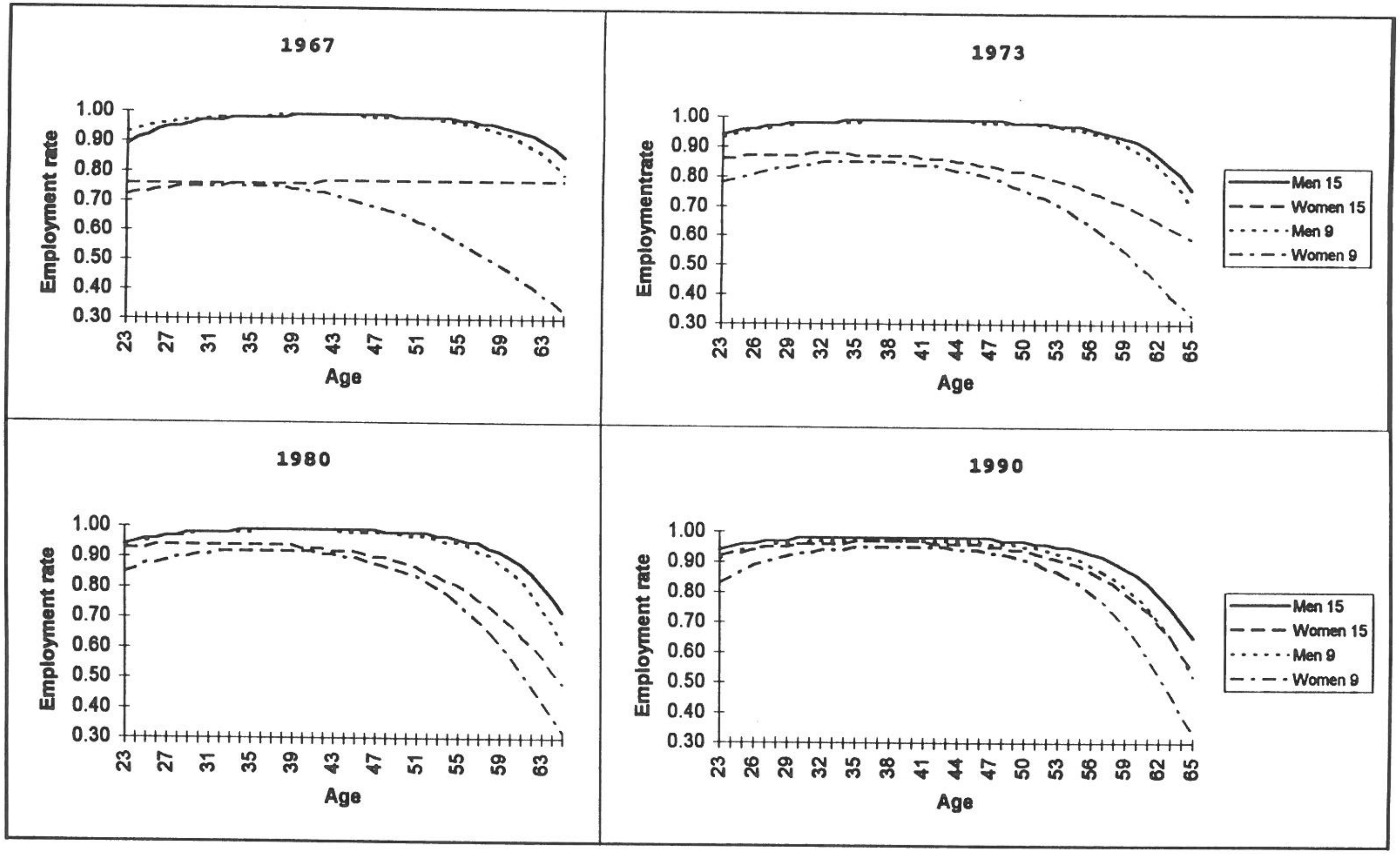
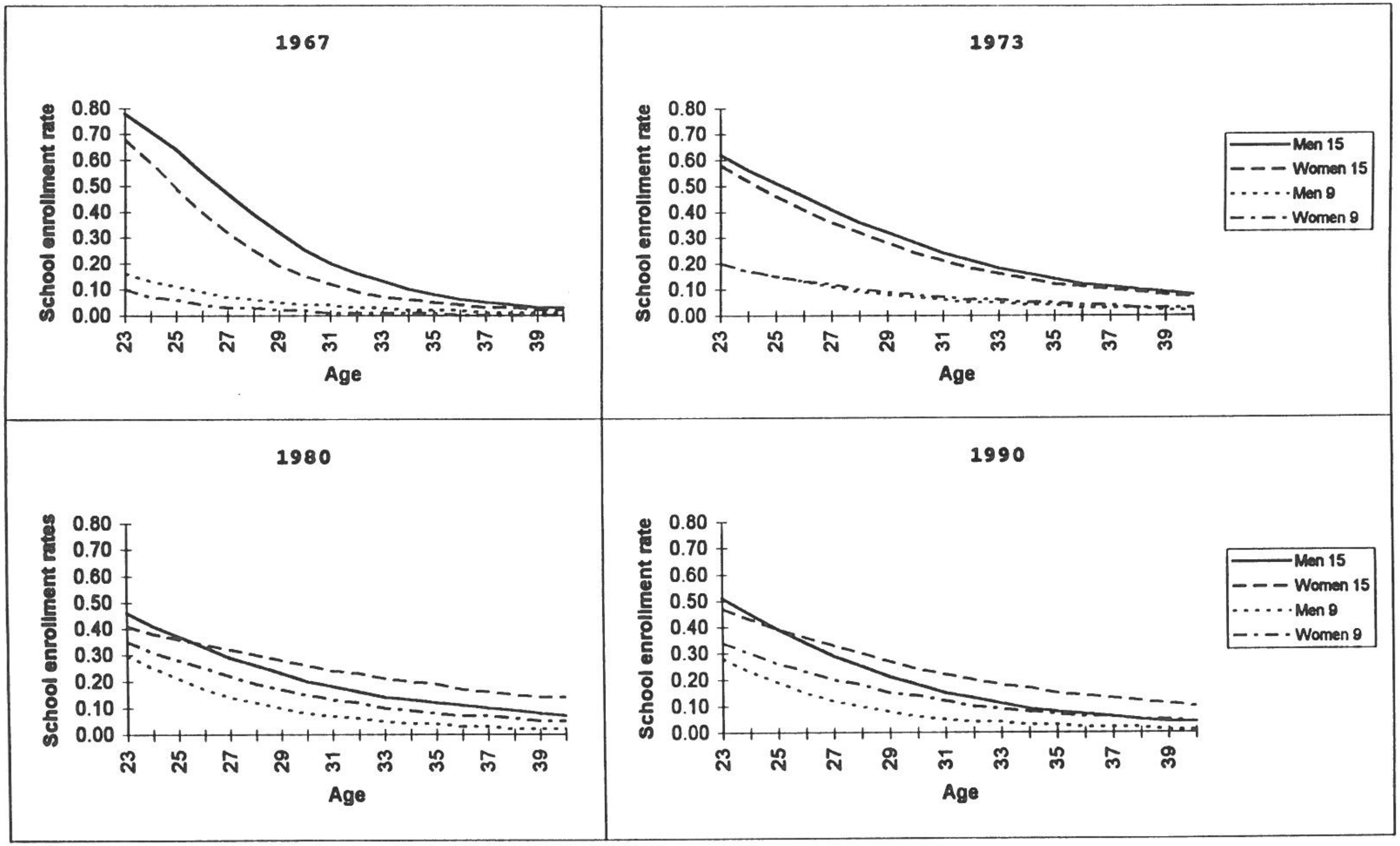


Figure 4. Predicted school enrollment rates. 9 and 15 years of education



income growth rate, (g), and the discount rate, (r), are the same as those used by Jorgenson and Fraumeni (1992b).

5. Results

5.1 Per capita computations

We start by presenting the results for our benchmark case with the discount rate 5.44 per cent, the projected income growth rate 1.89 per cent, and 10 hours a day for maintenance.[3] Later on we will show how sensitive our results are to these assumptions.

Table 2 reports lifetime market income before and after tax and lifetime nonmarket income for a typical case. The relative importance of nonmarket income is striking and important to keep in mind when interpreting the subsequent results. Even for men nonmarket income is about twice as high as market income after tax. For women nonmarket income was more than four times higher than market income after tax in 1967 and around 2.5 times higher in 1990.

As expected, the Swedish income taxes create a substantial gap between market income before and after taxes. In general, men receive around two thirds of their before tax income and women around three quarters.

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[3]These numbers are the ones used by Jorgenson and Fraumeni (1992b). We do not have any strong priors as to the discount rate (even if 5.44%, if anything, seems high). The income growth rate is rather in line with estimates of Swedish total factor productivity growth over our period.

Table 2 *Lifetime labour income divided into market (mi) and nonmarket (nmi) income from the age of 17. Educational level 10 years. Thousands of 1990 crowns*

	Market income	Market income before tax	Nonmarket income
1967			
Men	2 643.4	4 117.2	4 679.5
Women	1 212.0	1 675.9	5 565.8
1973			
Men	2 581.9	3 874.6	5 039.3
Women	1 551.3	2 094.8	5 457.2
1980			
Men	2 479.3	3 556.0	4 692.5
Women	1 700.9	2 338.6	5 200.1
1990			
Men	2 220.9	3 439.5	4 302.9
Women	1 640.4	2 392.3	4 412.3

The addition to lifetime income due to education is illustrated in two series of tables. *Tables 3.a - 3.d* show the value of extending education from 12 to 13 years for various age/sex-groups and for all the years of our analysis. *Tables 4.a - 4.d* give the same information for those who extended education from 9 to 10 years, i.e. one year more than the compulsory level in Sweden.

The rightmost columns in the tables show by how much lifetime income is raised by an extra year of schooling. For example, the first row in *Table 3.a* shows that 20-year-old men who extended their education from 12 to 13 years in 1967 raised their lifetime income (nonmarket plus market income after tax) from 8330.0 to 8565.2 thousands, or 235.2 thousands 1990 Swedish crowns. Since 72.0% of all 20-year-old men with 12 years of schooling enrolled in further education in 1967, the investment per capita was 170.1 thousands. In interpreting these figures one must keep in mind that nonmarket income is included.

Going through the two series of tables one can see three particularly striking patterns. *First*, both the additions to lifetime income and the investments per capita are much higher in 1967 than in the subsequent years. The reason for this is that the wage-premium to schooling declined markedly around 1970 (see e.g. Edin and Holmlund, 1992). A *second* pronounced result is that both the additions to lifetime income and the investments per capita are higher for women than for men. We believe that this is because of an effect of education on market hours that exists for women but not for men.[4] A *third* interesting result is that the impact of an extra year of schooling is higher for those who only have 9 years of education than for those with 12 years. The reason for this pattern is that our wage-equations imply marginal wage premia that are a declining function of the length of education.

[4] At least we can see in figures 2 and 3 that both employment rates and working hours for women tend to covary positively with educational level.

Table 3 *Investment in education per capita. Educational level 12 years. Thousands of 1990 crowns*

Table 3.a *1967*

Age	Investment per capita	School enrollment rate	Lifetime income e = 13	Lifetime income e = 12
Men				
20	170.1	0.72	8565.2	8330.0
25	247.6	0.35	7772.2	7070.9
30	63.1	0.12	6897.5	6382.5
40	6.9	0.02	6001.5	5581.0
Women				
20	437.2	0.65	8096.4	7421.3
25	167.0	0.22	6337.9	5584.6
30	29.0	0.06	5657.2	5152.2
40	3.1	0.01	4931.5	4503.1

Table 3.b *1973*

Age	Investment per capita	School enrollment rate	Lifetime income e = 13	Lifetime income e = 12
Men				
20	78.7	0.56	7730.5	7589.7
25	120.6	0.30	7509.2	7109.0
30	51.1	0.15	6980.9	6630.7
40	11.8	0.04	6040.3	5746.5
Women				
20	146.0	0.58	7184.8	6932.465
25	132.9	0.33	6702.2	6297.2
30	56.8	0.17	6139.5	5801.5
40	14.2	0.05	5203.3	4927.7

Table 3.c *1980*

Age	Investment per capita	School enrollment rate	Lifetime income e = 13	Lifetime income e = 12
Men				
20	34.3	0.52	7492.4	7426.4
25	42.9	0.26	7496.6	7332.5
30	25.8	0.12	7316.1	7104.3
40	7.9	0.04	6621.2	6400.4
Women				
20	91.9	0.46	7180.8	6980.4
25	88.0	0.30	6863.7	6569.9
30	52.2	0.19	6416.0	6140.8
40	17.4	0.08	5529.7	5318.1

Table 3.d *1990*

Age	Investment per capita	School enrollment rate	Lifetime income e = 13	Lifetime income e = 12
Men				
20	59.8	0.52	6788.0	6672.9
25	49.6	0.22	6576.2	6355.4
30	17.2	0.09	6297.8	6096.6
40	3.0	0.02	5730.1	5551.2
Women				
20	62.6	0.51	6215.2	6093.3
25	57.8	0.31	5951.4	5762.4
30	28.4	0.17	5619.5	5453.2
40	7.8	0.06	4995.7	4867.9

Table 4 *Investment in education per capita. Educational level 9 years. Thousands of 1990 crowns*

Table 4.a *1967*

Age	Investment per capita	School enrollment rate	Lifetime income e=10	Lifetime income e=9
Men				
17	431.1	0.47	8454.7	6937.0
20	285.8	0.29	8565.2	5872.2
25	58.4	0.11	7772.2	5264.8
30	18.5	0.04	6897.5	5022.0
40	3.7	0.01	6001.5	4406.4
Women				
17	619.1	0.44	8209.6	5456.4
20	162.4	0.22	8096.4	4476.9
25	21.2	0.06	6337.9	4175.5
30	5.6	0.02	5657.2	4055.1
40	0.9	0.00	4931.5	3575.0

Table 4.b *1973*

Age	Investment per capita	School enrollment rate	Lifetime income e=10	Lifetime income e=9
Men				
17	167.2	0.62	7621.1	7351.3
20	174.3	0.45	7336.4	6946.4
25	71.5	0.22	6752.5	6429.0
30	28.0	0.10	6350.7	6080.9
40	6.5	0.03	5516.9	5294.9
Women				
17	256.3	0.60	7008.5	6583.1
20	185.5	0.44	6533.7	6115.0
25	74.3	0.23	5954.4	5635.5
30	28.6	0.12	5579.5	5336.8
40	6.3	0.04	4800.3	4634.4

Table 4.c *1980*

Age	Investment per capita	School enrollment rate	Lifetime income e=10	Lifetime income e=9
Men				
17	69.3	0.69	7313.7	7111.4
20	93.1	0.48	7492.4	6966.3
25	55.0	0.21	7496.6	6610.1
30	23.4	0.08	7316.1	6307.1
40	5.4	0.02	6621.2	5595.1
Women				
17	141.7	0.63	7239.6	6514.1
20	123.7	0.49	7180.8	6218.8
25	61.4	0.28	6863.7	5811.7
30	27.4	0.15	6416.0	5502.1
40	7.0	0.05	5529.7	4851.5

Table 4.d *1990*

Age	Investment per capita	School enrollment rate	Lifetime income e = 10	Lifetime income e = 9
Men				
17	119.4	0.71	6654.3	6330.8
20	100.1	0.48	6788.0	6066.1
25	36.7	0.19	6576.2	5736.3
30	13.1	0.06	6297.7	5501.0
40	2.4	0.01	5730.1	4981.6
Women				
17	103.7	0.64	6255.0	5806.7
20	82.4	0.48	6215.2	5580.5
25	39.1	0.26	5951.5	5270.8
30	17.9	0.14	5619.4	5030.6
40	4.9	0.04	4995.5	4530.7

The sensitivity of our results to some of the most basic assumptions is illustrated in *Table 5*.[5]

Table 5 *Sensitivity analysis. Values for a 19 year old individual with 12 years of education.*

Benchmark: 5.44 % discount rate, 10 h maintenance

	Market income		Nonmarket income		Investment per capita	
1967	*Men*	*Women*	*Men*	*Women*	*Men*	*Women*
Benchmark case	2 846 996	1 406 894	5 011 236	6 467 316	34 951	266 242
Without taxes	1.57	1.41	1.50	1.39	1.71	1.53
3 % discount rate	1.79	1.75	1.71	1.78	1.62	1.68
7 % discount rate	0.72	0.73	0.76	0.74	0.76	0.76
8 h maintenance	1.00	1.00	1.22	1.18	1.40	1.18
12 h maintenance	1.00	1.00	0.78	0.82	0.60	0.82
1980						
Benchmark case	2 616 600	1 879 594	4 773 452	5 452 179	26 770	100 433
Without taxes	1.44	1.38	1.40	1.36	1.53	1.55
3 % discount rate	1.65	1.75	1.74	1.78	1.40	1.75
7 % discount rate	0.76	0.74	0.81	0.74	0.62	0.76
8 h maintenance	1.00	1.00	1.22	1.19	1.21	1.15
12 h maintenance	1.00	1.00	0.79	0.81	0.79	0.85

5.2 Aggregate computations

Our final task is to compute aggregate measures of the output of the Swedish education sector that can serve as alternatives to the input-based measures that are conventionally used in the national accounts. For this purpose we apply the per capita measures above (the benchmark case) and aggregate to total numbers by using studying rates from the Level of Living Surveys and population data from Statistics Sweden. In so doing, we compute the total addition to lifetime incomes that is generated by the activity in the Swedish school system; in other words, the output of the Swedish education sector. *Table 6* shows the results, from which we can draw a number of conclusions. *First*, the magnitude of the output is, as expected from the figures above, strongly dependent on whether income from leisure or income taxes are

[5] We present results only for the years 1967 and 1980 which are "extreme"; both in terms of wage differentials and tax rates. Still, the difference is modest between these years in terms of the results of the sensititivity analysis.

included. The output measure that includes the value of leisure and uses pre-tax income for market income is four to five times higher than the post-tax measure excluding the value of leisure. *Second*, the output of the education sector is a substantial fraction of total GDP (See *Table 9)*. Even using the measure that excludes leisure (but is pre income tax), we get numbers that are in the order of 4 - 7 percent of GDP. *Third*, and in our view most important, our new output-based measures differ markedely from the conventional input-based measures.This is very clear from *Table 7*, where both conventional and new measures are displayed. The fact that measures including the value of leisure markedly exceed the input-based ones is hardly surprising. However, we find it striking that our pre-tax measure excluding leisure differs so much from the one in the national accounts. In terms of general magnitude it is, if anything, surprising how closely the levels of the two series match. More importantly, however, the the time paths of the two types of measures are very different. This is especially the case between the years 1980 and 1990. While the input-based measure stays virtually constant over the decade, the output-based measure shows a marked fall over the same period, regardless of which of our measures we look at. The overall sluggish development of the output-based estimates, of course, reflects the decline of the wage premium associated with schooling over the period of study. This decline, however, takes place between 1967 and 1980, whereas our output measures continue to decline also between 1980 and 1990. Estimates in Edin and Holmlund (1992) indicate that the the rate of return to education actually rose over this period. It is a task for future research to clarify why our measures do not reflect this.

Our overall conclusion is that the discrepancies between the conventional measures and the new ones are so large, both in levels and growth rates, that a replacement of the old ones by any of our output-based ones would give rise to quite another picture of the performance of the Swedish economy over the period of study.

Table 6 *The Output of the Swedish Education Sector*

Billions of 1990 SEK

	After income tax						Before income tax		
	Including leisure income			Excluding leisure income					
	Men	*Women*	*Total*	*Men*	*Women*	*Total*	*Men*	*Women*	*Total*
1967	68.09	86.73	154.82	19.33	11.84	31.17	34.98	18.48	53.46
1973	54.43	69.40	123.83	9.53	23.52	33.05	17.63	36.45	54.08
1980	32.55	62.48	95.03	10.43	25.07	35.50	16.09	36.70	52.79
1990	37.46	47.05	84.52	7.30	15.22	22.52	12.83	24.81	37.63

Table 7 *The Output of the Swedish Education Sector according to the National Accounts Statistics and to our Computations*

year	National Accounts	Including leisure income	Excluding leisure income	Before tax, excluding leisure income
67		154820	31170	53460
68				
69				
70	53094			
71				
72				
73		123830	33050	54080
74				
75	58240			
76	59583			
77	60489			
78	61234			
79	63871			
80	66814	95030	35500	52790
81	68169			
82	68975			
83	69207			
84	70149			
85	69744			
86	68002			
87	65079			
88	63237			
89	64526			
90	66042	84520	22520	37630

The importance of human capital as a factor of production also stands out clearly in our calculations, displayed in *Table8.*[6] A comparison with the figures in *Table 9*, where estimates[7] of the stock of machinery and buildings in the Swedish business sector are reproduced, clearly indicate that the even our lowest estimates of the human capital stock (after tax, excluding leisure income) exceed the value of physical production capital by factors of 6 - 10. Time series of the human capital stock is a natural complement to time series of the stock of physical capital in studies of economic growth. To our knowledge, our estimates of the stock of human capital are the first performed using Swedish data.

Table 8 *Human Capital, Including and Excluding Leisure Income Billions of 1990 SEK*

	After income tax						Before income tax		
	Including leisure income			Excluding leisure income					
	Men	*Women*	*Total*	*Men*	*Women*	*Total*	*Men*	*Women*	*Total*
1967	16 928	14 311	31 239	6 456	2 207	8 663	9 876	2 951	12 827
1973	18 914	16 292	35 205	6 790	3 088	9 878	10 336	4 208	14 545
1980	20 330	18 051	38 381	6 560	3 740	10 300	9 423	5 100	14 523
1990	19 600	17 222	36 822	6 294	4 067	10 361	9 800	5 908	15 708

Table 9 *GDP and Capital Stock (Machinery and Buildings) in the Swedish Business Sector. Billions of 1990 SEK*

Year	GNP	Capital Stock
1967	793	783
1973	986	976
1980	1 115	1 191
1990	1 360	1 622

[6] Our estimate of the human capital stock comes as a by-product of our procedure to measure the output of the education sector. The measure is simply the expected lifetime incomes summed over the whole population.

[7] The estimates are due to Bengt Hansson, Bank of Sweden.

A last illustration of the results of our computations is given in *Table 10*, where the share of total investment in GDP is displayed.[8] The table clearly demonstrates both that investment in education is a non-negligible part of total investment in the Swedish economy and that the above mentioned decline in the output of the Swedish education sector between 1980 and 1990 is of such a magnitude that it significantly affects our view of total Swedish capital formation. Finally, we see from *Table 10* that investments in education and housing have been roughly of the same order of magnitude - investment in education being somewhat larger the first three of our four years, housing investment significantly larger in 1990.

Table 10 *Ratio of investments to GDP excluding and including investment in education (%)*

Year	Excluding investments in housing and education	Excluding investments in education	Including investments in education
1967	17,7	23,8	30,5
1973	17,3	22,0	27,5
1980	14,9	19,4	24,1
1990	17,3	22,3	25,1

6. Concluding remarks

In this paper we have demonstrated how an output-based measure of production in the education sector can be derived in a rather straighforward way from a typical micro data base with information on educational levels, schooling- and working hours and

[8]The investment ratio excluding investment in education is the ratio between total fixed capital formation according to the national accounts statistics (in both private and public sectors) and GDP.

wage rates. Our basic result is that output-based measures deviate markedly from the conventional input-based ones and that the difference is so large that the pattern of GDP growth would be significantly affected by replacing the conventional measure by the output-based ones.

Nonetheless, we want to conclude by noting two limitations inherent in our approach. *First*, we do not consider any (positive) externalities that may emerge from education. However, we do not regard this a serious shortcoming of the method *per se*. Rather, it would be a natural extension of the output-based approach to add the value of education that is not individually appropriable to our mesures of output.

Second, the approach that we have followed assumes that the market wage reflects the value of output produced by an employee. In the Swedish setting, this assumption is often questioned; it is commonly argued that the observed compression of the wage structure is due to trade unions striving for "solidaristic" wages rather than to traditional market forces. If the declining wage-premium to schooling during the period of our study has been caused by such non-competitive forces, caution is called for. In defence of our approach, note that we have used wage rates that employers (a majority of which are not in the public sector) have actually been willing to pay during the period of study. It is not obvious how private firms consistently paying their labour in excess of the value would survive. Furthermore, it is not obvious that the "solidaristic" wage policies implemented by blue-collar unions in the sixties and seventies affected wage differentials between educational groups. As a matter of fact, the university graduates are represented by other unions than the blue-collar workers, and it would be the relative power of these unions that could possibly affect the importance of non-competitive educational wage differentials. Moreover, the study by Edin and Holmlund (1992) actually suggests that changes in Swedish educational wage differentials are consistent with an analysis in terms of traditional market forces.

Appendix A. Documentation of the data programme[9]

General information

The data

The data used in this programme is panel data from the Swedish Level of Living Surveys (LNU), which was undertaken on four occasions: 1968, 1974, 1981 and 1991. The number of persons in the survey is roughly 5000, varying slightly between the years.

The raw data are stored in matrices, one for each year, ordered according to age, and with ten columns displaying survey investigation number, age, gender (0/1-variable), school hours, school enrollment (0/1-variable), market hours, employment (0/1-variable), hourly compensation, number of years in education in the survey year and number of years in education the year before. Input matrices with raw data can be generated using *makematrix* (see description below). These will contain a large number of empty cells and therefore can give some weird results if used to calculate education investments. They are available primarily for comparing with the matrices based on estimates.

The programme

To run the full programme, estimating the input variables, use the main procedure *humcap* and then the help routine *results* to access the results.

To run the calculations without making new estimations, use *getinput* to load the necessary input matrices (first enter the file editor and change the year in

[9]The programme has been written by Sofia Ahlroth and is available on floppy disks upon request to her, address: National Institute of Economic Research, Box 3116, S-103 62 Stockholm, Sweden. Regression output is available from Sofia or from Anders Forslund, Department of Economics, Uppsala University, PO Box 513, S-751 20 Uppsala, Sweden.

the file names with a global replace ([F6]) and then run *educinv.old* for the calculations.

The easiest way to obtain the results is to use the command file *getres* in the same way as *getinput* above.

Graphs

There are a number of files for graphic representation of the data. They are named after the matrices depicted: com.gra, empr.gra etc. These are frame files, and it is necessary first to run *getinput* or *getres* and to load necessary data, changing the strings attached to the graphs according to the data. There are also a number of files named comjmf.gra, whrsjmf.gra etc. containing input matrices generated from raw data together with the ordinary input matrices. The "raw" input matrices are available for 1981 (same names as the ordinary ones followed by an "o") and can be generated for the other years using the command file *makematrix*.

Procedures

Humcap

Parameter: year
Output: none
Calls: regrhead, taxmatr, educinv

This is the main procedure that runs all the necessary calculations, once a raw data matrix of the right format is available, starting from estimations of variables based on the panel data, and to the calculations of lifetime incomes and investments in education for the year specified. The data matrix's name should be of the form x|year (ex. x81).
First *regrhead* is called to get the input matrices, after which the average and marginal tax rates can be computed in *taxmatr*. Then the hourly compensation (com) matrices are recalculated to after-tax compensation in 1991 prices. The constants for *educinv* are set. Total time endowment (E) for a year is set to 14 hours a day (24 h less 10 h for maintenance) times 365 days. C is a constant, growth rate/discount rate. The growth rate is set to 1.89 % and the discount rate to 5.44 %. These are sent along with the input matrices to educinv to get

lifetime incomes and investment in education. All the input and output matrices are saved in data files under the names infile|year, outfile|year and nrfile|year.

Regrhead

Parameter: xmatr
Output: comm,comf,whrsm,whrsf,shrsm,shrsf,emprm,emprf,senrm,senrf
Calls: stew,olsrgr,logitrgr

For each input variable (com, whrs, shrs, empr, senr), relevant data is selected from the raw data matrix (xmatr) and purged from missing values. The dependent variable is defined and the new data matrix (xmatrS) is sent into *stew* to form the independent variable. Then, depending on variable, *olsrgr* or *logitrgr* is called, which sends back the input matrices that are then returned from *regrhead* (separate for men and women for each variable).

Stew

Parameter: xmatrS
Output: indep

Constructs the independent variables for the regressions (linear and quadratic combinations of age and education). Returns the variables in a matrix.

Olsrgr

Parameters: dep, indep
Output: matrm, matrf
Calls: gnrmatrO

Takes care of the preparation for input to the GAUSS routine *OLS*, calls *OLS* and then sends the resulting coefficient vector to *gnrmatrO* for generating of the input matrices which it then returns to *regrhead*.

GnrmatrO

Parameter: b
Output: matrm, matrf

Calculates the input matrices from the regression coefficient vector. The matrices are of the form 75x18 (age/education).

Logitrgr

Parameters: dep, indep
Output: matrm, matrf
Calls: gnrmatrL

Does the same as *olsrgr* but for logit estimations of 0/1-variables (senr, empr).

GnrmatrL

Parameter: b
Output: matrm, matrf

Same as *gnrmatrO* but adjusted to logit estimations.

Taxmatr

Parameter: ymim, ymif, year
Output: avtaxm,avtaxf,mtaxm,mtaxf

Loads matrices with tax rates for different income levels, estimated from taxes actually paid each year. The parameters ymim and ymif are matrices with average income for each age and education level for men and women. From these the appropriate tax rates are found and put into matrices with average and marginal tax rates.

Educinv

Parameters: comm, comf, whrsm, whrsf, shrsm, shrsf, emprm, emprf, senrm, senrf, avtaxm, avtaxf, mtaxm, mtaxf, nrofpers, nrofmen, nrofwom, nrofstud, nrstudm, nrstudf, year, E, C
Output: resname, results, nrname, nrmatr
Calls: calc, leis

This is the main programme which calculates market and nonmarket lifetime incomes for different ages and education levels and, given these, calculates investment in education per capita for one year. In all essentials following the algorithm used by Jorgenson-Fraumeni in their investigation of education investments in the US.
Constructs the necessary variables from the input matrices. Loads matrices with survival probabilities, specific for each year. Calls *leis* to calculate total time available to allocate between work and leisure, and *calc* for calculation of lifetime market and nonmarket income (mi, nmi). Given these, it calculates total lifetime income (life) and investment in education per capita for the year, (si), plus some figures to illustrate the results. Puts the results and illustrating figures into matrices which it returns to *humcap*.

Leis

Parameter: shrs, mhrs, E
Output: nmhrs

Calculates nonmarket hours: 24 h less maintenance hours (set to 10) and school hours.

Calc

Parameters: ymi, senr, sr, year, C
Output: zmi

Contains the recursive algorithm for calculating lifetime incomes following Jorgenson-Fraumeni.

Command files

Getres

Output: mim, mif, nmim, nmif, lifem, lifef, si, sim, sif, msim, msif

Loads the files containing results from educinv (outfile and nrfile) into matrices. Writes figures on the average investment per capita and per student, according to gender.

Getinput

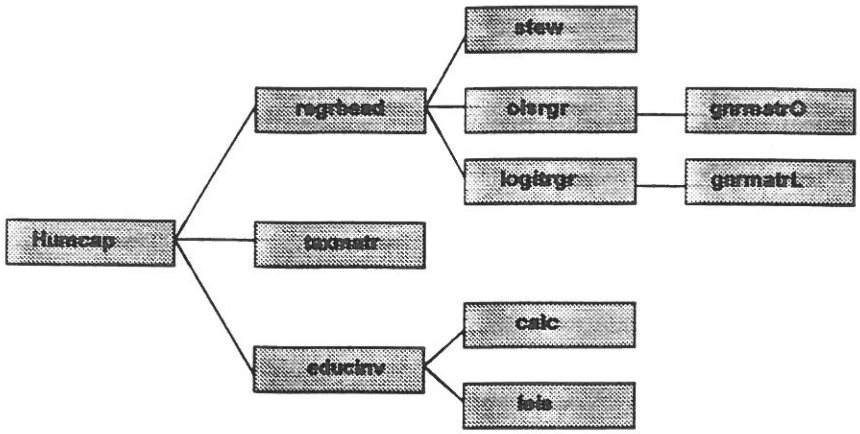
Output: comm, comf, whrsm, whrsf, emprm, emprf, senrm, senrf, shrsm, shrsf, avtaxm, avtaxf, mtaxm, mtaxf, nrofpers, nrofmen, nrofwom, nrofstud, nrstudm, nrstudf

Loads all the matrices necessary to run *educinv* from file (infile and nrfile).

Results

Calls *getres* and *getinput*. Use after running *humcap* to access all the results at once.

Overview of the GAUSS programme for calculating investments in education using survey data



Humcap
Main procedure. Parameter: the year for which to calculate investments in education

regrhead - procedure that handles the making of the input matrices to the calculations that is done in *educinv*.

taxmatr - calculates the average tax and marginal tax matrices on the basis on estimated income (hourly compensation times market hours) and actual taxes paid at different income levels the year in question.

educinv - hosts the recursive algorithm for calculating investments in human capital according to Jorgenson-Fraumeni.

stew - makes the independent variables for the regressions

olsrgr - ordinary least squares regressions.

logitrgr - logit estimations of the 0/1-variables (senr, empr).

calc - where the actual calculations are made

leis - calculates the nonmarket labour time (i.e. leisure time)

gnrmatrO - uses the OLS regression results to generate input matrices.

gnrmatrL - the reciprocal to gnrmatrO for logit estimations.

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Svensk resumé

När man vänder sig till de svenska nationalräkenskaperna för att ta reda på vilket bidrag som landets utbildning givit till bruttonationalprodukten (BNP) ett visst år, så återfinner man utbildning under rubriken "offentlig konsumtion". Om man sedan går vidare och tar reda på hur dessa tal beräknats, finner man att utbildningens bidrag till BNP beräknats genom att kostnaderna för att förmedla undervisningen, dvs i första hand de direkta kostnaderna för lärare, lokaler och undervisningsmaterial, summerats. Däremot beaktas inte den "insatsvara" i undervisningsprocessen som de studerandes egen tid kan sägas utgöra.

Denna redovisningsprincip, som Statistiska Centralbyrån använder, följer helt och hållet de internationella konventioner, som ett stort antal länder kommit överens om att tillämpa. Dessutom är det samma princip som tillämpas för övriga offentliga tjänster, nämligen principen att värdera till produktionskostnaderna. Det förefaller också rimligt att tro att detta tillvägagångssätt har betydande fördelar för viktiga användningar av nationalräkenskaperna. Ett exempel är traditionell konjunkturanalys, där offentlig konsumtion betraktas som en komponent i den totala efterfrågan på varor och tjänster. Summan av inköpen av arbetskraft och material utgör ju sektorns bidrag till den totala efterfrågan i ekonomin.

Men det står också klart att detta traditionella sätt att mäta utbildningens bidrag till landets samlade produktion har betydande brister. För det första ger det ingen information om det värde som utbildningen ger medborgarna. Därför finns ett behov av att kunna göra kompletterande beräkningar av utbildningssektorns bidrag till samhällsekonomin, vilka utgår från dess produktion snarare än dess användning av insatsvaror; eller, för att använda anglicismer, från "output" snarare än "input". För det andra beaktas inte alls att utbildning innebär en investering - en satsning på framtiden - vilket kan leda till en felaktig uppfattning om den samlade kapitalbildningen i ekonomin.

En ansats som tar sikte på att eliminera dessa båda brister har under senare år föreslagits av den amerikanske ekonomen Dale Jorgenson och han har dessutom tillämpat den på data för USA. Grundidén i Jorgensons ansats är att betrakta utbildning just som en investering. Genom att delta i utbildning kan man skaffa sig nya yrkesfärdigheter, vilka i sin tur höjer produktiviteten i framtida arbete. Denna höjda produktivitet kommer att återspeglas i de inkomster som de studerande erhåller i framtiden. Investeringen består därför i det tillskott till framtida inkomster som utbildningen ger upphov till. Eftersom summan av framtida inkomster - diskonterade med en lämplig räntesats - kan ses som ett förmögenhetsvärde bör utbildningsverksamheten värderas efter vilket tillskott den ger till de studerandes samlade förmögenhet, eller till det så kallade humankapitalet.

Inom ramen för Ekonomiska Rådets arbete på Konjunkturinstitutet har författarna till denna uppsats under det senaste året tillämpat Jorgensons ansats på svenska data.

Produktionen i den svenska utbildningssektorn definieras som det tillskott till livsinkomster som skolsytemet ger upphov till. Genom att använda tvärsnittsinformation om löneprofiler, sysselsättningsgrader, arbetstimmar, skoltimmar och fritid (alla relaterade till antal skolår), beräknar vi nya produktionsmått för utbildningssektorn som mäter "output" snarare än "input". Mått som räknas inklusive och exklusive värdet av fritid liksom före och efter skatt redovisas för åren 1967, 1973, 1980 och 1990.

Vår viktigaste slutsats är att de "output-baserade" måtten skiljer sig så markant från traditionella "input-baserade", att man får en ny bild av den svenska ekonomins allmänna utveckling (både avseende tillväxt och, framför allt, kapitalbildning) under den studerade perioden om man ersätter de senare med de förra.

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