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THE OUTPUT OF THE SWEDISH EDUCATION SECTOR

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The output of the Swedish education sector is defined as the addition to lifetime incomes generated by the schooling system. Using cross-sectional information on wages, employment rates, working hours, school-participation and leisure time, all by years of schooling, 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 is measured by the direct costs in the form of teachers' salaries, books, equipment etc. It is a commonplace to recognize 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 education sector: 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 (e.g. 1992a and 1992b) have developed a method to estimate the output of the education sector and have also applied this method on U.S. data. The purpose of this study is to apply their method to Swedish data. The point of departure is to view education as investment in human capital. The output of the education sector, 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

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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. Besides the valuation of market activities, the measure also accounts for changes in the value of time spent outside the labor market (parenting, enjoyment of leisure time etc.).

For a typical individual, 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 lifetime market income. Given the number of hours worked in the labor market and the individual's after-tax hourly wage rate, we can value nonmarket activities on the assumption that an optimizing 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 over all individuals engaged in education and over the changes in market and nonmarket lifetime incomes.

Some limitations of the analysis may be appropriate to mention 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, the approach does not 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. Paul Romer (1990). The externalities arising from this kind of non-rival knowledge play a key role in modern theories of endogenous growth. Third, insofar as schooling *per se* has an important part of consumption to it, this is not reflected in our measures. Finally, we measure formal schooling in calendar years, thus formally equalizing 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 engineers.

In principle, our problem of estimating lifetime incomes is straightforward to solve, given population-wide surveys providing data on educational levels, ages, wage rates, tax rates, working hours, etc. Of course, one also has to make more or less well-informed guesses about real income growth rates and discount rates. In our view the data requirements for an undertaking like this can, however, easily be overstated. Our ambition is to show that a rather typical micro data set for research purposes can do the job. We have chosen to use the Swedish Level of Living Surveys (LNU); a set of surveys of about 6,000 individuals representative of the Swedish population for the years 1968, 1974, 1981 and 1991. As described in more detail below, raw data from these surveys have been used to estimate the key inputs to our measurement, 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 education level e.

Section 2 introduces the variables appearing in the calculations and presents 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 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,
$a = 0, 1, \ldots, 74, 75, 75+$,—age,
$e = 6, 7, \ldots, 18+$,—educational attainment,
com—hourly compensation in the labor market, net of income tax,
empr—employment rate,
life—lifetime labor (market plus nonmarket) income per capita,
whrs—conditional market labor time, the number of working hours, conditional on being employed,
mhrs—market labor time per capita,
mi—lifetime market labor income per capita,
nmhrs—nonmarket labor time per capita,
nmi—lifetime nonmarket labor 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 labor income tax rate in a specified income bracket,
taxam—average marginal labor income tax rate in a specified income bracket,
ymi—annual market income per capita, net of labor income tax,
ynmi—annual nonmarket income per capita,
r—discount rate,
g—projected real income growth rate.

(i) *The Individual's Time Allocation*

We assume that the individual allocates her total available time between four activities: work in the labor 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 however 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* is given by

$$(1) \qquad nmhrs(y, s, a, e) = 14 * 7 * 52 - shrs(y, s, a, e) - mhrs(y, s, a, e).$$

(ii) *Market and Nonmarket Annual Labor Income per capita*

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

$$(2) \qquad ymi(y, s, a, e) = mhrs(y, s, a, e) * com(y, s, a, e).$$

Nonmarket labor income is derived on the assumption that an optimizing 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 labor income is given by

$$(3) \qquad \begin{aligned} ynmi(y, s, a, e) = {} & nmhrs(y, s, a, e) * com(y, s, a, e) * \\ & \times (1\text{-}taxam(y, ymi))/(1 - tax(y, ymi)). \end{aligned}$$

(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 labor 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 (*mi*)

$$(4) \qquad \begin{aligned} mi(y, s, a, e) = {} & ymi(y, s, a, e) \\ & + (\mathrm{senr}(y, s, a, e) * sr(y, s, a+1) * mi(y, s, a+1, e+1) \\ & + (1 - senr(y, s, a, e)) * sr(y, s, a+1) \\ & \times * mi(y, s, a+1, e)) * (1+g)/(1+r). \end{aligned}$$

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):

$$
\begin{aligned}
nmi(y, s, a, e) = {} & ynmi(y, s, a, e) \\
& + (senr(y, s, a, e) * sr(y, s, a+1) * nmi(y, s, a+1, e+1) \\
& + (1 - \mathrm{senr}(\mathrm{y, s, a, e}) * sr(y, s, a+1) \\
& \times * nmi(y, s, a+1, e)) * (1+g)/(1+r).
\end{aligned} \tag{5}
$$

Total lifetime income ($life$) is given by

$$life(y, s, a, e) = mi(y, s, a, e) + nmi(y, s, a, e). \tag{6}$$

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

$$si(y, s, a, e) = senr(y, s, a, e) * (life(y, s, a, e+1) - life(y, s, a, e)). \tag{7}$$

3. The Data

Our basic data set comes from the Swedish Level of Living Surveys (see Robert Erikson and Rune Åberg, 1987). These surveys were carried out in 1968, 1974, 1981 and 1991 and consist of personal interviews with around 6,000 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 hour, by piece-rate, by week, by month or by some other scheme. Then the respondent reports the actual level of compensation per period; those paid by piece-rate or "other scheme" report monthly earnings. The hourly wage rate is computed by means of the information on normal working hours per week.

The wage variable is only available for employed persons, which means that we will apply the wage-age-schooling structure for employed persons to self-employed persons too. According to available information, this procedure is not likely to create any considerable bias.[1]

Another section of the questionnaire asks questions about the labor 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 labor market income by multiplying the hourly wage rate and annual working hours, it is important to note the exact definitions of these variables.

[1]Anders Björklund and Christian Kjellström (1994) 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.

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

TABLE 1

SAMPLE CHARACTERISTICS: MEANS AND STANDARD DEVIATIONS (within parentheses)

	1967	1973	1980	1990
Log hourly wages				
Men	4.15	4.39	4.42	4.44
	(0.42)	(0.32)	(0.32)	(0.31)
	(#1,777)	(#1,699)	(#1,754)	(#1,650)
Women	3.83	4.12	4.23	4.24
	(0.43)	(0.35)	(0.28)	(0.24)
	(#1,123)	(#1,303)	(#1,587)	(#1,650)
Employment rate (*empr*)				
Men	0.87	0.85	0.84	0.83
	(#2,710)	(#2,636)	(#2,686)	(#2,620)
Women	0.58	0.65	0.72	0.75
	(#2,676)	(#2,645)	(#2,660)	(#2,581)
Annual working hours (*whrs*)				
Men	2,132.35	1,992.03	1,943.47	1,953.68
	(714.70)	(687.47)	(709.60)	(719.43)
	(#2,374)	(#2,233)	(#2,251)	(#2,183)
Women	1,406.01	1,370.25	1,432.34	1,619.76
	(811.83)	745.33	(673.28)	(638.02)
	(#1,563)	(#1,730)	(#1,921)	(#1,939)
School enrollment rate (*senr*)				
Men				
	0.10	0.12	0.12	0.12
	(#2,710)	(#2,636)	(#2,686)	(#2,620)
Women	0.07	0.11	0.13	0.14
	(#2,676)	(#2,645)	(#2,660)	(#2,581)
Conditional school hours (*shrs*)				
Men	1,367.04	1,210.96	1,041.67	1,200.35
	(787.55)	(694.89)	(695.64)	(697.85)
	(#264)	(#321)	(#337)	(#325)
Women	1,325.13	1,336.65	974.21	1,116.50
	(808.10)	(792.28)	(670.05)	(690.54)
	(#195)	(#281)	(#345)	(#369)
Years of education (*e*)				
Men	8.44	9.34	10.12	11.05
	(2.88)	(3.29)	(3.66)	(3.52)
	(#2,710)	(#2,636)	(#2,686)	(#2,620)
Women	8.18	8.88	9.61	10.70
	(2.56)	(2.88)	(3.23)	(3.26)
	(#2,676)	(#2,645)	(#2,660)	(#2,581)

Notes: 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. # = number of observations.

natural to exclude the payroll taxes for sickness pay and the employers costs for vacation pay from the hourly wage rate.[2]

Table 1 reports sample statistics for the variables picked from the Level of Living Surveys. The information in the table describes the marked changes in the Swedish labor 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.

4. Filling in the Blanks—From Raw Data to Input Matrices

As we distinguish between 18 different levels of education for what in practice amounts to 61 age groups and two sexes, we have a need for observations on 2,196 groups per year. The sample size in the Level of Living Surveys is in the order of magnitude of 6,000. 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 different elements in our matrices conditional on sex, age and level of education.[3]

The hourly compensation in the labor market is derived by regressing the logarithm of hourly wage rates for the sub-sample with observed positive wage rates on a, a squared, e, e squared, ae, ae squared, and a dummy for sex (both for intercept and slopes). The regression equation then is used to predict the hourly compensation levels for all combinations of age and educational levels for both sexes. This procedure might look straightforward, but two assumptions implicit in both our and Jorgenson's and Fraumeni's approach should be noted. First, we use wage equations that have been run on all workers to compute the value of nonmarket time for non-workers. This procedure might involve well-known sample selection effects which could be eliminated by estimating an extended model that includes a probit equation for the probability of being a worker (Heckman, 1979). However, because there is as yet no consensus in the literature how such an equation should be specified we have not made any attempts to control for such potential selection bias.[4] Second, we use the after-tax hourly

[2]We note though that we have not made any attempts to include the value of additional pension rights in our wage measure. This simplifying assumption of ours is not contradicted by the study of Jan Selén and Ann-Charlotte Ståhlberg (1991) in which a measure of the "total" wage that includes the value of additional pensions is compared with the traditional wage that we use. They run log wage equations on the Level of Living Surveys' data from 1968, 1974 and 1981. The impact of schooling is captured by two variables, years of schooling and "educational requirement" in the job. For 1968 their estimated coefficients of these two variables are 0.035 and 0.081 for the total wage, and 0.035 and 0.080 for the traditional money wage; for 1974 they get the coefficients 0.019 and 0.064 for the total wage, and 0.019 and 0.063 for the money wage; for 1981 they get 0.014 and 0.054 for the total wage, and 0.016 and 0.051 for the money wage. Indeed, these differences are small so we are confident that our estimates of additions to lifetime income are not affected.

[3]In our background working paper (Ahlroth, Björklund, and Forslund, 1994), we present both the estimated coefficients of these equations and display age profiles of the central variables for various educational groups.

[4]Further, a previous attempt to control for selection bias in wage equations run on the same data set suggests that wage equations are not sensitive to the Heckman correction procedure (Palme and Wright, 1992). In passing we also note that our wage equations—as well as the numbers used by Jorgenson and Fraumeni—also might suffer from omitted-variable bias (or "ability-bias"). Since there is no consensus in the literature about the magnitude of and proper treatment of this problem, we have made no attempt to solve it.

compensation to value leisure time for both workers and non-workers. For the latter group, the potential wage will underestimate their value of leisure time because non-participation represents a corner solution of their labor supply decision.[5] Only by estimating and applying a structural model of labor supply, it would be possible to improve the valuation of leisure time for non-workers.

We estimate conditional labor market time, *whrs*, and conditional school hours, *cshrs*, by means of the same type of equations as the hourly compensation. 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 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 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 percent, the projected income growth rate 1.89 percent, and 10 hours a day for maintenance.[6] 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 marked discrepancy between market income before and after taxes. In general, men receive around two thirds of their before tax income and women around three quarters.

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 columns to the right in the tables show how much lifetime income is raised by an extra year of schooling. For example, 20-year-old men who extended their education from 12 to 13 years in 1967 raised their lifetime income (nonmarket

[5]Like Jorgenson and Fraumeni, we abstract from involuntary unemployment. For Sweden in the years that we consider, this is not a very strong assumption.

[6]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 percent, 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

LIFE-TIME LABOR INCOME DIVIDED INTO MARKET (*mi*) AND NONMARKET (*nmi*) INCOME FROM THE AGE OF 17. EDUCATIONAL LEVEL 10 YEARS. THOUSANDS OF 1990 CROWNS

	Market Income After Tax	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

plus market income after tax) from 8015.2 to 8167.2 thousands, or 152.0 thousands 1990 crowns. Since 72.0 percent of all 20-year-old men with 12 years of schooling enrolled in further education in 1967, the investment per capita was 109.9 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 from 1967 to 1973. We have checked this explanation by recalculating both these variables using the wage equation of 1967 for all subsequent years. We found a completely different pattern with basically rising numbers until 1980 and only a small decline from 1980 to 1990. The decline in the wage premium is clearly documented in our working paper and further analyzed by e.g. Per-Anders Edin and Bertil Holmlund (1995).

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 our estimated equations for working hours and the employment rate imply quite large labor supply effects of education for women but not for men.

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.

The sensitivity of our results to some of the most basic assumptions is illustrated in Table 5.[7]

[7]We have not reproduced calculations for all four years. We chose 1967 and 1980 as "extreme" years, both in terms of wage differentials and tax rates. Still, the difference between the years in terms of the results of the sensitivity analysis is modest.

TABLE 3

INVESTMENT IN EDUCATION PER CAPITA.
EDUCATIONAL LEVEL 12 YEARS. THOUSANDS OF 1990 CROWNS

Age	Investment Per Capita	Sch. Enrollment Rate	Lifetime Income $e=13$	Lifetime Income $e=12$
(a) 1967				
Men				
20	109.9	0.72	8,167.2	8,015.2
25	237.3	0.35	7,685.1	7,012.9
30	62.5	0.12	6,881.9	6,371.5
40	6.9	0.02	6,001.2	5,580.8
Women				
20	379.7	0.65	7,812.3	7,226.0
25	163.4	0.22	6,299.4	5,562.4
30	28.9	0.06	5,651.3	5,148.6
40	3.1	0.01	4,931.5	4,503.1
(b) 1973				
Men				
20	78.7	0.56	7,730.5	7,589.7
25	120.6	0.30	7,509.2	7,109.0
30	51.1	0.15	6,980.9	6,630.7
40	11.8	0.04	6,040.3	5,746.5
Women				
20	146.0	0.58	7,184.8	6,932.5
25	132.9	0.33	6,702.2	6,297.2
30	56.8	0.17	,139.5	5,801.5
40	14.2	0.05	5,203.3	4,927.7
(c) 1980				
Men				
20	33.5	0.52	7,533.6	7,469.2
25	41.5	0.26	7,531.9	7,373.3
30	25.4	0.12	7,349.4	7,141.6
40	7.8	0.04	6,638.3	6,422.9
Women				
20	93.2	0.46	7,195.0	6,991.7
25	87.7	0.30	6,869.0	6,576.5
30	51.5	0.19	6,415.2	6,143.4
40	16.6	0.08	5,517.2	5,316.0
(d) 1990				
Men				
20	59.8	0.52	6,788.0	6,672.9
25	49.6	0.22	6,576.2	6,355.4
30	17.2	0.09	6,297.8	6,096.6
40	3.0	0.02	5,730.1	5,551.2
Women				
20	62.6	0.51	6,215.2	6,093.3
25	57.8	0.31	5,951.4	5,762.4
30	28.4	0.17	5,619.5	5,453.2
40	7.8	0.06	4,995.7	4,867.9

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

TABLE 4

INVESTMENT IN EDUCATION PER CAPITA. EDUCATIONAL LEVEL 9 YEARS. THOUSANDS OF 1990 CROWNS

Age	Investment Per Capita	Sch. Enrollment Rate	Lifetime Income $e=10$	Lifetime Income $e=9$
(a) 1967				
Men				
17	431.1	0.47	8,454.7	6,937.0
20	285.8	0.29	8,565.2	5,872.2
25	58.4	0.11	7,772.2	5,264.8
30	18.5	0.04	6,897.5	5,022.0
40	3.7	0.01	6,001.5	4,406.4
Women				
17	619.1	0.44	8,209.6	5,456.4
20	162.4	0.22	8,096.4	4,476.9
25	21.2	0.06	6,337.9	4,175.5
30	5.6	0.02	5,657.2	4,055.1
40	0.9	0.00	4,931.5	3,575.0
(h) 1973				
Men				
17	167.2	0.62	7,621.1	7,351.3
20	174.3	0.45	7,336.4	6,946.4
25	71.5	0.22	6,752.5	6,429.0
30	28.0	0.10	6,350.7	6,080.9
40	6.5	0.03	5,516.9	5,294.9
Women				
17	256.3	0.60	7,008.5	6,583.1
20	185.5	0.44	6,533.7	6,115.0
25	74.3	0.23	5,954.4	5,635.5
30	28.6	0.12	5,579.5	5,336.8
40	6.3	0.04	4,800.3	4,634.4
(c) 1980				
Men				
17	69.3	0.69	7,313.7	7,111.4
20	93.1	0.48	7,492.4	6,966.3
25	55.0	0.21	7,496.6	6,610.1
30	23.4	0.08	7,316.1	6,307.1
40	5.4	0.02	6,621.2	5,595.1
Women				
17	141.7	0.63	7,239.6	6,514.1
20	123.7	0.49	7,180.8	6,218.8
25	61.4	0.28	6,863.7	5,811.7
30	27.4	0.15	6,416.0	5,502.1
40	7.0	0.05	5,529.7	4,851.5
(d) 1990				
Men				
17	119.4	0.71	6,654.3	6,330.8
20	100.1	0.48	6,788.0	6,066.1
25	36.7	0.19	6,576.2	5,736.3
30	13.1	0.06	6,297.7	5,501.0
40	2.4	0.01	5,730.1	4,981.6
Women				
17	103.7	0.64	6,255.0	5,806.7
20	82.4	0.48	6,215.2	5,580.5
25	39.1	0.26	5,951.5	5,270.8
30	17.9	0.14	5,619.4	5,030.6
40	4.9	0.04	4,995.5	4,530.7

TABLE 5

SENSITIVITY ANALYSIS. VALUES FOR A 19 YEAR OLD INDIVIDUAL WITH 12 YEARS OF EDUCATION

Benchmark: 5.44 percent Discount Rate, 10 hours Maintenance

	Market Income		Nonmarket Income		Investment per capita	
	Men	Women	Men	Women	Men	Women
1967						
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

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 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 significant fraction of total GDP. 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 (Table 9 presents GDP figures in 1990 prices).

Third, and in our view most important, our new output-based measures differ markedly from the conventional input-based measures, compare with Table 7. 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, the evolution over time diverges between the two types of measures. This is especially the case between the years 1980 and 1990. Whereas 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 measures we look at. The overall sluggish development of

TABLE 6

THE OUTPUT OF THE SWEDISH EDUCATION SECTOR. BILLIONS OF 1990 CROWNS

	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

Note: For Swedish GDP in these years, see Table 9.

the output-based estimates, of course, reflects the decline of the wage premium associated with schooling over the period we study. This decline, however, takes place between 1967 and 1980, whereas our output measures also continue to decline between 1980 and 1990. Estimates in Edin and Holmlund (1995) indicate that 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 observation is that the discrepancies between the conventional measures and our 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 7

THE OUTPUT OF THE SWEDISH EDUCATION SECTOR ACCORDING TO THE NATIONAL ACCOUNTS AND TO OUR COMPUTATIONS. BILLIONS OF 1990 CROWNS

Year	National Accounts	Including Leisure Income	Excluding Leisure Income	Before Tax, Excl. Leisure Income
1967		154.82	31.17	53.46
1970	53.09			
1973		123.83	33.05	54.08
1975	58.24			
1976	59.58			
1977	60.49			
1978	61.23			
1979	63.87			
1980	66.81	95.03	35.50	52.79
1981	68.17			
1982	68.98			
1983	69.21			
1984	70.15			
1985	69.74			
1986	68.00			
1987	65.08			
1988	63.24			
1989	64.53			
1990	66.04	84.52	22.52	37.63

TABLE 8

HUMAN CAPITAL, INCLUDING AND EXCLUDING LEISURE INCOME. BILLIONS OF 1990 CROWNS

	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

The importance of human capital as a factor of production also stands out clearly in our calculations, displayed in Table 8.[8] A comparison with the figures in Table 9, where estimates of the stock of machinery and buildings in the Swedish business sector are reproduced, clearly indicates that 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.[9] 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 on Swedish data.

A last illustration of the results of our computations is given in Table 10, where the share of total investment in GDP is displayed.[10] 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, for some sense of the magnitudes, we see from the table that investment in education and housing investment roughly have been in the same order of

TABLE 9

GDP AND CAPITAL STOCK (MACHINERY AND BUILDINGS) IN THE BUSINESS SECTOR. BILLIONS OF 1990 CROWNS

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

[8]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.

[9]The estimates of the stock of machinery and buildings are from Bengt Hansson who has updated the numbers from his dissertation (Hansson, 1991).

[10]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. The figures for investment in education refer to calculations before tax excluding leisure income.

TABLE 10

RATIO OF INVESTMENTS TO GDP EXCLUDING AND INCLUDING INVESTMENT IN EDUCATION (%)

Year	Excl. Investments in Housing and Education	Excl. Investments in Education	Incl. 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

magnitude—investment in education being somewhat larger the first three of our four years, housing investment significantly larger in 1990.

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 straight-forward way from a typical micro data base with information on educational levels, schooling, working hours and wage rates. Our basic result is that output-based measures diverge markedly from the conventional input-based ones, and that the divergence is so large that the pattern of GDP growth would be significantly affected by replacing the conventional measure by the output-based ones.

Our choice to use estimated equations to predict hourly compensation, working hours and school enrollment rates for each combination of age, sex, and educational level was governed by the need to "smooth the data" and obtain reasonably reliable numbers for combinations of age, sex, and education with few observations. We are convinced, though, that future work to improve output-based measures of education in many ways would benefit from the use of rich micro data bases. We have emphasized that the well-known problems of selection and omitted-variable bias in estimating the returns to schooling also plague our (as well as Jorgenson's and Fraumeni's) output-based measures. Further, the valuation of leisure time for non-workers would be improved by the use of a structural model of labor supply. To "solve" these classical problems in labor economics is, indeed, no trivial task, but we are confident that a necessary condition for progress is the availability of a micro data base with rich information about the individual and the household to which she belongs.

Nonetheless, we want to conclude by noting two limitations inherent in our approach. First, we do not take account of any (positive) externalities possibly connected with education. However, we do not consider 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 measures 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 in the 1970s 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 we can first observe 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 labor in excess of their 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 possibly could affect the educational wage differentials. Moreover, the study by Edin and Holmlund (1995) actually suggests that changes in Swedish educational wage differentials are consistent with an explanation in terms of traditional market forces.

The changes in the wage premia for education also highlight another property of output-based measures of the education sector. The relatively high returns to schooling in 1967 contribute to high output estimates in the same year because the contemporary wage structure suggests a high expected contribution to lifetime income of education. However, a couple of years later the realized return of the education that took place in this year turned out to be much lower. As illustrated by our results, output based measures of the education sector are very sensitive to changes in the wage structure and one can expect large discrepancies between the expected contributions to lifetime incomes and the realized contributions.

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