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Tertiary Education, Productivity and Economic Growth: Evidence from Sweden

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Abstract

Over the last few decades, the capacity for higher education in Sweden has expanded dramatically, in terms of both the number of students and the number of institutions for higher (tertiary) education. We use a simple growth accounting approach to estimate how much tertiary education contributed to Swedish economic growth over the 2001-2010 period. We use a large sample of Swedish firms, including information on employees, to estimate the production functions, covering more than half a million firm-year observations. We differentiate labor input based on educational attainment and whether or not the individual has had some form of tertiary education. From this, we compute the components of economic growth. We find that approximately 50% of the growth in gross value added during the period can be attributed to the growth in higher education, approximately one quarter to the growth in capital and another quarter to the growth in total factor productivity. Furthermore, based on estimations of the technical rate of substitution with respect to education, we find that individuals with a tertiary education and working in the private sector are, on average, 2-3 times as productive as individuals with less education. Our results have implications for education and for labor market policies in Sweden.

JEL-codes: D24, I21, I25, I26, J24

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Introduction

From the early 1990s and onwards, Sweden—like most member countries of the OECD—has increased both the number and the capacity of institutions for higher education (HEI). As a consequence, the share of the population (workforce) with a tertiary education has more than doubled in the last two decades. Today, more than 40% of the working population has obtained a tertiary education. This quantitative expansion of tertiary education in Sweden has been justified by a perceived need to prepare the labor force for the "knowledge society" and an expected shift in demand towards production that is more intense in use of human capital. Much of this expansion has been geared towards the public sector, something that has been criticized for generating a human capital shortage in Swedish firms[1]. As a result, the average educational attainment in the private sector is significantly lower than in the public sector (approximately 25% today), while vacancy rates are high.

There is substantial literature on the link between education and growth. On the one hand, we have studies going back to the seminal contributions by Becker (1964) and Mincer (1958) that examine the effects of education on human capital and the private returns to education. Microeconometric studies suggest a causal link between education and both aggregate and individual incomes. Earlier macro studies, on the other hand, have found that an increase in educational attainment has no effect on economic growth

[1] Sweden offers an interesting case study, as it is a country with a fully subsidized system of higher education coupled with one of the lowest private returns on education within the OECD (see Hanushek et al. (2015) and Psacharopoulos and Patrinos, (2004) and Eklund and Pettersson, 2017).

(for a review see Krueger and Lindahl (2001). In a more recent study, Gennaioli et al. (2013) find that human capital and education are key factors in economic development. Gennaioli et al. conduct an extensive empirical analysis of 1569 regions across the world, covering approximately 97% of global GDP.

In this note, we analyze the extent to which the expansion of tertiary education has contributed to productivity and economic growth in Sweden. We use a large sample of 50 000–60 000 Swedish firms covering the 2001-2010 period and 85% of the value added. During this period, GDP grew annually by 2.2%, and GDP generated by the private sector grew by close to 2.7% per year, which corresponds to a total growth of 30 percent over the 2001–2010 period. The data include information on the educational attainment of employees, investments and the capital stock of firms. Using these data, we estimate the production function and apply a growth accounting approach to estimate how important the growth of tertiary education is for economic growth. We also estimate the difference in marginal productivity between individuals with and without a tertiary education, assuming that tertiary education reflects a difference in human capital.

We find that approximately 50% of the growth of value added that was generated by firms can be attributed to a rapidly raising share of employees with tertiary educations. Total factor productivity and capital investment each accounted for approximately one quarter of the growth of value added. Despite strong employment growth, individuals with less than a tertiary education only made a marginal contribution. We also find that, on average, individuals with a tertiary education had an average marginal productivity 2-3 times higher than employees lacking tertiary educations.

Growth and productivity

We use a simple production function with the following components: value added (Y_t), labor with higher education (tertiary education) (L_t), labor lacking higher education (H_t), capital (K_t), and total factor productivity (A_t) (see, e.g., Hansen and Griliches, 1970). We use the following Cobb-Douglas production function:

$$Y_t = A_t K_t^{\beta_K} {L_t}^{\beta_L} H_t^{\beta_H} \qquad 1)$$

where $\beta_K + \beta_L + \beta_H = 1$. By taking the logarithm of equation 1), we obtain:

$$lnY_t = lnA_t + \beta_K lnK_t + \beta_L lnL_t + \beta_H lnH_t \qquad 2)$$

which can be empirically estimated. Further, by subtracting lnY_{t-1} from lnY_t, and through necessary substitution, we can derive the Solow growth accounting equation:

$$\frac{\Delta A_t}{A_{t-1}} = \frac{\Delta Y_t}{Y_{t-1}} - \beta_K \frac{\Delta K_t}{K_{t-1}} - \beta_L \frac{\Delta L_t}{L_{t-1}} - \beta_H \frac{\Delta H_t}{H_{t-1}} \qquad 3)$$

where growth in total factor productivity is obtained as a residual.

First, we estimate equation 2. Next, we use these estimates to compute factor shares following equitation 3. We also use the information obtained from the estimation to compute the marginal rate of technical substitution (MRTS) between our two education categories. This provides us with information on the marginal rate at which an individual with a tertiary education can be substituted with an individual without a tertiary education, thus providing information on how much more productive individuals with a tertiary education are on average compared to individuals with no more than a secondary education.[2]

Data and estimations

We use data from statistics from Sweden that covers all firms and their employees for the period 2001 to 2010. Sweden had, in any given year, about one million firms. However, the majority of these firms were either inactive or had no employees; therefore, we exclude them in this study. We utilize information on the capital stock (total assets plus investments during year t), number and education of employees, and value added. We measure output as value added. Under these constraints, our sample includes 50 000-60 000 firms each year.

Table 1 below shows the estimations of a Cobb-Douglas production function estimated with the stochastic frontier model that we employ since the residuals reveal a skewed distribution. Furthermore, we chose to perform repeated cross-sectional estimations[3].

[2] The marginal rate of technical substitution (MRST) is defined as:

$$\frac{\partial X_i}{\partial X_j} = \frac{\partial f(X_1.X_2.\dots.X_k)/\partial X_i}{\partial f(X_1.X_2.\dots.X_k)/\partial X_j} = MRTS_{ij}$$

where X_i and X_j are production factor *i* and *j*, respectively, which is simply the quote between the marginal productivity of production factor *i* over the marginal productivity of production factor *j*.

[3] Small micro firms with only one or a few employees are dropped. Our estimation requires that each firm has at least one employee in each category. In terms of value added, our sample corresponds to approximately 85% of the private sector value added.

Table 1 Production functions

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Labor without tertiary (β_L)	0.510* (0.022)	0.516* (0.019)	0.517* (0.019)	0.512* (0.022)	0.511* (0.020)	0.500* (0.023)	0.504* (0.021)	0.499* (0.021)	0.503* (0.022)	0.510* (0.022)
Labor with tertiary education (β_H)	0.324* (0.021)	0.328* (0.019)	0.334* (0.020)	0.334* (0.021)	0.342* (0.021)	0.355* (0.025)	0.362* (0.024)	0.374* (0.024)	0.378* (0.023)	0.380* (0.024)
Capital (β_K)	0.166* (0.003)	0.156* (0.002)	0.150* (0.002)	0.155* (0.003)	0.147* (0.002)	0.145* (0.002)	0.134* (0.003)	0.126* (0.003)	0.119* (0.002)	0.111* (0.003)
σ_u^2	0.380	0.378	0.402	0.414	0.410	0.419	0.416	0.418	0.424	0.413
σ_v^2	0.430	0.418	0.463	0.429	0.440	0.445	0.458	0.456	0.458	0.456
γ	0.884	0.905	0.868	0.964	0.933	0.943	0.907	0.918	0.926	0.906
N	49622	51898	52730	56487	58322	60359	61959	61530	59883	62691
Restrictions: $\beta_L + \beta_H + \beta_K = 1$	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

The stochastic frontier model allows firms to be inefficient and operate below the efficient production front.[4] The stochastic frontier model is appropriate and allows firms to be inefficient and operate below the production front. The inefficiency term is assumed to follow an exponential distribution. All coefficients are statistically significant at one percent. Clustered standard errors are in brackets. Industry dummies (3 digit level) have been used.

To simplify the growth accounting computations, we assume Cobb-Douglas technology. Additional results – including translog estimations - are available from the authors upon request.

How much did higher education contribute to economic growth?

Between 2001 and 2010, the Swedish economy grew an average of 2.2% per annum. The corresponding figure for the private sector alone was close to 2.7%. In other words, over

[4] The difference between a regular OLS estimation of a Cobb-Douglas is that the stochastic frontier estimation includes two stochastic error terms. Jointly, these two error terms produce a stochastic variable with a skewed distribution. See Aigner m fl (1977) and Kneller and Stevens (2003).

the whole period, total factor income growth amounted to 30%. Total employment growth in the private sector was close to 12%, corresponding to a 1.4% annual employment growth.

All factor inputs grew: The number of individuals with higher education grew by 52% overall, and the capital stock grew by 40% overall, corresponding to 4.3 and 3.4% annual growth, respectively. By comparison, the number of employees with no higher education grew by a meager three percent over the entire period, which is less than 0.3% per annum. In other words, the share of employees with higher education has been growing rapidly, albeit from a low initial level. In 2010, approximately 22% of the employees in the private sector had some form of higher education, which was an increase from approximately 16 percent in 2001. In table 2, the growth in value added and factor inputs are reported.

Table 2 Growth in value added and factor inputs

	Growth in value added (private contribution to GDP)	**Capital**	**Labor with no tertiary edu.**	**Labor with tertiary edu.**
Total growth 2001-2010	0.300	0.521	0.029	0.400
Annual growth (Geometric mean)	0.027	0.043	0.003	0.034

Numbers are based on the full population of firms.

The contribution to growth in GDP from each factor of production is reported in table 3 for the period 2000-2010. Our calculations are based on the results from table 1. Almost half (46.8%) of the contribution to growth in GDP is attributed to growth in labor with tertiary education.

Table 3. Contributions to growth in gross value added

	Capital	Labor with no tertiary edu.	Labor with tertiary edu.	TFP	Total
Contribution to growth	0.073	0.015	0.141	0.072	0.300
Share of growth	24.4%	5.0%	46.8%	23.8%	100%
(Contribution to growth. Geometric mean)	1.007	1.002	1.013	1.007	1.027

Tur estimates of the output coefficients have been used to decompose the economic growth (equation 3) and compute the marginal rate of technical substitution (MRTS). See appendix for details. The MRTS reported in table 4 shows the magnitude by which one unit of labor with tertiary education is reduced by extra units of labor without tertiary education so that output remains constant.

Table 4. Marginal rate of technical substitution, labor with and without tertiary education

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
MRTS	2.86*	2.78	2.69	2.53	2.48	2.51	2.45	2.47	2.37	2.28

The calculations are based on the output elasticities from table 2 above. * $MRTS_{HL} = \left(\frac{\varepsilon_H}{\varepsilon_L}\right)\left(\frac{\bar{L}}{\bar{H}}\right)$.

Numbers in table 4 have a straight forward interpretation: Individuals with tertiary education were, on average 2.3-2.9, times more productive than individuals without higher education. MRTS declined somewhat over time. The results are robust with respect to model specification, and all are in the range of 2-3, which must be considered a significant difference in marginal productivity.[5]

5. Conclusions

Over the past few decades Sweden has—like most other OECD member countries—expanded higher education in terms of both the number of institutions for higher education and the number of students. As a consequence, the share of the Swedish labor force with some form of tertiary education has increased dramatically. The share of individuals in the labor force with tertiary education increased from 20 percent to more than 40 percent between 1990 and 2010.

We use a simple growth accounting approach to decompose Swedish economic growth from 2001–2010. Over this ten-year period, the Swedish economy grew by approximately 30%, or 2.2% per annum. Private gross value added grew slightly faster at approximately 2.7% per year. We find that the single most important factor was the growing number of employees with tertiary educations. This means that a small group of highly educated and highly productive individuals have driven a significant part of the growth in the private gross value added. The marginal productivity of labor with a tertiary education was, on average, 2-3 times that of labor that lacked a tertiary education.

[5] For stochastic frontier estimates without restrictions MRTS is 2.28-3.29. For OLS estimates, we get somewhat higher MRTS estimates (2.95-3.41). For larger firms with a higher share of employees with a tertiary education, the MRTS appears to fall somewhat.

When interpreting the results, it is important to note that, somewhat paradoxically, labor market matching deteriorated over the period we study. This suggests that there are significant productivity gains to be made if this education-employment mismatch can be reduced. It should also be noted that share of highly educated individuals is significantly lower in the private sector than in the public sector. By 2010 the share of employees in the private sector was just above 20%.

Our results also open up an avenue of interesting research questions: Do our results imply, for example, that most new jobs will require higher education attainment, or are the results an artifact of a compressed wage structure and high minimum wages?

Appendix 2. Growth accounting

Output and production factors						Growth				SFM Output elasticities (β-values)			SFM
År	Y (kkr)	K	L	H	L+H	dY_t/Y_{t-1}	dK_t/K_{t-1}	dL_t/L_{t-1}	dH_t/H_{t-1}	K	L	H	TFP
2001	916418541	2410681700	1220143	397471	1617614					0.166	0.51	0.324	
2002	910640225	2377315264	1255464	403964	1659428	-0.0063	-0.0138	0.0289	0.0163	0.156	0.516	0.328	-0.024
2003	947261433	2477442349	1232271	421497	1653768	0.0402	0.0421	-0.0185	0.0434	0.15	0.517	0.334	0.029
2004	983895873	2752317734	1245218	447727	1692945	0.0387	0.1110	0.0105	0.0622	0.155	0.512	0.334	-0.005
2005	1052117585	2933014027	1256837	469837	1726674	0.0693	0.0657	0.0093	0.0494	0.147	0.511	0.342	0.038
2006	1109150446	3033858906	1296552	500926	1797478	0.0542	0.0344	0.0316	0.0662	0.145	0.5	0.355	0.010
2007	1175287139	3097984887	1311957	528401	1840358	0.0596	0.0211	0.0119	0.0548	0.134	0.504	0.362	0.031
2008	1169597821	3393999438	1310135	540846	1850981	-0.0048	0.0956	-0.0014	0.0236	0.126	0.499	0.374	-0.025
2009	1103503520	3691520933	1204368	520592	1724960	-0.0565	0.0877	-0.0807	-0.0374	0.119	0.503	0.378	-0.012
2010	1191632111	3666452265	1255902	556499	1812401	0.0799	-0.0068	0.0428	0.0690	0.111	0.51	0.38	0.033
						Growth 2001 - 2010				Mean β-values			
					0.120	0.3003	0.5209	0.0293	0.4001	0.1409	0.5082	0.3511	0.072
										K	L	H	
							Contribution to growth			0.0734	0.0149	0.1405	
		Geometric means			1.011	1.0266	1.0428	1.0029	1.0342	1.007	1.003	1.016	1.007

Estimated output elasticities are based on the stochastic frontier model above (table 2).

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