External effects of education?

Evidence from the wage structure

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Abstract

This paper explores the idea that workers are more productive, the more educated their co-workers are. Evidence for such a relationship is found in the wage structure between firms. Two sources of matched employer employee data are used in an empirical analysis of individual's wages. The return to education is decomposed into its within- and between establishment dimensions. The evidence shows that there is an independent effect on workers pay of the average level of education at the establishment, in addition to the individual's return to education. This result is valid even after controlling for individual heterogeneity.

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1.Introduction[1]

The contribution of human capital to economic performance has been the target of a considerable body of research. One major issue is still unsettled: Are there considerable spillover effects of education over and above the effect of education on the person's own productivity? While evidence of individual's return to education abound (see Card, 1999), empircal attempts to sort out the importance of social returns to education are few. Krueger and Lindahl (1999) find that, after adjusting for measurement error, change in the years of schooling often has greater effect in cross-country regressions than in within-country micro-regressions. They do, however, stress the difficulty of separating causal effects of education in the cross-country data.

It is shown below that establishments with a higher average level of education pay all their workers more, even after careful control for individual heterogeneity. This observation is taken as evidence that there are positive effects on all workers' productivity from the average level of human capital of the firm. I do not attempt to sort out the source of this productivity effect. It may be that education gives organizing skills, abilities to innovate or other abilities which in themselves increase the productivity of the organization as a whole. Another mechanism may be through learning. Education gives both learning and teaching abilities, and the more educated persons there are, the more learning goes on in a firm. In both cases, the productivity of *all* workers increase with the share of educated workers in the establishment

Wage differentials for homogenous workers across plants creates a wedge between the social and private returns to education. The effect of working in a human capital intensive plant accrues to all workers, not only those with education. The difference between the social and private return thus depends on the level of segregation across plants. Since the standard market equilibrium does not support such a wage distribution, the observed evidence points to some kinds of frictions in the labor market as well. This friction means

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that the returns to experience in the labor market consists of two parts; one is the standard productivity effect through learning, the other is from job-to-job changes as the individual works himself upwards to more and more human capital intensive establishments.

The empirical analysis utilize two types of matched employer-employee data from Norway. The first is a panel survey from 1989 and 1993, where workers are stratified according to employer. The other is register data from 1995 and 1996, which is also a panel of workers with employer identification. The basic idea is to run a log wage regression with both individual level of education and the average level of education of the establishment in the same regressions. It turns out that there is an independent effect of the average level of education in addition to the wage differential arising from within firm variation. I build on the methods developed by Abowd et al (1999) to account for individual and firm-level heterogeneity. A simple method is proposed to sort out the within- versus between establishment effects of wages.

The main conclusion is that there is an independent effect of the average level of education at the establishment on own pay, in addition to the effect of the individual's level of education. The point estimate ranges from 0.9 to around 4 percent per year of average education. The size of the effect is as least as high as the external effect reported by Acemoglu and Angrist (2000) analyzing the relationship between U.S state wage levels and average schooling.

2. Productivity- and wage differentials.

I am not attempting in this paper to distinguish between several possible interpretations of the observation of wage differentials across establishments with different levels of human capital. Skills may be complimentary to other inputs and there may be spillover effects from educated workers to uneducated workers. Note that when I discuss externalities or spillover effects in this paper, I do not mean externalities between establishments or firms, but rather spillover effects between workers within the same establishment. This means that the employer "internalizes" the spillover effect, since it is not external to the employer. The externality involved is one between employees affecting the investment decisions of individuals. What is crucial for the discussion here is that the observed wage effects actually reflect productivity differences, and that these differences are not due to some other causal relationship between productivity and human capital at the plant level, but rather an effect of the human capital intensity itself. In this section I briefly discuss some of the mechanisms that may lead to such productivity differentials.

Kremer and Maskin (1996) present a model where there are complementary tasks within the firm that are differentially sensitive to skill. They find that the wage distribution and the pattern of skills-levels within firms are affected by the shifts in the distribution of skills. However, they solve the model for competitive wages only, where each skill group gets the same pay regardless of where they work. Moene and Wallerstein (1997) present a model where plant productivity and worker quality are complements. In competitive equilibrium the highest quality workers are employed in the most productive plants. Wage differentials across skills are higher than productivity differentials across skills. But as in Kremer and Maskin (1996) workers of the same quality are paid the same competitive wage across establishments. They show, however, in the context of decentralized bargaining, that wage differentials across plants may occur as a result of rent sharing. It seems clear that some sort of rent sharing is necessary for wage differentials to occur for given worker quality.

The observation that firms pay differently, strongly suggests that there exists productivity differences across these firms. This follows directly from an assumption that firms are on their demand curves for labor. Education intensive firms are more productive than less human capital intensive firms. The analysis in this paper does not attempt to sort out the causes of the productivity effect of education. It may be that educated and less educated workers are complements in production, or that education and plant productivity are complements. The underlying sources of this complementarity are not clear. It may be that educated workers are better innovators or complements to new technology, as suggested by Bartel and Lichetenberg (1987), or simply that education gives organizing skills that affects the overall production. Since education gives both learning and teaching skills, it may be the case that a more educated workforce improves on-the-job learning for all workers. Rauch (199x) shows that wages are higher in cities with more skilled workers, and Gleaser (1999) suggests that high wages in cities are due to human capital spillovers from learning.

A crucial question in this paper is of course if the observed wage differentials across establishments reflects plant-specific characteristics or just a bundling of worker quality. I thus go to some length to try to sort out this question, using individual as well as establishment fixed effects. However, also some other tests may be done. If some firms pay homogenous workers more than other firms, there must be some frictions or queues in the labor market. For workers in low-paying jobs it may pay to search for better jobs. As workers succeed in finding better jobs, their incentive for job search diminishes. If the wage differentials observed in this paper truly reflect firm-specific characteristics rather than just differences in worker quality, we would expect to find lower seniority, lower levels of experience and a higher probability of quitting from establishments with lower average levels of human capital as well.

3. Segregation and private versus social returns to schooling

An independent effect of the firm-specific level of human capital on individual wages creates a wedge between the private and the social return to education. Intuitively, the reason for this difference is that one person's education adds to the wage - or productivity - of his uneducated co-workers. This "spillover" effect is not reflected in the return accruing to the individual himself.

Formally, consider the following mechanism for determining the wage of individual i in firm or establishment f:

$$\ln w_{if} = \alpha + rs_{if} + R\overline{S_f} + \beta_1 x_{if} + \beta_2 x_{if}^{\ 2} + u_{if}$$

Equation (1) is a typical Mincer-equation, where s is the number of years of schooling and x is years of labor market experience, augmented with the spillover effect R of the average level of schooling, $\overline{S}_f$, at the firm or establishment.

Taking the overall mean gives:

$$\overline{\ln w} = \alpha + (r + R)\overline{S} + \beta_1 \overline{x} + \beta_2 \overline{x^2} + \overline{u}$$

Increasing the average level of schooling in the society thus yields a return of:

$$\rho = r + R$$

which then constitutes the social return to education.

Consider now the private return to education. We do not know, of course, at the time of investment what kind of establishment or firm the worker will be working for at any one time of his career. A forecast of individual wages is obtained by the standard Mincer equation:

$$\ln w_{if} = \alpha' + r' s_{if} + \beta'_1 x_{if} + \beta_2' x_{if}^{\ 2} + v_{if}$$

The OLS estimate of r', $\hat{r}'$, gives the private return to education. From the standard omitted variable formulae, we know that:

$$E(\hat{r}') = r + bR$$

where b is the regression coefficient of s in a regression of $\overline{S}_f$ on s, x and x^2. We thus find that the expected private return to education may be written as:

$$E(\hat{r}') = \rho - (1 - b)R$$

b is the regression coefficient of s in a regression of its own mean, $\overline{S}_f$, which means that that the level of b depends on the variation of s across versus within establishments (conditional on experience). If there is complete segregation, all workers with a given level of education works in the same firms, and b is 1. If all firms have identical human capital content, b is zero. In fact, (1-b) is actually the index of correlation or segregation suggested by Kremer and Maskin (1999) (after controlling appropriately for experience).

We obtain the following main result: The difference between the social and private returns to education is larger the larger is the "spillover-effect" of education within firms, as measured by the coefficient R, and the lower the level of segregation with respect to education across firms, as measured by the Kremer-Maskin-index.

It may also be useful to note that the returns to experience obtained in a standard Mincer-equation, β', also suffers from the same omitted variable bias. In this case, $E(\hat{\beta}_i) = \beta_i + cR$, where c is the regression coefficient of x (or x^2) in the regression of $\overline{S}_f$ on s, x and x^2. The regression coefficient in this regression measures the partial "effect" of experience on average schooling after eliminating the direct effect of your own level of schooling. If there are frictions in the labor market, and workers search on the job, we would expect c to be positive as individuals work their way upwards in the labor market, eventually ending up in the high paying - human capital intensive establishments.

4. Empirical implications, data and some preliminary evidence

Let us now sort firms according to their average human capital endowments. Denote the firms or establishments with higher average schooling as human capital intensive firms[2]. The above discussion has the following empirical implications:

Wage differentials within establishments, between workers with different levels of schooling, are higher than the productivity differential between workers within establishments. The reason is simply that more educated workers adds to the total productivity of the firm, and the firm is thus be willing to pay a premium for these workers.

Wages are higher in human capital intensive establishments. Both workers with and without education are paid more in human capital intensive establishments. Wage differences between firms are lower than the productivity differences between firms, because of the rent

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[2] This term refers to the skills mix of labor only, and does not intended to say anything about the relative use of human capital versus physical capital or other inputs.

sharing implicit in the wage setting procedure. Since human capital intensive establishments pay more, there is a positive correlation between high-wage firms and individual's levels of education. The overall private return to schooling thus arises both from wage differentials within establishment, and from the "crowding" in higher paying establishments.

Consider also the following empirical implications that do not follow from the above static framework, but which follows from considering also implications of firm-specific wage premia on search behavior and job-to-job transitions. Since workers in low wage firms would rather work in high-wage firms, there are queues into high wage firms. We thus expect human capital intensive firms to have lower quit rates. It follows that they have longer average seniority. The reason is that they pay more. We also expect average age to be higher in human capital intensive firms. Younger workers shop for better jobs, and as they reach a high-wage firm, they are less likely to leave. As a worker gets older, the likelihood that he or she has reached a high wage firm is larger. It follows that the returns to experience is positive, both from productivity differentials within firms (which are not a feature of the present model, since on-the-job training is not included), and from the gains from voluntary mobility between firms.

The data used in this paper is taken from two sources. *The NSOE data:* Norwegian Survey of Organisations and Employees (NSOE) was conducted by the Institute for Social Research and Statistics Norway in 1989 and 1993. The sample of employees is representative for wage earners in firms with more than one employee. The data consists of both individual and firm-level information. Both an individual- and an establishment-level survey was conducted. In the individual part of the survey, the response rate was 77 per cent. In the establishment level survey, the response rate was even higher; 87 per cent of the general managers agreed to take part in the survey. The individual part of NSOE consist of both register information and answers to personal interviews. Information on education, age, region, firm size and industry are taken from public registers. Level of work experience and hourly wage are taken from survey questions. Hourly wage is a constructed variable, based on information on working time and monthly or weekly pay. Individuals who were interviewed in 1989 were also interviewed in 1993. Some establishment characteristics were taken from registers in 1993, for example firm size, but there was no manager interviews in 1993.

The CSSD data: The Current System of Social Data is a data base produced maintained by Statistics Norway. In this paper I use register based information from 1995 and 1996 including information on gender, wages, experience, education and working time.

Information on w*ages* is taken from the Register of salaries and taxation, administrated by the authorities. *Experience* measures potential work experience, constructed by the following formula: (age-education-16). Level of *education* measures number of years with education after compulsory school. *Working time* is expected working hours per week, reported in three broad categories (4-19 hours, 20-29 hours and 30 hours and more). Seniority is based on administrative reports on starting dates. CSSD include information about current employer. Establishment information is taken partly from registers and partly from the aggregation of individual data.

While NSOE is based on a sample of workers from each establishment, CSSD include information on all workers within each establishment. A weakness of both data sources is that some of the movers change to employers about which we have only little information. In these cases, the aggregated data for the establishment, in particular average number of years of education, is based on only one observation. Note however that in the *within-establishment* regressions presented below, these observations are not included since at least two observations per firm is required to identify within-establishment effects.

Table 4.1. provide preliminary evidence from each data set. The preliminary evidence basically provide strong support for the empirical implications discussed above. The observations below are, taken at face value, at the same time inconsistent with a notion of a perfectly competitive labor market.

Table 4.1. Wage -, Tenure-, Age- and P(Stay)-Differentials by Human Capital Intensity. Deviations from sample means**.**
[TABLE IN AROUND HERE]

I have divided the establishments into three groups, the low-human capital firms with less or equal to 10 years of average schooling, medium-human capital firms with 11 years of average schooling and the high-human capital firms with 12 or more years of average schooling. The three first columns report the group's deviations from the sample mean. For instance, the low-human capital intensive employers in the survey pay 11.2 percent less than the average wage in the survey. The next three columns report differentials *after control for within establishment correlation with individual's levels of schooling*. For instance, the low-human capital intensive employers pay 7.5 percent less than the average wage, after control for individual returns to education within firms. Exact definitions are given below.

The first two rows of numbers report wage differentials. The deviation from sample mean report the difference between the average log wage for workers in a specific type of establishment, minus the sample mean of log wage. Employees in human capital intensive establishments earn 18-20 percent higher wages than the average worker, and 32-3 percent higher wages than the average employee in low-human capital intensive establishment (20.5+11.2=31.7).

The "deviation from mean residual" is calculated as the establishment specific mean of the residuals from a log-wage within-establishment regression[3] for individuals including a gender dummy, years of schooling and its square. We find that human capital intensive establishments pay more, even after control for the composition of workers. The difference between the unskilled group of firms and the high-skilled group, after control for individual returns to education, is about 20 percentage points in both data sets. This is strong evidence of the wage differentials that are the main focus of this paper.

There is no clear pattern in average seniority across the skill-groups of establishments. However, once we control for individual levels of education and gender, a clear pattern emerges: Employees in high human capital establishments stay longer. The difference shows up in both data sets, with the largest difference in survey data from 1989 where the difference is close to 1.75 years. This difference is between 1/5 and ¼ of the average seniority level in the sample.

Turning to age (or potential experience), we find that the human capital intensive firms employ younger workers. However, this is a reflection of the age structure of the population with different levels of education, and once we control for individual levels of schooling, the relationship turns around. Given education and gender, high-education establishments employ workers with 3-4 more years of experience than the low-education establishments. This is strong evidence in favor of systematic job-to-job transitions.

P(stay) is a dummy variable, taking the value of 1 if an individual is employed in the same establishment in period two (1989-1993 in NSOE, and 1996-97 in the CSSD). The deviation from residual mean is defined as the establishment specific mean of the residual from a within-establishment regression for individuals of this dummy variable, including gender, schooling and schooling^2. In the survey data. which covers a time period of four years, workers are on average, much more likely to stay in the human capital intensive

[3] This means that the estimation is based on within-establishment variation only, i.e. identical estimators to those obtained from including a dummy for each establishment.

establishments, after control for their personal endowment of human capital. The difference between the high- and low-education groups of establishments is rather large, and adds up to more than 20 percent of the probability of separating from the employer. In the register data, we find that workers in firms with medium human capital intensity have a higer probability of staying than workers in establishment with 10 or less years of average education. However, there seem to be a higher probability of separating from the highly educated establishments, an observation which is not in line with our story, and which is also contradicted by the survey data.

The observations regarding both seniority and the probability of staying (only for the survey data) support the notion that wage differentials are real establishment specific premiums. To see why, note that if the observed wage differentials were only aggregations of individual skills – related to the individual rather than to the establishment – we should not find lower separation rates in high-wage firms, because an individual wage premium should not, in that case, affect mobility, since it would increase both the inside and the outside option to the same degree[4]. The observed relationship with respect to age is also consistent with the notion that the observed wage differences are in fact establishment-specific wage premiums. With systematic job-to-job search, this is exactly the pattern we would expect if human capital intensive firms pay more.

The evidence produced in this section represents a first look at the data. It mainly illustrates the bivariate correlation between the establishment specific level of education and some key indicators of wages and labor supply, after appropriate control for the correlation between individual levels of education and the same variables within establishments. In the next sections, we produce a more careful analysis of the relationship between human capital intensity and wages, involving a large array of controls and methods.

[4] One could make up a story saying that persons with high unobserved skill, liked to work in human capital intensive firms, and thus stayed longer, but again this would require a non-competitive story, since in a competitive environment, we would expect workers to have to pay for any positive amenity.

5. Between- versus Within-Establishment Effects.

In this section, we decompose the variation in wages into the between- and within-establishment components of the effect of human capital on wages. We start off by reporting the results from a standard OLS on individual wages, augmented with establishment specific means of the average levels of human capital. We obtain:

From the survey data (NSOE):

N=3.975, years 1989, 93, CAPITAL LETTERS=ESTABLISHMENT SPECIFIC MEANS, adj.Rsq=0.503

*lnw= [constant] – 0.13*woman+0.002*seniority+0.02*experience-0.04(exp.*^{2}*/100)+0.04*education*
*+**0.022*EDUCATION**+0.012*EXPERIENCE-(0.002*SENIORITY)-0.06*WOMEN*
*+0.02*log(size)+0.03*city+0.05*Region+ industry dummies .*

From the register data (CSSD):

N=51.947, years 1995, 96, CAPITAL LETTERS=ESTABLISHMENT SPECIFIC MEANS, adj.Rsq=0.417

*lnw= [constant] – 0.22*woman+0.006*seniority+0.03*experience-0.06(exp.*^{2}*/100)+0.06*education*
***+0.071*EDUCATION**+0.003*EXPERIENCE-0.002*SENIORITY-0.11*WOMEN*
*+0.02*log(size)+industry dummies.*

where all reported coefficients are significant (1 pct level) except the coefficient for average seniority in the survey data, which is thus reported in brackets. We find a positive and significant effect of average years of schooling of the establishment, in addition to the effect of individual schooling. The returns to education is higher in the register data. This may have to do with the time period, there has been some increase in the returns to education in the private sector in the 90's (Barth and Røed, 1999), but it may also have to do with the fact that while the survey uses wage per hour, the register data uses earnings for full-time workers – defined as 30+hours – which may, to a larger degree be influenced by differences in hours. This may be a major factor behind the relatively large difference in estimated gender gap as well.

This first glance at the data strongly suggests that there is an independent effect of the average level of education of the establishment on wages in addition to the rate of return to each individual's level of education. Before I proceed with a more elaborate empirical analysis of this result, I want to eliminate two potential sources of bias[5]. The first is potential

[5] The reason why I do this before I do a more elaborate econometric analysis of heterogeneity etc. is that I have information on capital, other materials in cross section for one year and manufacturing only. Union data is also

correlation with physical capital and other inputs. It may be the case that there is a positive correlation between physical capital or other inputs and the level of education. I have data on capital (insurance value of physical assets) and other inputs for one year in the manufacturing sector only. Table 5.1 presents the results for the coefficients of individual years of education and establishment level of education from several specifications. The first model is simply the above equation estimated on the 1995 cross section data for reference. The second column presents the results for manufacturing only. The third column presents the results for manufacturing only, including also the insurance value of physical assets and the value of other inputs (materials) in the equation. We find that the effect of plant-level years of education are practically unaltered by this control. We may thus *rule out a physical capital explanation* for the human capital results.

The second potential objection to the above analysis is as follows: Unions are prevalent in Norway, and perhaps the result is only a reflection of union wage compression policy rather than of productivity differentials. The argument would go as follows: The local union compress wages and keep wages of highly educated employees below their level of productivity. The rent created by this policy is shared among employers and all employees through the bargaining process. In this case we would observe a positive correlation with average education, and within firm wage differentials that were lower than productivity.

To check for this, I have run separate regressions for establishments where collective agreements exists for some or all workers and for establishments where there is no bargaining but individual contracts only. If the above union-explanation of the educational premium is correct we should observe a high premium in the union sector, and no such premium in the non-union sector. Again we have data from 1995 only, and limit the analysis to this cross section. Contrary to the union-compression hypothesis, we find that the effect of plant level education is almost four times higher in the non-union sector than in the union sector. In the 1989 cross section, we have data on union membership. The last two columns of table 5.1 report results from separate regressions for union- and non-union members. Again it turns out that the between-establishment effect of human capital is stronger for non-union members than for union members.

With a caution that Norway may not be the best country within which to explore the distinction between the union versus non-union wage structure, because of the high degree of

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only available for one year. Ideally, of course, these factors should have been accounted for in the full analysis below as well.

coverage in this country, it seems fair to conclude that *union wage-compression is hardly the driving force behind the effect of establishment-specific education on wages*.

These simple OLS-models do not allow for establishment heterogeneity over and above the included variables, and do not cater to the fact that the dimension of the variation in the establishment-specific variables is much smaller than the number of individuals. An appropriate decomposition of the within-versus between establishment effects of the variables is obtained as follows. Individual wages are given by:

$$\ln w_{if} = \alpha + x_{if}\beta + \delta_f + u_{if}$$

for individual i in establishment f. x are standard human capital variables, including years of schooling. delta is a firm specific wage premium. We assume in this section that u has standard properties so that OLS on (1) is BLUE. We assume that the firm specific wage premium δ, may be written as:

$$\delta_f = a + \overline{x_{.f}}b + Z_f\gamma + v_f$$

where Z represent firm specific variables like firm size, industry etc. The coefficients, b, are the conditional correlations between the average human capital intensity of the establishment and the establishment specific wage premium. Assume that v and u are independent, and that var(v)=σ/n, where n is the number of employees in the establishment[6].

We are particularly interested in testing the size of the coefficient b for the average level of education. In our theoretical model, the coefficient b for education arises from the rent sharing inherent in wage setting and the fact that average education increases total productivity. However, the coefficient b for experience and seniority arises from job-to-job search and matching, not explicitly modelled in this paper. We expect a positive b for experience, as more experienced workers are more prevalent in high wage firms, but the sign for seniority may go both ways, depending on the relative weight of the positive correlation

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[6] The significance of this assumption will be clear below. A justification for this assumption is that the wage policy of a larger employer is more precise for two reasons, firstly a large employer has more contacts with the labor market because of more hires and secondly because a large employer uses more resources to keep informed (eg. by assigning a specific person or department to personnel issues).

arising from “good matches last” and the negative correlation arising from “movers gain” (see Topel, 1991 for a discussion).

Inserting (2) in (1) and taking the average over each establishment on both sides of the equality sign gives:

$$\overline{\ln w_{.f}} = \alpha_{between} + \overline{x_{.f}}\beta_{between} + Z_f\gamma + \varepsilon_f = (a+\alpha) + \overline{x_{.f}}(\beta + b) + Z_f\gamma + v_f + \bar{u}_{.f}$$

Between-establishment estimators are obtained from OLS regressions of the average low wage of the establishments on the average characteristics of the workers, x, plus the establishment specific variables, Z. Since u and v are independent, var(ε) = var(v)+var(u) = (σ_v+ σ_u)/n, and it is thus appropriate to weight the between-establishment regressions with the square root of the number of employees.

From (3) it is clear that we may estimate b as the difference between the between-establishment estimator ($\beta_{between}$) and the within-establishment estimator (β):

$$b = \beta_{between} - \beta$$

Since the between- and within-establishment variation in the data is orthogonal, we may use the formula for the sum of two independent stochastic variables to calculate the variance of b:

$$\text{var}(b) = \text{var}(\beta_{between}) + \text{var}(\beta)$$

and with normality assumptions, we may use a standard t-test to evaluate the significance of b.

Table 5.2. Between- and within establishment estimates of the returns to education.
Dependent variable: log hourly wage. [TABLE IN AROUND HERE]

We find, in accordance with what we found in the preliminary results, that there is a positive correlation between the level of experience and the wage premium of the establishment. Employees have a tendency to end up in higher paying establishments. We find a negative correlation between seniority and the wage premium of the establishment, reflecting the notion that job-changes pay off. We also find the ordinary firm size effect of wages, even with control for the firm-specific level of human capital.

The main result is that we find a significant, and rather large, effect of the average years of schooling of the establishment. Increasing average years of schooling by 1 year increases the wage of the establishment by about 6 percent according to the 95-96 register data and close to 2 percent according to the 89-93 survey.

6.Worker quality

One way of reconciling the competitive labor market model with evidence provided in the previous section, is to claim that what I find here is merely a reflection of a situation where better workers work in firms with a high level of human capital. As pointed out by Abowd et al (1999), the estimated firm-specific effects may be biased, if there are individual fixed effects in the wage equation, not accounted for in the estimation procedure. They also provide the exact formula for this bias. Intuitively, the problem arises since the estimate of a firm-specific effect may be thought of as comprising the real firm-effect plus an aggregate of the individual fixed effects of the workers in the firm. If the good workers tend to crowd into human capital intensive establishments, the OLS estimate of the effect of establishment specific human capital on wages is upwards biased.

In this section I deal with this potential bias in two ways, the first is to use first-difference estimates for the effects in order to sweep out the individual effects. Since there may still be some correlation between the firm specific effects and the estimated individual effects, we also use a variant of the ”persons-first-estimator” developed by Abowd et al (1999). In both cases I report the direct coefficients estimated from the difference equations as well as estimates from a two stage procedure, involving both dimensions of our data: individuals as well as establishments.

To see what I do, consider the following modification of (1):

$$\ln w_{ift} = \alpha + v_t + x_{ift}\beta + \delta_f + \theta_i + u_{ift}$$

the x’s now involve all variables that may vary over time for each individual (eg. Experience square). δ is establishment specific, and defined as before from (2), and involves both observed establishment characteristics, as the average years of schooling and industry, and an unobserved component ε. θ is the new feature of the model, and involves both the fixed individual characteristics of x from equation (1), like gender and education, which do not vary over time, as well as an individual specific fixed effect, α, taken out of the error term of (1):

$$\theta_i = x_i\beta + \alpha_i$$

The assumption that u is uncorrelated with v, in equation (1) is no longer a reasonable requirement, and we may now also allow for correlations between the α’s and the ε’s.

Because of the dimensionality involved, it is not feasable to estimate the equation with both person- and establishment dummies. We follow Abowd et al (1999a and 1999b), and introduce the auxhiliary vector Z, comprising of interaction terms between the establishment- and individual specific variables[7], into the regression:

$$\ln w_{ift} = \alpha + v_t + x_{ift}\beta + \overline{x_{.f}}b + F_f b_2 + Z_{if}\gamma + \theta_i + U_{ift}$$

which may be estimated on the assumption the error term U=(ε+u-Zγ), conditional on Z, is uncorrelated with the other right hand side variables. What we have done here, is to partition the establishment specific effect, δ, into one observable, and of column-one dimension, variables, and the unobservable part ε. Because of the dimensionality problem, we introduce the Z vector in order to deal with the potential correlation between the error term and the other right hand side variables.

First difference estimators

We report results from two specifications. The first is a simple first difference of (4) *without* the Z-vector. This is a standard within-person estimator. The second is a first difference model of (4) *including* the (difference of) the Z vector. In doing this, we effectively sweep out the individual specific characteristics θ. Note that we do not obtain a measure of the returns to education from these equations, since education is constant over time, it is included in θ. In order to obtain a standard estimates of the returns to education, we thus first obtain estimates of θ. This is done by plugging the estimated within-person coefficients into the level equation,(4) and take the difference between the observed wage and the predicted wage. The average of these residuals for each person is the estimated θ. We then have estimates of the coefficients for the time-varying parameters as well as for the individual effect, θ.

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[7] I use the same vector of interaction terms as Abowd et al.(1999) – interacting the individual averages of individual characteristics, gender, experience and seniority with firm characteristics: size, size square and industry.

Second step estimators

The second step involves estimating the coefficients for fixed individual characteristics, like gender, education, experience[8] and α. We simply regress θ on the observable characteristics for each individual, and estimate α as the residual from this regression.

We also provide second step estimates of the firm-specific variables. This is done by estimating a δ for each establishment by the following proceedure: We subtract the estimated return to individual time varying characteristics as well as θi from each observed log wage. The remaining residual is then averaged up for each establishment to an establishment specific effect, δ. Note that this estimator includes the returns to the estimated firm-specific variables as well as the Z's, but not the estimated individual effects θ. Next we regress δ on the observable characteristics of each establishment.

The second step estimator of the firm specific variables corresponds to the ”persons first effect” as defined by Abowd et al (1999a and 1999b). The only difference is that we have included the column one characteristics of the establishment directly in the within-person estimation. This may lead to the question of which estimator is preferable, the within-person estimator or the second step estimator after removal of the individual effect. Since we have only observations from two years, our data is weak in the time dimension, and the ’signal to noise’ ratio may be very high in the difference equations. The second step estimator utilize also the cross sectional variation in the data (after taking out the individual effect) and may thus be more preferable.

Within and between establishment estimators after removal of individual effect

However, this argument may be carried further, and we may want to use the difference estimators only where it is required. I thus report from a specification where I limit the use of the first difference equations only to produce consistent estimates of α. Our best possible estimate of α are from the residuals of the second step regression for θ, including education, gender and experience. My last specification is thus a procedure where I first subtract the estimated α's from the observed wage, and proceed according to the procedure in the prevoius section, with this *corrected wage*. We thus present within-and between

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[8] Experience cannot be identified in the within-person step in the register data, since everyone adds the same amount of Mincer-experience between two years. In the survey data, experience is treated as a time-varying variable, since it acutally varies between persons over the four years.

establishment estimates of the coefficients for the effect of education on the corrected wage as well. The point of this exercise is to utilize all the variation in the data to produce estimates of the coefficients, and limit the use of the first-difference to where it is necessary, namely to produce estimates of the unobserved individual effect α. Of course, all in all the estimates are no better than what the estimates of α can promise, however, they may, for the other variables, be better than the within-person estimators produced in the first step.

Results

The first difference-results with respect to establishment level of schooling is reported in the table 6.1. A standard first difference gives around 1 percent effect of one year of average schooling at the establishment level in the register data. The results from the survey are above 4 percent. In the step two estimation, where the firm specific components are regressed on firm specific characteristics, after taking out the individual effect, we obtain 1 to 1.5 percent in the register data and 4 – 5 percent from the survey data. We tend to prefer the step two results, because they are based on the cross section variation in the data as well, after correcting for individual effects. The first-difference equations are identifying the effect of average schooling only off the job-changers, based on two years in the register and four years (but only two observations) in the survey data. In the second step estimation, we use the job-changers only to identify theta, and then use cross sectional variation in wages as well to obtain the estimate of the b's.

In table 6.2 we report results from a decomposition of wages into the within- and between establishment dimensions, after taking out the alpha's from the wage. Note first that we have rather large adjusted R squares, suggesting that a very large part of the residual variation in log wages is removed with the alpha's. In this specification, we obtain an estimate of 1.6 percent from the register data and 4.5 percent from the survey.

Comparing now the results with and without control for individual heterogeneity, we find that the estimates for the register data were reduced considerably from a level of 7 percent in the OLS specification to a fairly consistent number around 1.5 percent with control for individual heterogeneity. The survey results started out at 2.2 percent, and produced results above 4 percent with control for individual heterogeneity. Our results are thus ambiguous with respect to the direction of the bias from individual heterogeneity. We may attribute the difference in the results to the fact that we have only observations from two points in time from both data sets, which should lead to some caution in the interpretation of the estimated individual effects. The result may also be due to differences in the time period between the two surveys, but is more likely to be due to other differences between the data sets. One obvious candidate is the fact that the register data also includes variations in hours among fulltime workers. This point is likely to produce an upward bias in the OLS of the register data results. To the extent that hours are constant for each individual between the two years, the removal of individual fixed effects removes this bias as well, driving the first difference results down. This bias is not present in survey data. Another difference is that the time period between the two years of observation is four years in the survey and only one year in the registers. We are identifying the individual effect from the firm specific effects of the variation among job-movers. This means that we have relatively more observations with the type of variation we need in the survey. On the other hand, we have more than ten times more observations overall in the register

What remains as clear from this exercise, is that careful attempts to control for individual heterogeneity does not remove the positive relationship between wages and the average human capital of the establishment. The point estimates are also of economic significance. Even the most conservative estimate of 1 percent higher wages per year of average schooling at the establishment, produces considerable variations in wages across firms.

7. Conclusions and discussion

There is an independent significant effect of the average level of education of the establishment on workers pay, even in addition to the coefficient for the individual's own education. The wage differential arising within establishment amounts to a rate of return of education of around 4 to 7 percent depending mainly on the data source. There is further an effect amounting to 1 to 4 percent, after control for individual observable and non-observable characteristics, of the *average number of school years* among all workers in the establishment. The results are fairly robust with respect to different specifications.

We take this as evidence in favor of the idea that there is an independent effect of the average level of human capital on the productivity of all workers of the firm. If the wage differentials occur as a result of rent sharing, as suggested above, the estimates represent a conservative measure of the productivity effect of establishment-level human capital, since the productivity gain is shared by workers and firms. We are not able to sort out learning, versus organizational or innovative skills effects of education. However, both Barth and Schøne (1999) and Schøne (2000) find similar effects of average levels of education after various methods of controlling also for on-the-job training activities. We hope to do some more work on this issue in the future. From the analysis here, it seems clear that the private returns to education arises both from wage differentials within establishments as well as from job-to-job movements across firms with different wage levels.

Of course, some caveats apply. Our control for physical capital and union wage compression are limited for data reasons to cross section analyses. However, the results were very comforting in that they gave no indications whatsoever that these two hypotheses might be of importance. Furthermore, the control for individual heterogeneity, albeit quite comprehensive in terms of variety of specifications and data sets, is based on only two data points for each data set. Also the firm-level information is weaker for many movers in the second period due to the sampling method. As in Abowd et al (1999) the analysis is undertaken without consideration of the endogeneity of mobility, even if the results on tenure and experience suggest that standard search mechanisms are working. However, the reported results with respect to tenure, separations and experience are at the same time consistent with the existence of firm specific wage differentials over and above what can be explained by the aggregation of individual fixed effects, adding support to the results on the independent wage effect of average human capital.

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Table 4.1. Wage-, Size-, Tenure-, Age- and P(Stay)-Differentials by Establishment Human Capital Intensity

	Deviations from sample mean			Deviations from mean residual		
	Establishment average years of schooling			Establishment average years of schooling		
	l.e. 10	11	g.e. 12	l.e. 10	11	g.e. 12
Wage						
(coeff. Log wage X 100)						
NSOE	-11.2	8.9	20.5	-7.5	7.1	12.1
CSSD	-18.8	-0.4	17.9	-7.7	0.1	12.9
Tenure						
(years with same empl.)						
NSOE	-0.13	0.31	-0.06	-0.59	0.42	1.15
CSSD	0.28	-0.18	-0.77	-0.26	0.22	0.07
Experience						
(Age-yrs. of education)						
NSOE	0.31	-0.2	-0.67	-1.27	0.71	2.77
CSSD	1.50	-0.68	-1.42	-0.91	-0.26	1.96
P(Stay)						
P(same employer)x100						
NSOE (1989-1993)	-0.22	0.33	0.35	-2.85	2.33	5.18
CSSD (1996-1997)	0.02	0.02	-0.06	0.01	0.02	-0.05
Number of observations						
NSOE	1148	542	389	1148	542	389
CSSD	11056	10686	6545	11056	10686	6545

Note: "Deviations from residual means" are differences from the sample means of the residuals from within-establishment regressions of the variable (eg. log wage) with years of schooling, its square and a gender dummy.

Table 6.1. The effect of individual- and plant-level education on wages. Dependent variable: log hourly wage.

	Register data - CSSD 1995					Survey data - NSOE1989	
	All employees	Manufacturing		Collective agreement	Individual contracts only	Union members	Non-union members
Individual's years of education	0.0575 (.00119)	0.0603 (.0025)	0.0603 (.0025)	0.0582 (.00126)	0.0557 (.00358)	0.0452 (.00300)	0.0416 (.00433)
Average years of education in plant	0.0507 (.00224)	0.0610 (.0065)	0.0574 (.0066)	0.0303 (.00243)	0.1132 (.00649)	0.02315 (.00490)	0.0314 (.00602)
Additional variables[a)]			Capital, Costs of materials	Union density		Union density, City	City
N adjusted R square	40,470 0.2574	10,759 0.2074	10.759 0.2084	33,357 0.2433	5,610 0.3940	2,055 0.4647	1,920 0.5090

Note: a) All models include a dummy for female, years of seniority, experience, experience squared and the establishment characteristics: average years of seniority, experience, share of women, log size and a 1-digit industry dummy.

Table 6.1. The Wage Structure Between- and Within establishments

Dependent variable: log Wage

	CSSD-1995-96			NSOE 1989-93		
	Between establ.	Within establ.	Between minus Within	Between establ.	Within establ.	Between minus Within
	b-between	b-within	b	b-between	b-within	b
Intercept	-0.0019		-0.0019	0.0006		0.0006
	0.0041		0.0041	0.0063		0.0063
Women	-0.3176 *	-0.2187 *	-0.0989 *	-0.1991 *	-0.1254 *	-0.0737 *
	0.0184	0.0030	0.0186	0.0202	0.0098	0.0225
Experience	0.0659 *	0.0302 *	0.0357 *	0.0340 *	0.0225 *	0.0115 *
	0.0038	0.0004	0.0038	0.0031	0.0012	0.0033
Experience sq./100	-0.1261 *	-0.0521 *	-0.0740 *	-0.0626 *	0.0386 *	-0.1012 *
	0.0086	0.0009	0.0086	0.0067	0.0025	0.0072
Seniority	0.0021	0.0059 *	-0.0038 *	0.0002	0.0025 *	-0.0023
	0.0013	0.0002	0.0013	0.0014	0.0007	0.0016
log (# of employees)	0.0195 *		0.0195 *	0.0200 *		0.0200 *
	0.0037		0.0037	0.0043		0.0043
City				0.0812 *	-0.0147	0.0959 *
				0.0218	0.0118	0.0247
Region				0.0670 *		0.0670 *
				0.0153		0.0153
Years of schooling	**0.1219 ***	**0.0596 ***	**0.0623 ***	**0.0610 ***	**0.0446 ***	**0.0164 ***
	0.0029	0.0005	0.0040	0.0050	0.0022	0.0055
Year dummy	Y	Y		Y	Y	
Industry dummies	Y			Y		
adj. R square	0.6127	0.5719		0.6395	0.6774	
# of est. dummies		1898			606	
N	1441	51054	1441	607	3670	607

Note: The between establishment model is estimated on establishment specific means only and is weighted with the square root of the number of observations per establishment. The Between minus within column reports the difference between the between-and within-estimates for the coefficients. The standard errors are calculated as the square root of the sum of the variances of the two models.

Table 6.1. Individual fixed effects

First differences. Dependent variable:Delta log (wage).

	CSSD 1995-1996		NSOE 1989-1993	
	First difference	Step two	First difference	Step two
Standard first difference:				
Individual's years of education		0.0723 *		0.0373 *
		0.0010		0.0023
Establishment mean education	0.0127 *	0.0154 *	0.0476 *	0.0479 *
	0.0032	0.0018	0.0055	0.0044
'Persons-first' (including Z's)				
Individual's years of education		0.0795 *		0.0371 *
		0.0009		0.0023
Establishment mean education	0.0094 *	0.0130 *	0.0471 *	0.0457 *
	0.0035	0.0004	0.0059	0.0065

Note: First differences including also city(NSOE), seniority, experience square, average experience, seniority and gender of establishment and 1-digit industry (all first differences.) ‘Persons first’ also includes the auxiliary interaction terms (Z) between individual characteristics and the establishment specific characteristics. See text for exact definition. Second step involves regressing the individual spesific term (Theta) on individual non-time varying characteristics, and regressing the establishment -specific terms (F) on firm-characteristics (see text for details).

Table 6.2 The Wage Structure Between- and Within establishments

Dependent variable: Corrected log (wage).

	CSSD-1996-97			NSOE 1989-93		
	Between Establish.	Within Establish.	Between Minus Within	Between Establish.	Within Establish.	Between Minus Within
	β-between	β-within	B	β-between	β-within	b
Intercept	-0.0036		-0.0036	-0.0001		-0.0001
	0.0020		0.0020	0.0025		0.0025
Women	-0.3087 *	-0.2475 *	-0.0612 *	-0.1713 *	-0.0944 *	-0.0769 *
	0.0088	0.0017	0.0089	0.0081	0.0053	0.0097
Experience	0.0492 *	0.0496 *	-0.0004	0.0316 *	0.0313 *	0.0003
	0.0018	0.0002	0.0018	0.0012	0.0007	0.0014
Exp. Square/100	-0.0883 *	-0.0909 *	0.0026	-0.0481 *	-0.0501 *	0.0020
	0.0041	0.0004	0.0041	0.0027	0.0014	0.0030
Seniority	0.0014	-0.0002	0.0012 *	0.0006	0.0027 *	-0.0021 *
	0.0003	0.0001	0.0003	0.0006	0.0004	0.0007
log (# of employees)	0.0041 *		0.0041 *	0.0115 *		0.0115 *
	0.0018		0.0018	0.0017		0.0017
City				0.0364	0.0376	-0.0012 *
				0.0087	0.0064	0.0108
Region a)				0.0403 *		0.0403 *
				0.0061		0.0061
Years of schooling	**0.0878 ***	**0.0722 ***	**0.0156 ***	**0.0835 ***	**0.0386**	**0.0449 ***
	0.0018	0.0004	0.0018	0.0020	0.0012	0.0023
Year dummy	Y	Y		0.0670 *		0.0670 *
Industry dummies	Y			0.0153		0.0153
adj. R square	0.8311	0.7888		0.9312	0.8736	
# of est. dummies		1440			606	
N	1441	51054	1441	607	3670	607