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**Do Higher Wages Reflect Higher Productivity?**
Education, Gender and Experience Premiums in a Matched Plant-Worker Data Set

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**Abstract:**
Do wage differences between workers with high and low levels of education, between males and females and between workers with different levels of experience reflect differences in productivity? We address this set of questions on the basis of a data set with variables for individual workers matched with a comprehensive data set for manufacturing plants in Norway for the period 1986-93. The results suggest that workers with higher education tend to be more productive, roughly in accordance to their wage premium. Female workers are *cet. par.* found to be less productive than male workers, and this is reflected in their wages. Experienced workers are on average found to be more productive. For workers with 8 to 15 years of experience, the productivity premium exceeds the wage premium, while the opposite is the case for workers with more than 15 years of experience.

**Discussion Papers** comprise research papers intended for international journals or books. As a preprint a Discussion paper can be longer and more elaborated than a usual article by including intermediate calculations, background material etc.

# 1 Introduction

Norway has invested heavily in education in recent decades. The average educational attainment in Norway was below the OECD average in 1960, while in 1995 Norway was among the OECD countries with the highest average educational attainment[1]. However, growth accounting calculations as documented in Hægeland (1997) show that these investments have contributed relatively little to economic growth. The low estimate for the growth contribution from education is driven by the low wage premiums for education in Norway, and a crucial assumption for such estimates is that relative wages correspond to relative productivity.

A number of studies have documented small educational wage differences in Norway relative to other countries, see e.g. Asplund et al. (1996) and Kahn (1996). Does the compressed wage distribution reflect small differences in productivity between various categories of labor, or are relative wages poor proxies for the productivity differenences between educational categories? Several authors, e.g. Freeman (1996) and Kahn (1996), have pointed out that Norway represents an exception to the trend in most Western countries in the eighties and nineties, towards a more decentralized wage determination and increasing wage differences. The wage distribution in Norway is very compressed compared to other countries[2], especially at the bottom. Both Freeman and Kahn attribute this to a high degree of centralized bargaining. The importance of centralized bargaining in the wage determination suggests that the growth accounting assumption of wage differences reflecting productivity differences may be questionable.

In this empirical analysis we compare differences in wages and productivity across workers with different educational levels. We also examine the wage and productivity effects of experience. Various theories of compensation and human capital investment predict that wage profiles over the working career do not follow the productivity profiles and we test such predictions. A third issue we consider is whether wage differences between male and female workers reflect differences in productivity. Our results indicate that the higher wages earned by workers with higher education largely correspond to their higher productivity. Experienced workers are more productive than unexperienced workers and they also earn higher wages; the wage premium is lower than the productivity premium for workers with 8-15 years of potential experience, while the opposite is the case for workers with more than 15 years of experience. Women are found to be less productive than men, with wages corresponding to

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[1] See Wolff (1994) and OECD (1997).

[2] See ch. 3 in OECD (1995), especially fig. 16.

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their lower productivity.

Our analysis is based on a new data set for plants, combining information from the annual Norwegian census of manufacturing plants with register files for individual workers. This new data set makes it possible to disaggregate the work force of each plant according to different characteristics. Workers are classified according to education, gender and experience, and we estimate relative wages and relative productivity of these labor categories for the period 1986-93.

There exist few studies comparing wages and productivity at the plant level. Most earlier studies at the micro level have used various proxies for productivity, such as performance pay (Foster and Rosenzweig, 1993) or superiors' evaluations (Medoff and Abraham, 1980, 1981). Griliches and Regev (1995), in their study of Israeli manufacturing firms, found that an occupation-based, wage-weighted labor quality index contributed significantly to explaining labor productivity. We employ a more direct measure by estimating how plant productivity vary with work force composition. More specifically, we estimate plant level production functions where workers with different characteristics are allowed to have potentially different productivity levels. The estimated productivity differences are compared to corresponding estimated wage differences. Our methodology draws on the work by Hellerstein, Neumark, and Troske (1996) who estimated relative wages and relative productivity for various worker characteristics on U.S. plant level data. Their work in turn builds on Hellerstein and Neumark (1994, 1995), who analyzed relative wages and productivity with respect to gender and experience on Israeli data. Due to a better match of workers and plants, we are able to relax some of the restrictive assumptions made by Hellerstein and her coauthors.

The rest of the paper is organized as follows. Section 2 presents the econometric framework for estimating relative wages and productivity, and discusses some econometric issues. Section 3 offers details on sample and variable construction, while estimation results are presented and discussed in sections 4 and 5. Section 6 concludes and points out directions for future research.

# 2 The econometric framework

## 2.1 Plant level wage equations

Consider a worker $i$ with schooling level $s$, gender $g$ and experience level $e$. Schooling is categorized into unskilled (U), low level education (L), medium level education (M) or high level education (H), where the educational levels correspond to years of schooling in the four intervals: less than 11 years; 11 to 12; 13 to 14; and 15 or more years. Gender is male (M) or female (F), while experience is divided into the intervals short (S), medium (M) or long (L). Medium and long experience correspond to 8-15 years and more than 15 years of potential work force experience, where potential work force experience is defined as age minus years of schooling minus six. To take an example; a worker with characteristics $(s, g, e) = (M, F, S)$ corresponds to a worker with 13 or 14 years of schooling, who is female and has no more than 7 years of potential work experience. We denote the wage for this worker by $w_{MFS} = w_0 \lambda_{MFS}$, where $\lambda_{MFS}$ is the worker's wage relative to the reference wage $w_0$ which denotes the wage of an unskilled male with short experience. More generally, we denote the wage of a worker with characteristics $(s, g, e)$ by

$$w_{sge} = w_0 \lambda_{sge} \qquad \begin{array}{l} s \in \{U, L, M, H\} \\ g \in \{M, F\} \\ e \in \{S, M, L\} \end{array}$$

Following Hellerstein, Neumark, and Troske (1996), we sum together the wage bill for all $L_j$ working hours carried out in plant $j$, and write the total wage costs in plant $j$

$$
\begin{aligned}
W_j &= w_0 L_j \left( \sum_{s=U,L,M,H} \sum_{g=M,F} \sum_{e=S,M,L} \lambda_{sge} s_j^{sge} \right) \\
(1) \qquad &= w_0 L_j \left( 1 + \sum_{s=U,L,M,H} \sum_{g=M,F} \sum_{e=S,M,L} (\lambda_{sge} - 1) s_j^{sge} \right)
\end{aligned}
$$

where $s_j^{sge}$ is the share of the labor force in plant $j$ with characteristics $(s, g, e)$. The last equality in (1) follows since

$$\sum_{s=U,L,M,H} \sum_{g=M,F} \sum_{e=S,M,L} s_j^{sge} = 1.$$

Furthermore, $\lambda_{UMS} \equiv 1$ since we have normalized such that $w_0$ is the wage for an unskilled male with short experience. Defining the hourly wage rate in plant $j$ as $w_j$ $(= W_j / L_j)$, equation (1) can be

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rewritten

(2)
$$w_j = w_0 \left[1 + s_j(\lambda - 1)\right]$$

with the vectors $s_j = (s_j^{UMS}, s_j^{UMM}, s_j^{UML}, s_j^{UFS}, \dots s_j^{HFL})$ and $\lambda = (1, \lambda^{UMM}, \lambda^{UML}, \dots \lambda^{HFL})'$.
The vectors $s_j$ and $\lambda'$ have dimensions $(1 \times 24)$.

The estimated *plant level* wage equation is

(3)
$$\ln w_j = \alpha_0 + \ln \left(1 + s_j(\lambda - 1)\right) + e_j,$$

where $e_j$ is an error term. (3) is an estimating equation non-linear in the (primary) parameter vector $\lambda$. In the Appendix we have formally shown how the plant-level wage equation (3) can be derived from wage equations for individual workers. We emphasize that (3) is no behavioral equation. It simply expresses the average wage of the plant as a weighted average of the wages of different types of workers. To allow for wage differences across plants reflecting compensating differences and other factors, we have added a number of regressors controlling for industry (2-digit ISIC), region, ownership structure, plant size, plant age and plant type (e.g. if the plant is part of a multi-plant firm). In addition, we have included capital intensity and capital purchases as proxies for unobserved worker skills which are complementary to capital. There is a large literature on the estimation of similar wage equations; see e.g. Griliches (1977) and Willis (1986) for an overview of some of the econometric issues and results. Individuals rather than plants are the usual units of observation in such studies. Estimating wage equations at the plant level has the benefit that we have better information about the left hand side variable – the hourly wage – than is usually available in data sets for individual workers.

## 2.2   Plant level production functions

We assume that the plant level production function is

(4)
$$\ln(Y_j) = \alpha_0 + \alpha_K \ln K_j + \alpha_L \ln L_j^*$$
$$+ \frac{1}{2}\beta_{KK} (\ln K_j)^2 + \frac{1}{2}\beta_{LL} \left(\ln L_j^*\right)^2 + \beta_{KL} \ln K_j \ln L_j^*$$

where $\ln Y_j$ and $\ln K_j$ are the logs of value added and capital input for plant $j$. $\ln L_j^*$ is log of *effective labor inputs* which is defined by summing working hours with weights reflecting differences in productivity, i.e.

(5)
$$\ln L_j^* = \ln \left( L_j \left( 1 + \sum_{s=U,L,M,H} \sum_{g=M,F} \sum_{e=S,M,L} (\phi_{sge} - 1)s_j^{sge} \right) \right).$$

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$\phi_{LMS}$ is the productivity of a male worker with low education and short experience, relative to the productivity of an unskilled male with short experience; and so forth, parallel to the definitions of the $\lambda$s in the plant level wage equations.

We have estimated equation (4) subject to (5) after adding an error term. As in the wage equation, we have also added a number of other regressors, allowing productivity to vary with industry, region, ownership structure, plant age and plant type. The estimating equation, obtained by inserting (5) into (4), is non-linear in the parameter vector $\phi$.

## 2.3   Some econometric issues

The wage equation (3) and the production function (4), subject to (5), have been estimated simultaneously using the method of maximum likelihood. The equations have been estimated on the basis of plant level data with time averaged variables for the whole sample period, e.g.

$$(6) \qquad\qquad w_j = \frac{1}{T_j} \sum_{t=1}^{T_j} w_{jt},$$

and so forth for the other variables. $T_j$ is the number of years observed for plant $j$. The variable transformation in (6) corresponds to the so-called between-estimator for panel data. It is well-known that the between-estimator has desirable properties to reduce biases caused by measurement errors[3], and with our non-linear estimation problem biases due to measurement errors can be particularly serious[4]. We have an unbalanced panel and we have weighted each observation according to the number of years the plant is observed.

As is well known, estimation of both wage and production function equations are subject to omitted variable biases and other potentially serious econometric problems; see e.g. Griliches (1977, 1979) on wage equations and Griliches and Mairesse (1998) on production functions. In both equations we have tried to reduce the omitted variable problem by controlling for a number of variables as described above. One of these deserves further mentioning. In the production function, we have included investment as a regressor, drawing on Olley and Pakes (1996). Olley and Pakes argue that differences in productivity $(A_j)$ will show up as differences in investment, i.e. $I_j = \psi(A_j, \cdots)$. Assuming that $\psi$

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[3]See Mairesse (1990).

[4]The shares, $s_j$, in the equations above are likely to be subject to measurement errors and experiments with fixed effect estimation for both equations clearly supported this claim.

is monotonic in $A_j$, we have that

$$A_j = \psi^{-1}(I_j, \cdots).$$

Hence, we can account for (unobserved) differences in productivity by a polynomial in $I_j$ and other variables in the investment function. See Griliches and Mairesse (1998) for a discussion of the limitations of this procedure.

The equations above distinguish between 24 different categories of labor, and the basic estimates have been obtained from regressions where we impose no restrictions on the relative wages and productivities. Below we will also present estimates where we have constrained the parameters such that wage and productivity differences associated with gender, experience and education are independent of each other, i.e.

(7) $$\lambda_{sge} = \lambda_{s..} \, \lambda_{.g.} \, \lambda_{..e},$$

(8) $$\phi_{sge} = \phi_{s..} \, \phi_{.g.} \, \phi_{..e} \, .$$

Such a decomposition contradicts standard human capital theory, and we will discuss this issue when we present the results. One could think about the decompositions in (7) and (8) as just an organizing device in interpreting the results, analogous to variance decomposition by considering the main effects (i.e. $\lambda_{s..}, \lambda_{.g.}, \lambda_{..e}, \phi_{s..}, \phi_{.g.}, \phi_{..e}$) and then examine interaction terms. Imposing the constraints (7) and (8), we have normalized the parameters such that $\lambda_{U..} = \lambda_{.M.} = \lambda_{..S} = \phi_{U..} = \phi_{.M.} = \phi_{..S} = 1$. The set of restrictions in (7) and (8) have been imposed by a minimum distance procedure on the basis of the unconstrained estimates of the $\lambda$s and the $\phi$s. Define the vector of unconstrained $\lambda$- and

$\phi$—estimates by $\widehat{\gamma}$, with associated covariance matrix $\widehat{\Sigma}_\gamma$, and denote the constrained parameter vector

$$
l(\gamma^c) = \begin{pmatrix}
1 \\
\lambda^c_{..M} \\
\lambda^c_{..L} \\
\lambda^c_{.F.} \\
\lambda^c_{.F.}\lambda^c_{..M} \\
\vdots \\
\lambda^c_{H..}\lambda^c_{.F.}\lambda^c_{..L} \\
1 \\
\phi^c_{..M} \\
\phi^c_{..L} \\
\phi^c_{.F.} \\
\phi^c_{.F.}\phi^c_{..M} \\
\vdots \\
\phi^c_{H..}\phi^c_{.F.}\phi^c_{..L}
\end{pmatrix}
$$

Then the constrained estimates are given as

$$
\widehat{\gamma}^c = \arg\min_{\gamma^c} [\widehat{\gamma} - l(\gamma^c)]' \widehat{\Sigma}_\gamma^{-1} [\widehat{\gamma} - l(\gamma^c)].
$$

# 3  Sample and variable construction

Our sample covers all manufacturing industries for the period 1986-1993, and is based on the "Time Series Files" for Norwegian manufacturing establishments which are constructed from the annual census carried out by Statistics Norway. See Halvorsen, Jensen, and Foyn (1991) for documentation. In this study, only operating plants with more than five employees have been included. Observations that did not report the variables required have been eliminated. We have also dropped observations with an extremely low (less than 5 percent) or high (more than 95 percent) share of wage costs in total revenue believing that such extreme shares indicate observations with gross measurement errors.

Plant wage payments incorporate salaries and wages *in cash and kind*, social security and other costs

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incurred by the employer. Capital services are constructed on the basis of fire insurance values for buildings and machinery, as well as rental costs for rented capital and average real rates of return and depreciation for the different capital types[5]. We have chosen value added, net of taxes and subsidies, as our output measure. Thus, costs and revenues are adjusted for taxes and subsidies, reflecting the prices on which firms base their decisions. Nominal variables are deflated using National Accounts deflators.

Information about the composition of the work force in each plant is obtained from the "Register Data Files" in Statistics Norway. These files are based on a matching of registers containing individual information on essentially all Norwegian citizens. Of particular interest for our study is that the files contain information on individuals' main employer, working time per week and educational attainment in addition to basic demographic information. Working time per week is reported by employers in three categories: 4-19 hours, 20-29 hours and 30 hours or more. The data on educational attainment are gathered from the register of the highest completed education of the population. Here all types of formal education exceeding 300 hours are registered. The variable "years of education", attached to each individual in the register, measures the standard number of years required to obtain the highest educational degree that the individual possesses. This implies that if a person who holds a masters degree takes undergraduate courses in another field, it does not show up in the data as an increase in years of education.

The information extracted from the "Register Data Files" is merged with the information from the manufacturing statistics on the basis of plant/employers' identification numbers. There is not a perfect correspondence between the identification numbers in the two data sets. On average, we are able to assign a disaggregated work force constructed from the "Register Data Files" to 90 percent of the plants in our sample from the manufacturing statistics. Furthermore, for some plants there is a deviation between the number of employees in the two data sources. Where this deviation is substantial, the composition of the plant's work force may be suspected not to be accurate, and such observations have therefore been excluded[6]. When constructing the shares reflecting the composition of the work force in each plant, we have weighted each individual according to working time with the weights 1/3, 2/3 and 1 for the three categories of working time per week. Our experience variable is a measure of *potential* experience, defined as age minus years of education minus six, as explained above.

In total, the clean-up procedure described above removed 29 percent of the plants from our sample (38

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[5]See Klette (1994), Appendix A, for details.

[6]The exact exclusion criterium was to drop the observation if the ratio of the number of employees constructed from the register files to the number of employees from the manufacturing statistics was smaller than 2/3 or greater than 4/3.

percent of the *plant-year* observations), but our final sample does not seem to be seriously biased. For instance, the average plant size in the original manufacturing data set before clean-up is 34 employees while the average plant size in our final sample is 38. Table 1 reports summary statistics (time-averages) of work force composition and other variables for the plants in our sample.

# 4 Primary estimation results

## 4.1 Unconstrained estimates

The results from the unconstrained estimation of the plant level wage equation and the plant level production function are reported in Tables 2 and 3, respectively. Table 4 presents the estimates of the included dummies. The two equations have been estimated simultaneously by maximum likelihood which facilitates testing of equality of relative wages and productivity. Separate estimation of the two equations using non-linear least squares revealed that the residuals of the two equations were highly correlated[7]. Including the residuals from the productivity equation as a regressor in the wage equation raised $R^2$ by about 10 percentage points, implying that productivity differences not accounted for by regressors in the production function have substantial power in explaining wage differences. Thus, there are significant gains in efficiency associated with simultaneous estimation.

The estimated $\lambda$'s in Table 2 reflect the wage of the corresponding labor category relative to the reference wage, defined in Section 2.1 as the wage of an unskilled wage male with short experience. For instance, the interpretation of the parameter for "unskilled, female, short experience", i.e. of $\widehat{\lambda}_{UFS} = 0.783$, is that females with less than 11 years of education and less than 8 years of experience receive an hourly wage that is 21.7 percent lower than the reference wage.

The interpretation of the estimated $\phi$'s in Table 3 is similar: The parameter estimate for "unskilled, female, short experience", i.e. $\widehat{\phi}_{UFS} = 0.845$, says that an unskilled female with less than 8 years of experience are 15.5 percent less productive than a corresponding male.

Some of the estimates of the wage and productivity parameters are rather imprecise. As seen from Table 2 and Table 3, a general tendency is that the results are more imprecise the higher the education

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[7]The correlation between the two residuals were found to be 0.46.

category. The standard errors of the estimates are also larger for female workers, especially females with long experience. This pattern reflects the composition of the work force in manufacturing as shown in Table 1. In general, females are in the minority and especially females with high education and long experience constitute a small part of the work force in most manufacturing plants.

## 4.2 A closer look at the wage equation

The point estimates in Table 2 indicate a positive wage premium to education. The positive premium to education seems to apply to both males and females, and all experience categories, that is $\widehat{\lambda}_{Hge} > \widehat{\lambda}_{Mge} > \widehat{\lambda}_{Lge} > \widehat{\lambda}_{Uge}$, except for females with short experience. Only some of these differences are statistically significant on a 5 percent level[8].

Within educational categories, for all levels of experience, there is a clear tendency that males earn higher wages than females. However, the positive male wage premium is significant only for unskilled workers and for workers with medium education and experience.

Except for females with high education, the estimates indicate that workers with medium experience are paid more than those with short experience. The positive wage premium for experience is significant for males and females who are unskilled or have low education. There is little systematic difference in wages between workers with long and medium experience.

## 4.3 A closer look at the production function and the relative marginal productivities

Looking at the estimates presented in Table 3, we see that the production function estimates do not reveal a pattern as clear cut as in the estimation of the wage equation. The point estimates indicate that workers with low education are more productive than unskilled workers, but the difference is significant only for females with long experience. Workers with medium education are found to be more productive than workers with low education, except for females with short or medium experience. The results also indicate that highly educated workers tend to be more productive than workers with

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[8]In the following, we use a 5 percent significance level if nothing else is explicitly stated.

medium level of education, except for workers with long experience. However, the productivity premiums for workers with high and medium education are imprecisely estimated and the differences are not statistically significant.

The productivity effects of experience are mixed. The estimates indicate that workers with medium experience, except highly educated males, are more productive than workers with short experience, and this difference is significant for unskilled males and males with low education. However, except for females with low and medium education, workers with long experience are found to be *less* productive than workers with medium experience, but none of these differences are significant.

Males are found to be more productive than females except for workers with long experience and low or medium education and short or medium experience and high education. The gender productivity difference is significant only for unskilled and low educated workers with short experience.

## 4.4    Comparing wage and productivity premiums

We will now compare relative wages and productivity levels for different categories of workers. Given the setup of our estimation problem, the reference category "unskilled males with short experience" forms a benchmark: When we interpret a result such as a wage premium exceeding a productivity premium, bear in mind that such arguments apply *relative* to the reference category and that they are conditional on this normalization. It is straightforward to adjust our arguments to alternative normalizations.

Starting out comparing the estimates in Table 2 and Table 3, we see that for all but five worker categories relative productivity exceeds relative wages. None of the differences are significant, but the finding may be an indication of a wage distribution that is compressed relative to the productivity distribution. Next, to highlight the main patterns in our results, we have decomposed our parameter estimates in Tables 2 and 3 by the minimum distance procedure spelled out in section 2.3. Table 5 presents the results where we impose the restrictions that wage and productivity differences associated with gender, experience and education are independent of each other.

Regarding the effects of education, the minimum-distance estimates reveal a clearer pattern than the unconstrained estimates. For both wage and productivity, we find a positive premium for all education

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levels. They are statistically significant, except for the productivity effect of high versus medium education. For low education, the productivity premium is significantly smaller than the wage premium. The medium education category has a somewhat smaller wage premium than productivity premium, but they are not significantly different from each other. Highly educated workers are roughly paid according to their productivity.

The wage and productivity premium for medium experience are estimated to 39 and 62 percent, respectively. Both are significantly different from zero, and the productivity premium is significantly larger than the wage premium. The wage premium for long experience is almost equal to that of medium experience. Workers with long experience are found to be significantly less productive than those with medium experience, however, but still significantly more productive than workers with short experience. Thus according to our results, the wage-experience profile only partly reflects the productivity-experience profile.

The female-male wage difference is estimated to approximately -18 percent, while the corresponding productivity difference is found to be -17 percent. Both are highly significant, and the results indicate that females' lower wages reflect that females are less productive.

## 4.5   Discussion of our results in view of related research

**Education:**   In general, our estimated wage differences are somewhat larger than what is found in other Norwegian studies based on wage equations estimated at the level of individual workers. While we find a wage premium for an additional year of education in the range of 6 to 9 percent, the results from other studies are typically in the range of 4-6 percent; see Asplund et al. (1996), Kahn (1996), Longva and Strøm (1996) and Barth (1997). Our larger estimates partly reflect that our sample covers manufacturing only, while the other studies (except Barth, 1997) also incorporate workers in the public sector. The educational wage premium is typically found to be larger in the private than in the public sector, cf. Asplund et al. (1996). Wage premiums to education are usually found to be higher in the U.S. than what is found for Scandinavian countries, see for instance Buchinsky (1994).

In the introduction we raised the question of whether estimates of the growth contribution from education tend to be downward biased for Norway due to smaller differences in wages than the differences in terms of productivity. Our results indicate that this is not the case; where there is a

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significant difference between the wage and productivity premiums (i.e. for low education), it goes the other way. Thus we find that the low wage premiums for education largely reflect small productivity differences.

Hellerstein, Neumark, and Troske (1996) distinguish only between college and non-college workers so it is difficult to make a detailed comparison with their results on education in the U.S. One striking finding in their study is that the estimated productivity premium for education substantially exceeds the wage premium. Comparing our results to the findings for the U.S. by Hellerstein et al., indicates that the educational productivity premium is much higher in the U.S. than in Norway. Taking this finding at face value, it raises the question of why this is the case? Providing an answer to this question is beyond the scope of this study, but one possible explanation may be school practices. In Norway, the school system is relatively "egalitarian", at least at the primary and secondary levels. An egalitarian education system gives smaller differences in capabilities (innate plus learned abilities) between pupils than an elitist system and thereby smaller differences in relative productivity between educational groups. One could also argue that the productivity enhancing effect of education may differ between countries, because of differences in curriculum relevance and resources per student[9]. Sorting out the importance of the different explanations for the small educational premium in Norway is a research topic we want to address in future work.

What do the estimates for educational wage premiums in Table 5 suggest about the returns to different levels of education? In this respect we are interested in both private returns measured by wages, and social returns as proxied by productivity gains. We account only for costs of education due to forgone earnings or production, ignoring costs of tuition, books and other school materials. Incorporating these additional costs would reduce the social returns, while they would not reduce the private returns much since these costs are largely covered by the government. We have calculated private returns adjusting for taxes, stipends and subsidized loans[10], but we also present estimated returns without these adjustments for comparison. The calculated internal rates of return in Table 6 show that both the private and the social rates of return are highest for medium education; 10.4 and 18.7 percent. It is lowest for low education where the social return is only 1.3 percent. The progressive tax system reduces the

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[9]For a discussion of the effects of resources on schooling outcome, see Card and Krueger (1996) and Hanushek (1996).

[10]When calculating the internal rate of return, we have assumed that potential working time (after compulsory schooling) is 45 years. An unskilled worker is assumed to have 9 years of education, while low, medium and high education are to take 3, 5 and 8 years of extra education, respectively. Opportunity costs are wages or productivity at the current level of education, so that a person taking high education in the last three years of schooling has an opportunity cost equal to the wage/productivity of a person with medium education. We have used the tax rates and the standard amounts for stipends and loans to medium and high education for 1993. The value of student loans are calculated as the value of interest exemption during education, and we have assumed no stipends and loans for low education.

private returns to education substantially, and naturally most for high education. Stipends and loans offset about half of the effect of progressive taxation, as can be seen by comparing the rates of return in the first three columns in Table 6.

In our calculation of the rates of return to education, we assume that the productivity effects are causally related to education, and not due to education as a sorting device, as suggested by Arrow (1973) and Spence (1974). If our wage and productivity estimates are biased upwards by ability selection, this will give us too high an estimate of the true rate of return to education. On the other hand, there is also a bias in the opposite direction in our estimated rates of return to higher education, since higher education reduces the risk of becoming unemployed, and our estimated returns do not account for costs associated with unemployment.

**Experience:** Our finding of wages rising with experience has been widely documented also in previous empirical analyses in Norway and elsewhere (see references below). Human capital theory explains this as mirroring productivity, since on-the-job training and learning add to workers' human capital. If this additional human capital is general, wages should rise in line with productivity, cf. Becker (1993, ch.3). If, however, this human capital is job specific, the wage effect is not clear, but generally wages are expected to rise slower than productivity, cf. Hashimoto (1981). An explanation of wages rising with experience can also be based on efficiency wage theory as developed by Salop and Salop (1976) and Lazear (1979, 1981), and this theory has the additional prediction that productivity exceeds wage for workers with little experience while the opposite is true for workers with longer experience.

Our results on experience are consistent with both human capital theory and efficiency wage theory. The pattern in our estimates suggests that there is considerable "on-the-job-learning", i.e. formal and informal human capital investment in the first 15 years of peoples' careers. Only part of this is reflected in current earnings, the rest of it is deferred until later, keeping wages almost stable even if productivity declines towards the end of the career.

Not many studies have empirically examined the direct relationship between productivity and experience. Medoff and Abraham (1980, 1981) studied whether the higher pay of experienced workers can be explained by higher productivity, using supervisors' annual performance ratings of their subordinates as proxies for productivity. In contrast to our findings, they concluded that productivity

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plays only a small role in explaining the increase in earnings with respect to experience. Hellerstein and Neumark (1995), in a study of Israeli firms, find that the relationships between age (which is close to our measure of experience), earnings and productivity, mirror each other closely and even closer than in our estimates, but their estimates are quite imprecise. For the U.S., Hellerstein, Neumark, and Troske (1996) find that older workers are paid more than younger workers, despite being less productive.

**Gender:** It is a well established fact that females earn lower wages than males, even after controlling for education and experience, and it is a commonly held view that this difference may at least in part be attributed to wage discrimination, cf. e.g. Barth (1992). Our findings are broadly in line with the results of Hellerstein and Neumark (1994) from Israel, that the negative female wage premium roughly reflects productivity differences. In contrast, Hellerstein, Neumark, and Troske (1996) found that the negative wage premium exceeded the productivity differences, indicating that females are subject to wage discrimination in the U.S.

Turning to empirical work on the Norwegian labor market, we find larger gender and experience wage premiums than in the wage equations estimated by Kahn (1996) and Longva and Strøm (1996). According to Kahn's estimates, the experience premium is lower for females, and Longva and Strøm find that the education premium for females are lower than for males. Such interactions between gender, education and experience are not captured in our set of constrained estimates in Table 5. However, the restriction of no interactions imposed in Table 5 is not rejected by our overidentifaction test.

Human capital theory offers an explanation for gender productivity and wage differences. Bulow and Summers (1986) and Lazear and Rosen (1990) argue that higher worker-job separation rates lead to less training and less promotion for women. Hiring and promotional practices may contain elements of discrimination. Petersen et al. (1997) study the gender wage gap in Norway. Comparing wages for men and women who work in the same occupation and establishment, they conclude that (pure) wage discrimination is not the central force in explaining the gender wage gap. They find that it is mainly occupational segregation, and also establishment segregation, that drive the gap. That is, Petersen et al. find that the main part of the wage differences is due to females being segregated into jobs and establishments with low wages[11].

In addition to discrimination, preferences may also affect gender differences in wages and productivity.

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[11]Winter-Ebmer and Zweimüller (1997) obtain a similar conclusion based on a study from Austria.

Traditionally, females have had the major responsibility for child care and housework within the family. When searching for a job, this may imply that they emphasize other attributes of the job than wages, such as commuting time and flexibility of working hours, more than males. Other things equal, this implies that females on average get worse job matches in terms of wages and productivity, even if their opportunities are identical to those of males. There is some empirical support for this hypothesis. The estimates of Aaberge, Dagsvik, and Strøm (1995) indicate that a large part of the gender wage difference may be attributed to differences in preferences. Similarly, Van den Berg and Gorter (1997) found that female workers, especially those with children, tend to have higher disutility of commuting time, suggesting that females may be more apt than males to accept a low-wage match to avoid long commuting time.

Finally we would like to mention two "non-explanations". Females on average work fewer hours than males and this is not fully captured by our crude working time categories[12]. Hence, the labor shares for the female categories have an upward bias. However, this bias in the labour shares does not explain the negative wage and productivity premiums for females since one can show that an upward bias in the employment share of a worker category will bias the estimated premium towards zero[13]. Another possibility is that firms, in their reporting of total hours worked, do not take full account of part-time work and sick-leaves (where females are over-represented) and overtime (where males are over-represented), thereby overreporting hours worked in plants with a large share of female workers. This will cause the estimated wages and productivity of females to be biased downwards. However, reported plant level hours clearly suggest a positive relationship between hours per full-time equivalent worker and the share of male workers - indicating that the estimated lower female productivity is not due to an upward bias in reported hours in plants with a large share of female workers.

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[12]We have examined data from the "Level of living" surveys, Statistics Norway (1992), and they show that within our categories, females work fewer hours than males in manufacturing.

[13]We have carried out sensitivity estimates with different assumptions about working hours for male and female workers which confirmed this conclusion and which also revealed that reasonable changes in these assumptions have a negligible effect on the estimated gender premia.

# 5 Wage and productivity premiums in different subsamples

## 5.1 The late eighties versus the early nineties

There is abundant evidence that the labor market outcomes of the less skilled have deteriorated in the OECD countries over the last two decades. In most countries, the less skilled share of employment has declined *along with* constant or increasing relative skill prices[14]. A number of explanations have been put forth, and the hypothesis that has received the most support is that skill-biased technological change is the driving force behind the decline in the demand for less skilled workers; cf. Berman, Bound, and Griliches (1994). The primary effect of skill-biased technological change is, by definition, to alter relative productivity in favor of skilled workers. In a frictionless labor market, this would immediately be reflected in relative wages, but the Norwegian labor market can hardly be regarded as frictionless, with a number of regulations and a high degree of centralized wage setting. The emphasis on "solidaristic wage setting" in Norway in the period we study suggests that changes in relative productivity may not be fully reflected in relative wages.

To assess the importance of skill-biased technological change, we have examined how relative wages and productivity have developed over time, by splitting our sample into two subperiods, 1986-89 and 1990-93, and performing separate estimation on the two subsamples. The results are presented in Table 7a and 7b. Comparing the estimates for the two periods, we note that the relative productivity of highly educated workers increased rather substantially from the late eighties to the early nineties. This finding indicates technological change favoring workers with high education. Interestingly, this change in relative productivity is not reflected in relative wages. Relative to medium and low education, the wage premium to high education has increased, but not relative to unskilled workers. Wages increase more steeply with education than does productivity in the late eighties, while the opposite seems to be the case in the early nineties.

We also find that productivity premiums for experienced workers have been reduced from the late eighties to the early nineties, and that this is partly reflected in wage premiums. There are two possible interpretations of this decline. Technological change may have increased the productive value of "new" relative to "old" skills, so that skills obtained through experience and education more than a decade ago become obsolete to a larger extent than before. Another possible explanation could be that the cyclical

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[14]See, for instance, Berman, Machin, and Bound (1995).

downturn that Norwegian manufacturing experienced in 1988-91 led to little hiring of younger workers, thereby increasing the average experience level in the short experience worker categories. We have, however, estimated the average experience level within each category and they are very similar in the two periods we consider.

## 5.2 Small versus large plants

The positive relationship between employer size and wages has been well established through studies by Brown and Medoff (1989), Davis and Haltiwanger (1996) and others; evidence for the Nordic countries is presented by Albæk et al. (1997). One of the main findings in this literature is that only a part of this wage-size relationship can be explained by the fact that larger plants hire more educated workers. This is confirmed in our data. There is a positive wage-size relationship and it is prevalent also when we control for the educational level of the work force. This is evident in the estimates from the plant level wage equation in Table 2 where the number of employees enters with a positive and significant coefficient even when we control for worker characteristics.

In our data set, larger plants employ a higher share of workers with medium and high education than smaller plants. Does the positive employer-size wage effect reflect higher wage premiums to education in larger plants? And if so, do higher wage premiums reflect higher productivity premiums? Kremer (1993) has suggested that the answers to these questions are positive, arguing that larger employers pay higher returns to skill because the technology adopted by large employers induces greater complexity of the workers' tasks and greater skill complementarity among workers. In line with this argument, Brown and Medoff (1989) find larger returns to human capital in large firms, while Albæk et al. (1997) find no such effect for the Nordic countries.

To shed further light on this issue we have divided our sample into two subsamples with "small" and "large" plants. The plants have been divided into the two subsamples according to number of employees, and Tables 8a and 8b present our estimates[15]. In general, we find that the wage and productivity premiums with respect to our included characteristics are much smaller in small plants[16]. The most striking finding is that the wage and productivity differences are substantially larger for high

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[15]We have divided the sample at the median plant size corresponding to 14 employees.

[16]Davis and Haltiwanger (1996) find that unobservable characteristics play a much larger role for wage setting at smaller plants, indicating that larger plants rely more on standard wage rate policies relating wages to worker characteristics that are easily observed. This is consistent with our finding (not reported) that the basic wage equation explains much less of the variation in plant wages for small than large firms.

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education in large plants. In both small and large plants, wages increase with education, and the relationship is steeper in large plants. The results on the relationship between wage and productivity premiums for education in large versus small firms are more mixed. In large plants, both low and medium education receive a wage premium that significantly exceeds the productivity premium, while wages and productivity roughly correspond for workers of high education. In small plants, medium education is underpaid relative to productivity. Wage premiums for experience are also higher in large plants, and again the results on their relation to productivity premiums are mixed. There is no clear indication that the productivity effects of experience are greater in large firms. Finally, we find a larger negative female productivity premium in large firms.

# 6 Concluding remarks

Do higher wages reflect higher productivity? Based on a comparison of wages and productivity across plants with different compositions of their work forces, our main answer to this question is yes. In particular, wage returns to education correspond quite well to productivity differences, except for workers with low education, i.e. with education 2-3 years above compulsory schooling. This group is found to be overpaid relative to its productivity. Calculations of internal rates of return to education suggest that medium education, i.e. with 4-5 years above compulsory schooling, is the most profitable, both in terms of private and social rates of return. Our separate estimates for the late 1980s versus the early 1990s show an increase in the relative productivity of workers with high education, indicating skill-biased technological change.

One of the issues motivating our study was the low contribution of education to economic growth in Norway relative to other countries, found in growth accounting calculations. Our results lend no support to a hypothesis that this low contribution is due to the wage distribution being compressed relative to the productivity distribution, and the results suggest that using relative wages as proxies for relative productivity in growth accounting is a quite good approximation.

The wage premium for workers with long experience (more than 15 years) is found to exceed their relative productivity, while the opposite is true for workers with medium experience (8-15 years). This finding suggests that the wage-experience profile can not fully be explained by the standard human capital theory with on-the-job training and learning, indicating that theories based on efficiency wage arguments are also relevant.

The most controversial of our findings is perhaps that the lower wage for females relative to males corresponds to a productivity difference of equal size. This result suggest that pure wage discrimination is not a major explanation for the wage differences between male and female workers, at least in manufacturing.

The framework we have used and our results raise some questions and point out directions for further research. First, our model framework treats workers of different categories as perfect substitutes (but with different productivity), and this is obviously a restrictive assumption that we want to relax in future work. Second, the differences in wages and productivity between male and female workers raise further questions: Do they extend to others sectors in the economy? How far can matching and human capital theories go in explaining these male-female differences? Another more general topic, which might be of relevance for the male-female differences, relates to the measure of education: The *type* of education – not only the length of it – is important for wages and probably also for productivity. Are some types of education more productive than others; e.g. is it engineers, MBA's or other types of education that gives the high productivity premium for high education in our estimates? In future work, we want to include information on the type of education and try to answer such questions. Finally, firms differ with respect to investments in training of their work force, and it is interesting to test whether different levels of training affect the productivity effects of experience. In this respect it will also be crucial to distinguish between general and firm-specific experience. The data sources used in this study can be developed further to address these and other questions.

# 7  Appendix

In this appendix, we show how to derive the firm level wage equation from the wage equation for individual workers. Consider the wage equation for an individual worker $i$ in firm $f$, with a vector $\Delta_{if}$ of observable, categorical characteristics:

$$w_{if} = W_f^0 \left(1 + \Delta_{if}\beta + u_{if}\right)$$

where $W_f^0$ is the *reference* wage rate in firm $f$ which might differ across firms in different industries, firms of different sizes and so forth. This reference wage rate is chosen as the wage rate for an unskilled male with short experience in our analysis above. $\Delta_{if}$ is a $(1 \times J)$-vector with a one in position $j$ if worker $i$ in firm $f$ has a set of characteristics $j$ (e.g. medium level of education, female, short experience), and a zero in position $j$ otherwise. $\beta$ is the $(J \times 1)$-vector giving the wage premium for each categorical characteristic and $u_{if}$ is the wage premium to unobservable characteristics.

The total wage bill in firm $f$, $C_f$, is given as

$$
\begin{aligned}
C_f &= \sum_{i \in I_f} w_{if}\, h_{if} \\
&= W_f^0 \sum_{i \in I_f} h_{if} \left(1 + \Delta_{if}\beta + u_{if}\right).
\end{aligned}
$$

(9)

Define $H_f = \sum_{i \in I_f} h_{if}$, i.e. total hours worked in firm $f$ and $S_f$ as the vector with the shares of workers with various characteristics such that element $j$ is $S_f^j = \left(\sum_{i \in I_f} h_{if}\Delta_{if}^j\right) / H_f$. Then (9) can be rewritten

(10) $$C_f / H_f = W_f^0 \left(1 + S_f\,\beta + V_f\right)$$

where the left hand side is the *average* wage rate in firm $f$ and $V_f = \left(\sum_{i \in I_f} h_{if}u_{if}\right) / H_f$ is an error term associated with the average wage premium to unobservable characteristics in firm $f$. Taking logs of (10), we find

$$
\begin{aligned}
\overline{w}_f &\equiv \ln\left(C_f / H_f\right) = \ln W_f^0 + \ln\left(1 + S_f\,\beta + V_f\right) \\
&\simeq w_f^0 + \ln\left(1 + S_f\,\beta\right) + V_f^*,
\end{aligned}
$$

where $V_f^* = V_f / \left(1 + S_f\,\beta\right)$. This is the equation we have estimated above, after replacing $w_f^0$ ($\equiv \ln W_f^0$) by a number of observable firm characteristics such as industry, size and regional dummies.

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## Table 1. Summary statistics of selected variables

| Variable | Mean | Std. Dev. | Min | Max |
|---|---|---|---|---|
| Number of employees | 38.13 | 99.41 | 6 | 3497.59 |
| Capital services (in NOK 1000, 1986 prices) | 4046.57 | 22192.71 | 1.79 | 938227.8 |
| Number of years plant observed | 5.21 | 2.560 | 1 | 8 |
| *Employement shares:* | | | | |
| Unskilled male short experience | 0.0557 | 0.0784 | 0 | 0.8333 |
| Unskilled female short experience | 0.0205 | 0.0460 | 0 | 0.7183 |
| Unskilled male medium experience | 0.0766 | 0.0852 | 0 | 0.8889 |
| Unskilled female medium experience | 0.0249 | 0.0478 | 0 | 0.6369 |
| Unskilled male long experience | 0.3097 | 0.1989 | | 1 |
| Unskilled female long experience | 0.1414 | 0.1609 | 0 | 1 |
| Low education male short experience | 0.0562 | 0.0734 | 0 | 0.6667 |
| Low education female short experience | 0.0209 | 0.0416 | 0 | 0.3889 |
| Low education male medium experience | 0.0677 | 0.0796 | 0 | 0.6974 |
| Low education female medium experience | 0.0148 | 0.0330 | 0 | 0.4 |
| Low education male long experience | 0.1293 | 0.1242 | 0 | 0.9 |
| Low education female long experience | 0.0139 | 0.0342 | 0 | 0.5 |
| Medium education male short experience | 0.0030 | 0.0140 | 0 | 0.25 |
| Medium education female short experience | 0.0029 | 0.0148 | 0 | 0.5 |
| Medium education male medium experience | 0.0095 | 0.0292 | 0 | 0.5455 |
| Medium education female medium experience | 0.0028 | 0.0132 | 0 | 0.25 |
| Medium education male long experience | 0.0267 | 0.0497 | 0 | 0.5714 |
| Medium education female long experience | 0.0044 | 0.0185 | 0 | 0.4219 |
| High education male short experience | 0.0026 | 0.0133 | 0 | 0.3529 |
| High education female short experience | 0.0010 | 0.0077 | 0 | 0.1875 |
| High education male medium experience | 0.0054 | 0.0023 | 0 | 0.5 |
| High education female medium experience | 0.0009 | 0.0094 | 0 | 0.3929 |
| High education male long experience | 0.0083 | 0.0278 | 0 | 0.375 |
| High education female long experience | 0.0009 | 0.0091 | 0 | 0.2938 |

Total number of plants in sample: 7122.

**Table 2.  Estimates of the plant level wage equation (3).  Dependent variable: Log(plant hourly wages)**

| *Relative wage parameters ($\lambda$'s):* | | |
|---|---|---|
| Unskilled female short experience | 0.783 | (0.089) |
| Unskilled male medium experience | 1.452 | (0.105) |
| Unskilled female medium experience | 1.095 | (0.100) |
| Unskilled male long experience | 1.402 | (0.079) |
| Unskilled female long experience | 1.125 | (0.063) |
| Low education male short experience | 1.166 | (0.087) |
| Low education female short experience | 1.075 | (0.115) |
| Low education male medium experience | 1.631 | (0.102) |
| Low education female medium experience | 1.543 | (0.144) |
| Low education male long experience | 1.697 | (0.095) |
| Low education female long experience | 1.689 | (0.156) |
| Medium education male short experience | 1.632 | (0.363) |
| Medium education female short experience | 0.965 | (0.351) |
| Medium education male medium experience | 2.247 | (0.235) |
| Medium education female medium experience | 1.557 | (0.363) |
| Medium education male long experience | 2.000 | (0.142) |
| Medium education female long experience | 1.980 | (0.280) |
| High education male short experience | 2.305 | (0.591) |
| High education female short experience | 3.143 | (0.982) |
| High education male medium experience | 2.391 | (0.364) |
| High education female medium experience | 2.100 | (0.887) |
| High education male long experience | 2.392 | (0.262) |
| High education female long experience | 2.012 | (0.560) |
| | | |
| *Other regressors:* | | |
| log L | 0.039 | (0.003) |
| log K/L | 0.049 | (0.004) |
| log investments | 0.005 | (0.001) |
| | | |
| Dummies | Included[1] | |
| $R^2$-adj. | 0.4776 | |
| RMSE | 0.1580 | |
| Obs. | 7122 | |

Estimated simultaneously with production function (cf. Table 3) using maximum likelihood. Robust standard errors in parentheses.

$R^2$-adj. and RMSE applies to least squares single equation estimation.

[1] Included dummies: Industry (2-digit), region, age of plant, ownership, and type of plant.

**Table 3.** Estimates of the plant level production function (4) and (5). Dependent variable: log value added measured in factor prices

*Translog parameters:*

| | | |
|---|---|---|
| $\alpha_K$ | 0.066 | (0.078) |
| $\alpha_L$ | 0.724 | (0.126) |
| $\beta_{KK}$ | 0.042 | (0.009) |
| $\beta_{LL}$ | 0.025 | (0.017) |
| $\beta_{KL}$ | -0.022 | (0.011) |
| log investments | 0.018 | (0.002) |

*Relative productivity parameters ($\phi$'s):*

| | | |
|---|---|---|
| Unskilled female short experience | 0.845 | (0.229) |
| Unskilled male medium experience | 1.867 | (0.299) |
| Unskilled female medium experience | 1.458 | (0.283) |
| Unskilled male long experience | 1.473 | (0.194) |
| Unskilled female long experience | 1.209 | (0.160) |
| Low education male short experience | 1.302 | (0.235) |
| Low education female short experience | 0.924 | (0.272) |
| Low education male medium experience | 1.906 | (0.278) |
| Low education female medium experience | 1.848 | (0.405) |
| Low education male long experience | 1.608 | (0.216) |
| Low education female long experience | 1.885 | (0.379) |
| Medium education male short experience | 2.051 | (1.178) |
| Medium education female short experience | 0.054 | (1.382) |
| Medium education male medium experience | 2.750 | (0.658) |
| Medium education female medium experience | 1.574 | (1.068) |
| Medium education male long experience | 2.187 | (0.364) |
| Medium education female long experience | 3.287 | (0.949) |
| High education male short experience | 3.281 | (1.823) |
| High education female short experience | 3.566 | (3.180) |
| High education male medium experience | 3.169 | (1.281) |
| High education female medium experience | 4.007 | (2.550) |
| High education male long experience | 2.045 | (0.696) |
| High education female long experience | 1.624 | (1.182) |

| | |
|---|---|
| Dummies: | Included[1] |
| $R^2$-adj. | 0.9197 |
| RMSE | 0.3251 |
| Obs. | 7122 |

Estimated simultaneously with wage equation (cf. Table 2) using maximum likelihood.
Robust standard errors in parentheses.
$R^2$-adj. and RMSE applies to least squares single equation estimation.
[1]Included dummies: Industry (2-digit), region, age of plant, ownership, and type of plant.

## Table 4. Estimated coefficients for dummy variables

| | Wage equation | | Production function | |
|---|---|---|---|---|
| Food, beverages and tobacco (ISIC 31) | -0.057 | (0.008) | -0.071 | (0.019) |
| Textiles (ISIC 32) | 0.019 | (0.012) | 0.049 | (0.025) |
| Wood and wood products (ISIC 33) | -0.087 | (0.007) | -0.010 | (0.014) |
| Paper and paper products (ISIC 34) | 0.039 | (0.009) | 0.006 | (0.017) |
| Chemicals (ISIC 35) | 0.003 | (0.010) | 0.063 | (0.024) |
| Mineral products (ISIC 36) | 0.015 | (0.013) | 0.107 | (0.029) |
| Basic metals (ISIC 37) | 0.001 | (0.015) | 0.023 | (0.038) |
| Other manufacturing industries (ISIC 39) | -0.025 | (0.022) | -0.011 | (0.038) |
| $0 < \text{Age} \le 2$ | 0.042 | (0.013) | -0.059 | (0.036) |
| $2 < \text{Age} \le 4$ | 0.032 | (0.017) | -0.050 | (0.038) |
| $4 < \text{Age} \le 9$ | 0.036 | (0.007) | 0.017 | (0.015) |
| $9 < \text{Age} \le 14$ | 0.010 | (0.008) | 0.009 | (0.017) |
| Regional subsidy zone 1 | -0.169 | (0.016) | -0.245 | (0.038) |
| Regional subsidy zone 2 | -0.135 | (0.078) | -0.127 | (0.018) |
| Regional subsidy zone 3 | -0.098 | (0.007) | -0.082 | (0.016) |
| Regional subsidy zone 4 | -0.070 | (0.006) | -0.046 | (0.012) |
| Regional subsidy zone 5 | -0.046 | (0.008) | -0.011 | (0.021) |
| Publicly owned | 0.004 | (0.019) | -0.030 | (0.046) |
| Foreign share 20-49 percent | 0.074 | (0.016) | 0.168 | (0.042) |
| Foreign share 50+ percent | -0.001 | (0.046) | 0.034 | (0.100) |
| Main plant in multi-plant establishment | -0.019 | (0.006) | -0.032 | (0.013) |
| Minor plant in multi-plant establishment | 0.017 | (0.008) | -0.032 | (0.013) |
| Assistance department | 0.115 | (0.023) | 0.035 | (0.041) |

Robust standard errors in parentheses.
The largest categories have been chosen as the level of reference. These are: Metal products, machinery and equipment (ISIC 38), Plant age>14, Regional subsidy zone 6, Foreign share 0-19 percent, Single plant firm.

**Table 5. Results from constrained (MD) estimation. Full sample**

|  | Relative wages | | Relative productivity | | p-value relative wages = relative prod. |
|---|---|---|---|---|---|
| Female | 0.818 | (0.009) | 0.829 | (0.022) | 0.589 |
| Medium experience | 1.385 | (0.037) | 1.624 | (0.106) | 0.013 |
| Long experience | 1.377 | (0.026) | 1.332 | (0.064) | 0.431 |
| Low education | 1.200 | (0.013) | 1.096 | (0.032) | 0.000 |
| Medium education | 1.497 | (0.035) | 1.550 | (0.091) | 0.466 |
| High education | 1.821 | (0.067) | 1.798 | (0.177) | 0.868 |
| # of plants | | 7122 | | | |
| Chi-sq. (d.f.=34) | | 30.42 | | | |

Standard errors in parentheses.

**Table 6. Internal rates of return for different levels of education**

|  | Private returns (wages) | | | Social returns (productivity) |
|---|---|---|---|---|
|  | Before tax | After tax, without stipends | After tax, with stipends | |
| Low education (vs. unskilled) | 5.6% | 5.1% | 5.1% | 1.3% |
| Medium education (vs. low education) | 11.6% | 9.3% | 10.4% | 18.7% |
| High education (vs. medium education) | 5.8% | 4.4% | 5.0% | 3.9% |

**Table 7a. Results from constrained (MD) estimation. 1986-1989**

|  | Relative wages | | Relative productivity | | p-value relative wages = relative prod. |
|---|---|---|---|---|---|
| Female | 0.815 | (0.009) | 0.830 | (0.221) | 0.424 |
| Medium experience | 1.361 | (0.036) | 1.510 | (0.084) | 0.043 |
| Long experience | 1.330 | (0.024) | 1.229 | (0.049) | 0.027 |
| Low education | 1.241 | (0.015) | 1.158 | (0.032) | 0.003 |
| Medium education | 1.557 | (0.040) | 1.457 | (0.086) | 0.154 |
| High education | 1.747 | (0.066) | 1.446 | (0.148) | 0.015 |
| # of plants | | 6178 | | | |
| Chi-sq. (d.f.=34) | | 37.12 | | | |

Standard errors in parentheses.

**Table 7b. Results from constrained (MD) estimation. 1990-1993**

|  | Relative wages | | Relative productivity | | p-value relative wages = relative prod. |
|---|---|---|---|---|---|
| Female | 0.824 | (0.010) | 0.815 | (0.026) | 0.702 |
| Medium experience | 1.245 | (0.031) | 1.294 | (0.081) | 0.501 |
| Long experience | 1.294 | (0.025) | 1.148 | (0.059) | 0.010 |
| Low education | 1.123 | (0.013) | 1.034 | (0.033) | 0.004 |
| Medium education | 1.370 | (0.032) | 1.507 | (0.088) | 0.078 |
| High education | 1.838 | (0.065) | 2.045 | (0.159) | 0.114 |
| # of plants | | 5310 | | | |
| Chi-sq. (d.f.=34) | | 33.93 | | | |

Standard errors in parentheses.

## Table 8a. Results from constrained (MD) estimation. Large plants

| | Relative wages | | Relative productivity | | p-value relative wages = relative prod. |
|---|---|---|---|---|---|
| Female | 0.813 | (0.009) | 0.754 | (0.023) | 0.005 |
| Medium experience | 1.463 | (0.060) | 1.573 | (0.146) | 0.388 |
| Long experience | 1.417 | (0.039) | 1.202 | (0.080) | 0.004 |
| Low education | 1.258 | (0.018) | 1.098 | (0.038) | 0.000 |
| Medium education | 1.489 | (0.043) | 1.235 | (0.102) | 0.005 |
| High education | 2.079 | (0.077) | 2.062 | (0.164) | 0.893 |
| # of plants | | 3561 | | | |
| Chi-sq. (d.f.=34) | | 76.68 | | | |

Standard errors in parentheses.

## Table 8b. Results from constrained (MD) estimation. Small plants

| | Relative wages | | Relative productivity | | p-value relative wages = relative prod. |
|---|---|---|---|---|---|
| Female | 0.820 | (0.013) | 0.847 | (0.053) | 0.567 |
| Medium experience | 1.268 | (0.039) | 1.466 | (0.176) | 0.220 |
| Long experience | 1.305 | (0.029) | 1.294 | (0.115) | 0.919 |
| Low education | 1.149 | (0.016) | 1.079 | (0.061) | 0.197 |
| Medium education | 1.445 | (0.042) | 1.587 | (0.174) | 0.378 |
| High education | 1.580 | (0.080) | 1.399 | (0.315) | 0.497 |
| # of plants | | 3561 | | | |
| Chi-sq. (d.f.=34) | | 21.38 | | | |

Standard errors in parentheses.

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