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Experience and Schooling: Substitutes or Complements?

Abstract:
This paper investigates whether returns to experience and seniority vary between workers with different levels of education and between different types of firms. Using a large administrative dataset for Norwegian manufacturing, I find that more educated workers have higher experience and seniority premiums, indicating that they accumulate more human capital (both general and firm-specific) than workers with less education. Firm characteristics are also found to be important for experience and seniority premiums. Indicators of technological change seem to be more important for returns to experience and seniority than indicators of technological level. The results suggest that workers learn from their colleagues, and that they learn the skills that their colleagues possess.

Keywords: Wages, experience, seniority, firm and worker characteristics,linked employer-employee data.

JEL classification: J24, J31.

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1 Introduction

An important question when designing educational policies is whether skills acquired in school and on the job are complements or substitutes. Heckman (2000) argues that the former is the case: Complementarity between schooling and on-the-job human capital accumulation implies that it is more profitable to invest in the skills for skilled workers, while substitutability means that there is more to gain from investing for the less skilled, and that workplace training may easily compensate for a lack of skills from formal schooling. This has implications for returns to experience and firm-specific seniority in the labor market. If the complementarity hypothesis is correct, it implies larger returns to experience and seniority for more educated workers. A related hypothesis is that educated workers to a greater extent are able to generalize knowledge acquired on the job, making it useful also in other work environments. If this is the case, the importance of seniority premiums (relative to experience premiums) will be greater for less educated workers.

During the last fifteen years, a number of studies have estimated the returns to labor market experience and firm-specific seniority, but there has been little focus on differences between types of workers. In addition to variations between types of *workers*, there may also be variations between types of *firms* with respect to returns to experience and seniority. However, there are few studies of the importance of firm characteristics in this respect[1].

Both the scope for and the returns to on-the-job human capital accumulation may vary with characteristics of the firm. If a worker learns more the more skilled (along some dimension) his colleagues are, then experience and/or seniority premiums will be higher in firms with a highly skilled workforce. Technologically advanced environments are more skill-demanding but also offer more learning opportunities. It is not obvious, however, what skills that are more important where the technological *level* is high. It may be that advanced technologies require more on-the-job training to be mastered. On the other hand, skill obsolescence is more rapid in such environments. If this is the case, experience and seniority premiums will be relatively large for the first few years and flatten out in technologically advanced firms. The returns to experience and seniority may also depend on the rate of technological *change*. By definition, technological change makes technology-specific skills obsolete. As Howitt (1998) notes, "..there are many examples (secretaries, middle management, mainframe computer programmers, electrical engineers) where

[1] This is probably due to a lack of comprehensive linked employer-employee datasets. The potential value for researchers of such datasets has long been appreciated (see e.g. Willis, 1986), but to some extent they have become available only recently. Over the last few years, a number of studies using linked employer-employee data have been published, see Abowd and Kramarz (1999) for a survey.

the information revolution has forced people to undertake substantial knowledge investments to avoid economic losses." In other words, technological change tends to depreciate specific knowledge attained on the job. However, technological change often comes hand in hand with organizational change, cf. Bresnahan (1999). Such changes may depreciate specific human capital in the form of knowledge of the organization of the firm. However, it may also appreciate the same capital. Successful implementation of new technology (see Bartel and Lichtenberg, 1987) and new organizational structure may depend on highly skilled key personnel who knows the firm well. Such personnel will often be highly educated workers with long seniority. We may therefore expect technological change to have adverse effects on the seniority premiums of workers with low education, while the effects on highly educated workers are ambiguous.

In this paper, I address the issues described above using a comprehensive linked employer-employee dataset for Norwegian manufacturing industries, focusing on the role of firm and worker characteristics on returns to experience and seniority. Workers are classified with respect to their level of education, while plants are classified by the composition of their workforce (by education, experience and seniority) and by indicators of technological level and technological change. My main finding is that worker and firm characteristics do matter for the returns to experience and seniority. There are large variations in returns across types of workers and plants. Seniority and experience premiums are found to increase with the level of education. This indicates that educated workers continue to accumulate more human capital also on the job than their less educated colleagues and have a higher wage growth throughout their career. The returns to seniority and experience in high-tech industries are found to be similar to those of manufacturing as a whole, while they are higher in plants with high investment levels. They are also affected by the composition of the plant's workforce: Workers seem to take advantage of the skills of their colleagues, and this is reflected in experience and seniority premiums.

There are not many studies that compare experience and seniority premiums for different types of workers and firms. Topel (1991) compares white- and blue-collar workers, while Manning (1998) compares the premiums for workers of different educational levels. Both find that the differences in premiums between worker categories are small. Bratsberg and Terrell (1998) compare white and black young males and find similar seniority premiums but higher experience premiums for whites. Bronars and Famulari (1995), using a US worker-establishment dataset, find significant dispersion in within-job wage growth across employers, even when conditioning on worker characteristics. Margolis (1996) and Abowd, Kramarz and Margolis (1999), analyzing French data, find significant heterogeneity in returns to seniority between firms. Since their data sets do not contain detailed firm characteristics, they are not able to address the question of what kind of firms that offer high wage growth. Møen (2000) compares experience-earnings profiles for workers with technical education in R&D-intensive firms versus other firms in Norwegian manufacturing. He finds that the former group has a steeper wage growth over the career, but that they have lower starting wages.

2 Estimating returns to experience and seniority

Estimated earnings functions typically show positive coefficients for education, experience and seniority. The traditional interpretation of such findings comes from human capital theory, originally put forward by Becker (1964): The coefficient for schooling reflects human capital acquired through formal education, the experience coefficient reflects general human capital acquired on the job, while the seniority coefficient reflects human capital specific to the individual's current job[2].

However, there exist other plausible interpretations. Lazear (1981) considers delayed compensation - in the form of a rising wage profile - as a device of stimulating worker efforts and reduce costly quits. The key element is that the firm and the worker enter into a contract (explicit or implicit) where wages are below marginal product at the beginning of the employment relationship and above marginal product towards the end. This will reduce shirking and other kinds of misbehavior at work, since a worker who is caught shirking and fired will not reap the benefits of higher wages towards the end of the contract period. Salop and Salop (1976) show that a rising wage profile may induce self-selection of high productivity (i.e. low quit propensity) workers. Both theories predict that it may be optimal for a firm to have workers' wages increasing with seniority, even if senior workers are not more productive than junior workers.

[2] If the accumulated human capital is *general* in the sense that it is useful also at other employers, Becker argues that the employer will be unwilling to pay the direct costs of training and/or indirect costs of forgone output associated with the human capital investment. Accumulation of general human capital on the job is therefore financed by the worker through a lower wage in the investment (training) period. Since the length of a career is finite, it is optimal to invest more in the beginning of the career. Wages will increase with experience for two reasons. First, as the worker's general human capital increases, his alternative wage increases, and therefore his wages are adjusted accordingly. Second, as training costs paid by the worker through lower wages diminish, wages rise. If the cost of investment consists purely of forgone output, wages should equal marginal productivity at any point in time. If human capital accumulated on the job is *specific*, Hashimoto (1981), by formalizing Becker's original idea, shows that with the existence of transactions costs in assessing worker productivity, it is optimal for firms and workers to share costs and benefits of investments in specific human capital. The implication of this is that wages will rise with plant-specific seniority, but at a slower pace than productivity. Recent studies, cf. Acemoglu and Pisckhe (1999) and the references listed there, show that firm-sponsored training often produces knowledge that is useful not only within the firm. That firms pay for general training poses a challenge to traditional human capital theory. In the traditional framework, the labor market is assumed to be competitive. The fundamental point in Acemoglu and Pischkes argument is that *general human capital is made specific by labor market imperfections*, and this induces firm-sponsored general training. This implies that in the presence of labor market imperfections, the wage structure does not reveal the *intrinsic* generality/specificity of human capital, but rather its generality/specificity given the structure of the labor market.

Search, matching and self-selection mechanisms may also generate a positive relationship between wages and experience and seniority, without any human capital accumulation on the job nor incentive contracts, and with wages equalling productivity at any time. Jovanovic (1979a,b) provide two examples of such models.

Experienced workers have had more opportunities to find a good match, and are better matched on average. This generates a positive wage-experience relationship, and also a positive correlation between experience and seniority. Well-matched workers search less for new jobs, are less likely to accept new job offers, and therefore tend to stay longer in their jobs. As Topel (1991) emphasizes, the wage-seniority relationship may also result from different mobility patterns of workers of different ability. If more productive workers are more stable (less mobile and/or less likely to be laid off), there will be a positive relationship between wages/productivity and seniority, even without any human capital accumulation on the job.

Different approaches have been suggested to control for search, matching and self-selection effects when estimating returns to experience and seniority. To fully discriminate between human capital accumulation and delayed compensation mechanisms, one needs data on productivity or performance. This paper takes a non-structural approach, see Altonji and Shakotko (1987) and Topel (1991). The point of departure is a standard Mincer equation. Taking into account that the error term may be correlated with experience and seniority due to optimizing behavior (i.e. endogenous mobility) by workers, one tries to eliminate (some of) the endogeneity bias by e.g. differencing or using instrumental variables[3]. The next section presents the econometric model, which follows Topel (1991).

3 Econometric specification

The following wage model is the point of departure in many studies of returns to seniority[4]:

$$w_{ijt} = \alpha + \beta_X X_{it} + \beta_S S_{ijt} + \varepsilon_{ijt} \tag{1}$$

[3] There are also other approaches in the literature. The *structural approach*, see e.g. Wolpin (1992) and Manning (1998), attempts to explicitly model the behavioral process of search, matching and turnover. Another approach is to look for exogenous variations in seniority, rather than to try to model or control for the endogenous variation. This *quasi-experimental approach* utilizes information on earnings losses for workers whose jobs are terminated for exogenous reasons, e.g. plant closings. An example of this approach is Jacobson, LaLonde and Sullivan (1993).

[4] The framework in this paper assumes that conditional on observable characteristics, returns to experience and seniority are homogeneous across individuals. The econometric framework developed by Dustmann and Meghir (1999) allows for unobserved heterogeneity in learning potential across individuals and different possibilities for human capital accumulation across firms, and accounts for workers' self-selection (through job-shopping) into firms offering the optimal learning package.

where w_{ijt} is the real log wage of individual i in firm j at time t, X_{it} is total labor market experience, S_{ijt} is seniority with the current employer, and ε_{ijt} is an error term. Other variables may also be included in (1), such as gender, education, industry as well as higher order terms of experience and seniority and interaction with firm and worker characteristics, but they are omitted here for the ease of exposition. Assume that the error term may be decomposed into the following terms:

$$\varepsilon_{ijt} = \psi_i + \phi_{ij} + u_{ijt} \tag{2}$$

ψ_i is a fixed individual specific error component, while ϕ_{ij} is a match specific term. The latter captures both a firm effect and a pure match effect. u_{ijt} has classical properties. This error structure implies that within-job wage innovations are serially uncorrelated, which implies that past wage changes are not informative of future wage changes, and that heterogeneity among jobs in predictable wage growth is assumed away[5].

Consider the following auxiliary regressions (see Altonji and Williams, 1997):

$$\phi_{ij} = b_X X_{it} + b_S S_{ijt} + e_{ijt} \tag{3}$$

$$\psi_i = c_X X_{it} + c_S S_{ijt} + v_{ijt} \tag{4}$$

If there is job shopping over a career, and workers tend to end up in better matches as their labor market experience and hence the number of job offers (possible matches) they have received increase, b_X is positive. The sign of b_S is ambiguous: If a good match makes a worker less likely to quit her job, or if it reduces the risk of being laid off, b_S will tend to be positive. However, voluntary job changers gain from their move, and will be in the sample with low S_{ijt} and high ϕ_{ij}. This will tend to make b_S negative. Altonji and Williams (1997) point out that given $cov(\psi_i, X_{it}) = 0$, $cov(\psi_i, S_{ijt}) > 0$ and $cov(X_{it}, S_{ijt}) > 0$, then c_X is negative and c_S is positive in. As is clear from the discussion above, OLS on (1) will produce biased estimates. It is difficult to assess the direction and magnitude of the OLS bias, cf. Altonji and Williams (1997).

Topel (1991) proposes a two-stage estimator to estimate the returns to seniority and experience. The first step estimates (1) in first differences

$$\Delta w_{ijt} = \beta_X + \beta_S + \Delta u_{ijt} \tag{5}$$

utilizing that individual and match-specific errors are constant and vanish when taking first differences. Estimation of (5) by OLS gives a consistent estimate of the sum of the experience

[5] Following Topel and Ward (1992), I test this assumption on the estimating sample. A null hypothesis of serially uncorrelated within-job wage innovations is not rejected.

and seniority effects $\beta_X + \beta_S$[6]. In the second stage, β_X is estimated separately by the following equation:

$$w_{ijt} - (\beta_X + \beta_S)\, S_{ijt} = \alpha + \beta_X X_{ij0} + \varepsilon_{ijt} \tag{6}$$

where X_{ij0} denotes labor market experience at the start of the employment relationship (i.e. $X_{ij0} = X_{it} - S_{ijt}$).

Extending the model to allow experience and seniority premiums to vary with *worker* characteristics is straightforward. When allowing for interaction with *firm* characteristics, the first stage is straightforward since it estimates higher order terms and the sum of first-order effects from within-job changes. The second stage, however, identifies the first order experience from initial experience, that is, experience accumulated in other firms, whose characteristics often are unobserved. If we choose not to confine the analysis to workers whose entire labor market careers are observed in the data, i.e. young workers, we can either assume that experience premiums are homogeneous across firms, which implies that accumulation and remuneration of general human capital is the same in all types of firms, given individual worker characteristics. Or we can assume that experience premiums in workers' previous employment relationships equal those of the current. This allows for differences in experience premiums across firms, but assumes that the type of the current firm is a good proxy for the type of previous firms.

Bias

Since both ψ_i and ϕ_{ij} are likely to be correlated with X_{ij0}, the Topel estimator will produce biased results. There is also a negative correlation between X_{ij0} and ψ_i. This gives a downward bias in the estimate of β_X, and hence an upward bias of β_S. Topel shows that the bias in the estimators equal:

$$\begin{aligned} E\beta_X^{TOPEL} - \beta_X &= b_X + \gamma_{X_oS}\,(b_X + b_S) + \gamma_{X_0\psi} \\ E\beta_S^{TOPEL} - \beta_S &= -b_X - \gamma_{X_oS}\,(b_X + b_S) - \gamma_{X_0\psi} \end{aligned} \tag{7}$$

where γ_{X_oS} is the coefficient from a regression of seniority on initial experience, and $\gamma_{X_0\psi}$ is the coefficient from a regression of the unobserved individual effect on initial experience. The likely positive correlation between experience and match quality ($b_X > 0$), contributes to a positive bias in the estimated returns to experience and the opposite for the seniority premium. It is not

[6] Topel (1991) notes that if change of job is a result of optimizing behavior, then workers will leave bad jobs (in terms of offering low wage growth). The jobs included in estimation of (5) may therefore be a selected sample of surviving jobs ("stayers"), which may have experienced a higher growth rate. Thus estimation of (5) may give an upward biased estimate of $\beta_X + \beta_S$.

possible to assess the size of b_X, but the other terms in the bias expression may be estimated. Since we have assumed in (3) that $E\phi_{ij} = b_X X_{it} + b_S S_{ijt} = b_X X_{ij0} + (b_X + b_S) S_{ijt}$, $b_X + b_S$ may be estimated by inserting $(b_X + b_S) S_{ijt}$ on the right hand side of (6) and use least squares. $\gamma_{X_o S}$ may be estimated by least squares on the estimating sample.

$\gamma_{X_0 \psi}$ is not directly observable or estimable. Topel argues that the importance of this bias component can be assessed by instrumenting for initial experience in the second step. A valid instrument is total experience, which is correlated with initial experience but uncorrelated with the individual effect. The bias of the IV estimator is:

$$\begin{aligned} E\beta_X^{IV} - \beta_X &= b_X + \frac{\gamma_{XS}}{1-\gamma_{XS}} (b_X + b_S) \\ E\beta_S^{IV} - \beta_S &= -b_X - \frac{\gamma_{XS}}{1-\gamma_{XS}} (b_X + b_S) \end{aligned} \tag{8}$$

where γ_{XS} is the coefficient from a regression of seniority on total experience. By combining (7) and (8) we get an estimate of $\gamma_{X_0 \psi}$.

4 Sample and variable construction

Individual level data The main data source for this study is the Norwegian system of register data, established and maintained by Statistics Norway. In this integrated data base, individual information about essentially all Norwegian residents is gathered from a number of governmental administrative registers. In addition to basic demographic information, the system contains information about education, income and employment relations.

The dataset used in this study covers the years from 1986 to 1995. The focus is on manufacturing industries, mainly because data on plant characteristics is more readily available in manufacturing, see below. I have restricted the analysis to males. Females have on average different career patterns than males, often with a looser connection to the labor market because of childbearing etc. Since the dataset does not have information on actual labor market experience, we have to rely on potential experience, which overstates actual experience to a greater extent for females. Individuals younger than 20 and older than 64 were excluded from the sample. Experiments with other exclusion criteria, such as restricting the sample to 25-54 year olds, had only minor effects on the results. Self-employed and part-time workers were excluded. Information about hours worked are available in broad intervals only: Less than 4 hours, 4-19 hours, 20-29 hours, and 30 hours or more per week. I have restricted the sample to full-time workers, defined as individuals working 30 hours or more per week.

The earnings measure used is total annual taxable labor income. (Wages and earnings will be used interchangeably throughout the paper). Since the earnings measure reflects annual earnings, observations whose employment relationships started or terminated within the actual year was deleted (here, short leaves have not been ignored, see below). Individuals that have received labor market compensation or have participated in active labor market programs have been excluded. The individuals in the sample have thus been working full time for their main employer the entire year. The dataset also has information on the number of additional employment relationships (multiple jobs). Where relevant, this has been controlled for by using dummies for the number of additional jobs.

The dataset contains information on the highest completed level of education for each individual. The measure of years of schooling is the standard number of years necessary to complete this level. It does not necessarily reflect the actual number of years spent in school, since an individual may use shorter or longer time than standard to complete an education. Observations with missing information on education, or reported education of less than seven years, which was the compulsory amount of schooling in early post-war years, have been excluded. Due to a considerably lower quality of data on educational attainment, foreign-born individuals have been excluded from the sample. I allow for different returns to experience and seniority across broad educational categories, defined as *primary* (up to 9 years of schooling), *secondary* (10-12 years) and *tertiary* education (13 years or more).

The measure of plant-specific seniority is constructed as follows: In the data, individuals' labor market status and employer is reported for the second quarter of the year. For individuals with multiple employment relationships, their main employer is reported. The starting date of this relationship is also reported, along with the termination date, if the relationship ends within the given year. The registration of starting and termination dates started in May 1978. For a number of the employment relationships that existed at that date, there was no reliable information on the starting date, and a starting date of April 30, 1978 was imputed in the register. These observations have been excluded from the sample. This gives a sample that is biased in favor of short seniority relationships, though it is less serious for later years. However, experiments with various specifications show that this exclusion only has minor effects on the results. The data show a number of short breaks in employment relationships, in that a person-plant relationship terminates but is started up again shortly afterwards. Since it is probably the case that a person who temporarily quits a job still has some seniority if he returns shortly afterwards, I have ignored leaves of less than six months when calculating plant-specific seniority. Seniority is then calculated as the time since the start of the employment relationship, evaluated at the end of the year considered. The experience measure used is potential labor market experience, defined as age minus years of schooling minus seven, which is the standard school-starting age. In the estimating equations, seniority and experience are included as quartics.

Individuals with annual earnings below NOK 50 000 (1986 value) have been excluded from the sample, since this suggests that the individual has not been working full time for the entire year. In addition, a cross-section regression of log annual earnings on education, experience, seniority, county, and industry was performed, and observations with the absolute value of a standardized residual greater than 3 were deleted.

The Topel estimator requires at least two observations of an employment relationship. The sample is therefore restricted to employment relationships with at least two consecutive observations meeting the above criteria. Individuals who change their level of education during the estimation period have been excluded. The main reason for this is that it suggests that the individual may not have been working full time. Individuals with large fluctuations in year-to-year earnings (more than +/- 0.4 log points) were also excluded. Finally, I also excluded observations to which I was unable to match information on plant characteristics, either because of an imperfect match between the register data system and the manufacturing statistics (see below) or because of missing plant-level observations.

Details of the trimming procedure is given in Table 1 . The final sample consists of more than 830 000 individual-year observations. Table 2 provides summary statistics for key individual level variables.

Plant characteristics The information on characteristics of the workforce of the plants is taken from the same source as above. Average years of schooling, experience and seniority have been calculated. In these calculations, I have not excluded females, observations with "extreme" reported earnings, changing level of education, missing consecutive observations etc. Part-time workers have not been excluded, but they have been weighted according to their expected hours worked. Neither have observations with registered starting date of April 30, 1978 been excluded. For these observations, I have imputed seniority as average seniority within gender, age and experience categories of individuals with an earlier registered starting date.

For other plant characteristics, I utilize information from the "Time Series Files" for Norwegian manufacturing establishments which are constructed from the annual manufacturing census carried out by Statistics Norway, see Halvorsen, Jensen and Foyn (1991) and Statistics Norway (1997) for documentation. I use information on the number of employees in the plant, the age of the plant, and on investments and capital stock. Constructing a proxy for (embodied) technological change, I use the plant's investments in machinery and define an investment ratio as the machinery investments in the last three years divided by the machinery capital stock. The measure of the capital stock is based on reported fire insurance values. There are a lot of missing observations, and little effort has been made to identify and correct erroneous reports on this point. Following Klette (1999), I have also calculated the capital stock in year t using the perpetual inventory method based on fire insurance values and investment figures in year *t-1* and *t+1,* where available. The mean of the three estimates of the capital stock is then used. For all plant characteristics, I assume that the figures are relatively constant over time, and I calculate a plant average for the period 1986-90 and 1991-95, respectively. A plant is defined as "high-tech" if it belongs to the industries manufacture of machinery (ISIC 382), manufacture of electrical equipment (ISIC 383) and manufacture of technical instruments (ISIC 385). Table 3 provides summary statistics for key plant level variables.

5 Empirical results

5.1 Homogeneous returns specification

My results confirm the findings of earlier studies that returns to seniority in Norway are modest. Table 4a presents estimates where returns to experience and seniority are assumed to be identical across educational groups, using both OLS and the Topel procedure[7]. In Table 4b, experience and seniority premiums are calculated on the basis of the estimates in Table 4a. The estimated ten-year seniority premium is 2.3 percent, while the ten-year experience premium is 33.3 percent. Hence, seniority premiums are almost negligible compared to experience premiums. Table 4a and 4b show that the Topel method yields lower seniority premiums and higher experience premiums than OLS. When estimating experience and seniority profiles, I control for a number of worker and plant characteristics that may influence earnings, some of them are reported in Table 4a. A higher share of females in the plant are associated with lower wages for male workers: A male worker in a plant with no females earns 2.9 percent more than in a plant where females constitute half the workforce.

Wages, conditional on the worker's individual characteristics, also increase with the average education of the plant's workforce. The effect of one extra year of average education on individual wages is almost four percent. One possible explanation of this finding is the O-ring theory of Kremer (1993): Production processes consist of multiple, complementary tasks. Individual

[7] I have also carried out estimations using the method proposed by Altonji and Shakotko (1987) for most of the specifications presented in this paper. I do not report results, but in most cases, they are qualitatively similar to those obtained using the Topel procedure.

marginal productivity increase with education, hence the cost of failure (by workers of all education levels) is higher in high education plants. This implies that the marginal product, and wages, of high-quality (unobserved) workers of all education levels is higher in such plants.

The effect on individual wages of plant average seniority is negative and convex within the relevant interval. A worker in a plant with average seniority of ten years earns *cet. par.* 3.5 percent less than a worker in a (hypothetical) plant with zero average seniority. For experience, the pattern is the opposite: A worker in a plant with average experience of ten years earns *cet. par.* 3.7 percent *more* than a worker in a (hypothetical) plant with zero average experience. As common in the literature, see e.g. Davis and Haltiwanger (1996), we also find that larger plants pay higher wages. The effect of capital intensity on wages is found to be slightly negative.

The results show that seniority premiums in Norway are small compared to estimates on American data, such as Topel (1991), Altonji and Williams (1997) and Bratsberg and Terrell (1998). The estimates are similar to other studies on Norwegian data: Barth (1997) finds a ten-year seniority premium of 3.6 percent, while Schøne (1999) on a sample of public sector engineers finds ten-year seniority premiums of 4 to 5 percent. This indicates that Norway has a compressed wage distribution also along this dimension[8]. Experience premiums are similar to what is found on American data.

5.2 Do returns vary with education?

Table 5a presents the results from estimating a model where returns to experience and seniority are allowed to differ between workers with primary, secondary and tertiary education. Calculated experience and seniority premiums are presented in Table 5b. Figure 1 plots these premiums graphically. Both experience and seniority premiums increase with education. Workers with primary education are found to have a ten-year seniority premium that is essentially zero, and in fact negative for higher levels of seniority. The ten-year premiums for secondary and tertiary education are 3.9 and 6.3 percent, respectively. With one exception (secondary vs. tertiary education at low levels of seniority) the differences are statistically significant. The earnings-experience profiles for primary and secondary education more or less overlap, while experience premiums for the tertiary category are significantly higher. The ten-year experience premiums are 29.6 percent for primary, 30.7 percent for secondary, and 41.2 percent for tertiary education. The estimated effects of plant characteristics are very similar to the model with homogeneous returns.

[8] Several studies have documented that Norway has a compressed wage distribution, at least compared to the US, see e.g. Aaberge et al. (2000). Educational earnings differentials are modest, and they have been fairly stable in the eighties and nineties, see e.g. Barth and Røed (1999) and Hægeland, Klette and Salvanes (1999).

Combined with the finding that the coefficient for years of schooling drops when we allow for different experience and seniority premiums, this indicates that some of the returns to education are realized gradually. It lends support to the hypothesis that human capital has dynamic complementarities. Skills beget skills, and education makes human capital investment on the job more profitable, see Heckman (2000). This has implications for the design of educational policy: Workplace training may not easily compensate for formal schooling. The dynamic complementarity implies that human capital investments early in life, e.g. in primary and secondary school, are the most profitable[9].

Bias assessment

It is important to try to assess the magnitude of the bias in the estimated returns to check whether any differences in bias between educational groups may overturn any of the findings above. The potential bias arises in the decomposition of the first order effects[10]. Table 5c reports the estimated first order experience and seniority premiums using the Topel and the IV methods, and also the estimable components of the bias expressions in (7) and (8), namely $(b_X + b_S)$, γ_{X_oS} and γ_{XS}. These are estimated separately for the three educational categories. From (7) and (8) we get

$$E\beta_X^{IV} - E\beta_X^{TOPEL} + \left(\frac{\gamma_{XS}}{1-\gamma_{XS}} - \gamma_{X_oS}\right)(b_X + b_S) = \gamma_{X_0\psi}$$

Inserting estimated values for β_X^{IV}, β_X^{TOPEL}, $(b_X + b_S)$, γ_{X_oS} and γ_{XS} we get an estimate for $\gamma_{X_0\psi}$, the bias contribution from individual heterogeneity. The calculations indicate that this contribution is modest. The $-b_X$ term in the bias expression is not identified, and any conclusion on the level and change in the true seniority premium hinges on assumptions about b_X. There is no valid procedure for decomposing $b_X + b_S$ into b_X and b_S. As seen from the last row of Table 5c, the difference in the identifiable parts of the bias amounts to at most 0.9 percentage points when comparing ten-year premiums. Hence, the identifiable components of the bias do not seem to change any of the conclusions.

Have the returns changed over time?

Figure 2 graphs estimated seniority and experience profiles for 1986 and 1995 (the first and last year in the sample), coming from a specification where experience and seniority variables were

[9] Another interpretation of the differences in seniority premiums, however, is that delayed compensation schemes are more common among highly educated workers. To investigate this further, one must compare seniority premiums in terms of both wages and productivity, e.g. using an extension of the framework in Hægeland and Klette (1999).

[10] In addition, there is a potential bias arising from the sample consisting of surviving jobs, see Section 3.

interacted with a time trend. Table 6 reports the estimated differences between the two years. The results show a marked increase over time in both experience and seniority premiums for all categories. The increase in seniority premiums appear to be largest, the ten-year premiums are found to be six to eight percent higher in 1995 than in 1986, while the corresponding differences in experience premiums are from three to five percent. Using a time trend may be restrictive. Estimating for subperiods separately instead of using a time trend reveals the same pattern. A possible objection is that this may reflect business cycle conditions more than a secular increase. To check this, I ran a specification which interacted experience and seniority premiums with a business cycle indicator. The indicator used is an index of capacity utilization in Norwegian manufacturing, indicating a peak in 1986, a recession through 1992, and recovery thereafter. The results, reported in Table 7 and Figure 3, indicate that the finding above is more than a business cycle phenomenon. Experience premiums appear to be higher in booms, while the effects on seniority premiums are small.

5.3 The importance of plant characteristics

As stated in the introduction, the work environment may have importance for the scope for on-the-job human capital accumulation and its depreciation and remuneration. In this subsection, I investigate the interaction of plant characteristics and experience and seniority premiums. In Section 3, I suggested two alternative specifications. One implies that accumulation and remuneration of general human capital are the same in all types of plants, given individual worker characteristics. Hence, there is no interaction between *experience* and plant characteristics. The other specification allows for interaction between plant characteristics and both experience and seniority. This allows for differences in experience premiums across plants, but assumes that characteristics of the current plant are good proxies for the characteristics of the plants the worker has been employed in previously. Below, I report results from the second specification only. Using the first specification gave qualitatively similar results.

In the estimations, I normalize the plant characteristics as follows: Let Z_j denote a plant characteristic of plant j. Z is normalized

$$Z_j^N = \frac{Z_j - \min\left(Z_{k\in J}\right)}{\max\left(Z_{k\in J}\right) - \min\left(Z_{k\in J}\right)} \tag{9}$$

where J denotes the plants in the sample. Hence Z_j^N is between 0 and 1, except for the high-tech industry characteristic which is an ordinary dummy variable. In the estimations, Z_j^N is interacted with experience and seniority and their respective squares. separately for the three education categories. Table 8 shows the correlations between the plant characteristics I use in this studies (investment intensity, capital intensity, a dummy for high-tech industry, plant size, and average experience, seniority and education of the plant workforce). All the correlations are in the interval from -0.5 to 0.4. Hence, each of the variables may be interpreted as representing *separate* plant characteristics. The signs of the correlations are intuitive. E.g. plants with a highly educated workforce are more likely to be in the high-tech industries, they tend to be larger, have a higher rate of investment, and their workers have lower experience and seniority.

Average level of education Figure 4 graphs estimated seniority- and experience-earnings profiles. The curves marked with "o" are the profiles for the plants with the lowest average education ($Z_j^N = 0$), those with "+" are for the plants with the highest average education ($Z_j^N = 1$). Table 9 reports the estimated differences between the two profiles for 3, 5, 10 and 20 years of seniority/experience. The most striking finding is that experience premiums are higher in plants with a highly educated workforce. This applies to all three educational categories, and the estimated differences are quite large: For primary education, the difference in ten-year experience premiums between the plant with the highest education level and the plant with the lowest level is 30.7 percent, for secondary education 47.2 percent, and for tertiary education 18.8 percent. The estimated differences in seniority premiums are small, and statistically significant for secondary education only. The results indicate that working in a plant with a highly educated workforce leads to a higher rate of accumulation of *general* human capital, which is reflected in higher experience premiums. This effect seems to be strongest for workers with secondary education. Of course, this may also partly reflect general skills that workers have acquired in other plants. That seniority premiums are no higher in education intensive plants, indicates that educated workers do not pass on *specific* human capital to their colleagues to a greater extent than other workers.

Average level of experience Somewhat in contrast to having highly educated colleagues, it seems that working in plants with experienced workers facilitates learning of plant-specific rather than general skills. This can be seen from the higher seniority premiums in high-experience plants for workers with education on the secondary and, to a smaller extent, primary level in Table 10 and Figure 5. The seniority premium differences seem to come in at high seniority levels. Workers with primary and secondary education have much lower experience premiums in high-experience plants. Workers with tertiary education have lower seniority premiums if they work in high-experience plants, while experience premiums do not differ much with average plant experience for this category. The ten-year difference in seniority premiums for the three groups are 1.4, 4.5 and -24.9 percent, while the corresponding differences in experience premiums are -25.0, -24.2, -5.4 percent. Hence, total within-job wage growth is lower in high experience plants.

Average level of seniority Qualitatively, the results in Table 11 and Figure 6 are similar to those presented in the previous paragraph. In plants with a high level of average seniority, experience premiums are lower for all educational categories, while seniority premiums are higher for workers with primary and secondary education and lower for those with tertiary education than in plants with low average seniority. One interpretation of these findings is that workers with high seniority have accumulated a lot of plant-specific human capital. Working with such people stimulates the accumulation of specific human capital at the expense of general human capital, and this is reflected in higher returns to seniority and lower returns to experience. This does not seem to apply to workers with tertiary education. However, an alternative interpretation is that workers tend to stay longer in plants where seniority profiles are steeper, either because of specific human capital investments or as a discipline device.

Investment intensity The most striking result from Table 12 and Figure 7 is that seniority premiums for workers with tertiary education are much higher in investment intensive plants. The ten-year seniority premium is estimated to be 30.4 percent higher in the plant with the highest investment intensity relative to the plant with the lowest intensity. For workers with secondary education, the estimated difference is 11.4 percent. For workers with primary education, the estimated difference is small. The interaction between experience premiums and investment intensity is much weaker, with somewhat higher experience premiums in investment intensive plants for workers with primary and secondary education, and the opposite for those with tertiary education.

One interpretation of this finding is that investment intensive plants are more "turbulent" workplaces in the sense of larger changes in technology, work practices and organization. It may be that the plant-specific capital of workers with low education are tightly linked to the technology in use, and that changes in technology associated with a high level of investment depreciate such knowledge, contributing to lower seniority premiums. Educated workers often have more managerial and organizational responsibilities, and *their* plant-specific capital may be more linked to the performance of such tasks. Organizational changes following high levels of investment may place greater demands on such skills, leading to higher seniority premiums, cf. Bresnahan (1999)

Capital intensity Table 13 and Figure 8 show that seniority premiums in capital intensive plants are significantly higher (10.6 percent for the ten-year premium) for workers with secondary education, while the differences are small and insignificant for other categories. Experience premiums are found to be significantly higher in capital intensive plants for workers with tertiary education, the estimated difference in ten-year premium is 14.1 percent. For primary and secondary education, the corresponding differences are negative, -8.0 and -7.5 percent respectively. Table 8 shows that capital intensity is negatively correlated with investment intensity and the high-tech industry dummy, which indicates that the technological level and its rate of change may be lower in capital intensive plants and, accordingly, that plant-specific capital depreciates more slowly. More investment in and/or less depreciation of plant-specific human capital may then lead to steeper seniority profiles in capital intensive plants. A related hypothesis is that tasks in capital intensive plants are more complicated and require more learning and investment in plant-specific capital. However, such hypotheses find support for secondary education only.

High-tech industries vs. other industries Table 14 and Figure 9 show that the differences in experience and seniority profiles between "high-tech" industries and the rest of manufacturing are small, but statistically significant. Seniority premiums are slightly lower in high-tech industries for all worker categories; the ten-year premiums are 1-3 percent lower. Experience premiums are found to be slightly higher in high-tech industries, the differences in the ten-year premiums are 3-5 percent. Given that investment intensity is a valid indicator of technological change, the result suggest that the rate of technological change, rather than the technological level itself, is more important for seniority and experience premiums.

Plant size Larger plants may have larger internal labor markets and better opportunities for within-plant job changes, which may lead to higher seniority premiums in large plants. However, the results in Table 15 and Figure 10 only supports such a hypothesis for workers with secondary education. For workers with primary education, the estimated differences are negligible, while workers with tertiary education are found to have somewhat *smaller* seniority premiums in large plants. Estimated differences are small and mostly insignificant.

6 Concluding remarks

Experience and seniority premiums differ between different types of workers and different types of plants. Using a large administrative dataset for Norwegian manufacturing, I find that more educated workers have higher experience and seniority premiums, indicating that they accumulate more human capital (both general and firm-specific) than workers with less education. The finding confirms the notion that human capital acquired in school and on the job are complements, not substitutes: The more you know, the more easily you learn. Human capital accumulation on the job does not compensate for lack of formal schooling. The second important finding is that experience and seniority premiums vary with the composition of the workforce in the plant. Workers in plants with a highly educated workforce have higher experience premiums, while workers (with low and middle education) in plants which have a workforce with high average experience or seniority are found to have higher seniority premiums. One interpretation of this is that workers learn from their colleagues, and they learn the skills that colleagues possess: Workers with high education have high general skills, while the skills of workers with long experience/seniority are more specific.

My findings also indicate that seniority premiums vary more with the rate of technological change than the technological level itself. For workers with low education, seniority premiums are found to be smaller in investment intensive plants. This is consistent with a hypothesis that the firm-specific capital of low educated workers to some extent is linked to the physical equipment they use, and if a lot of this equipment is replaced, their specific human capital depreciate, leading to lower seniority premiums. Seniority premiums of highly educated workers are higher in investment intensive plants. This may indicate that their firm-specific capital is more linked to the organization than the physical equipment, and that it becomes more essential when the rate of change is high.

The plant characteristics used in this study are admittedly imprecise indicators of the characteristics of main interest. A natural follow-up of this paper is to utilize survey information on more direct measures of technological and organizational change, to assess the validity of the interpretation of the results above. A possible extension of this analysis is to allow for individual heterogeneity in returns to experience and seniority and to analyze how workers self-select into plants offering different learning opportunities, see Dustmann and Meghir (1999). Another area for future work is to utilize insights from the literature on *industry-specific* human capital, cf. Neal (1995), to analyze whether human capital acquired in plants with a given set of characteristics more valuable in plants with similar characteristics.

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Table 1: Sample trimming procedure

Total number of observations in Norwegian manufacturing	2 969 405
- Females	764 120
- Individuals Younger than 20 or older than 64 years	132 296
- Self-employed	18 535
- Part time workers	50 411
- Individuals that were hired within the year	142 616
- Individuals that separated within the year	188 476
- Individuals registered as unemployed or on active labor market programs	95 088
- Individuals with missing education information	39 393
- Foreign-born individuals	39 244
- Individuals with unreliable seniority information	22 958
- Individuals with recorded starting date April 30, 1978	358 579
- Individuals with earnings below NOK 50 000 (1986 value)	12 163
- Individuals with extreme earnings |Standardized residual|>3	14 008
Valid single-year observations	1 091 518
- Level of education not constant	81 557
- No consecutive observations	66 108
- Individuals with large rise or fall in earnings	29 093
Sample size before including plant-level data	914 760
- Individuals in plants not included in the time series files of manufacturing statistics or with less than five employees	83 633
Main sample	831 127

Table 2: Worker characteristics

	All observations	Primary education	Secondary education	Tertiary education
Share of sample	1	0.27	0.59	0.14
Earnings (1995 prices)				
Mean	251 000	217 000	243 700	346 900
Standard deviation	79 900	48 200	66 800	102 400
10th decile	175 600	168 200	176 500	233 700
90th decile	356 000	278 900	373 900	481 900
Years of schooling				
Mean	10.68	7.95	10.97	14.61
Standard deviation	2.30	0.84	0.91	1.67
10th decile	7	7	10	13
90th decile	13	9	12	17
Experience				
Mean	21.93	28.72	19.63	18.74
Standard deviation	11.86	12.26	10.85	9.87
10th decile	7	11	7	7
90th decile	40	45	36	34
Seniority				
Mean	7.22	8.27	6.94	6.34
Standard deviation	5.85	6.73	5.52	5.10
10th decile	2.00	2.21	1.98	1.87
90th decile	13.59	15.66	13.15	12.00

Table 3: Plant characteristics

	All plants	Less than 50 employees	50-100 employees	More than 100 employees
Number of plants	9049	7662	744	643
Number of employees				
Mean	36.83	14.48	69.41	265.45
Standard deviation	99.58	10.76	14.24	280.33
10^{th} decile	5	5	52	109
90^{th} decile	75	32	90	514
Capital services (1995 prices) per employee				
Mean	71 800	69 200	71 300	103 000
Standard deviation	88 900	83 500	73 800	143 300
10^{th} decile	18 600	18 700	16 500	20 000
90^{th} decile	136 700	130 700	147 000	216 200
Years of schooling				
Mean	10.20	10.24	9.87	10.13
Standard deviation	1.29	1.32	1.03	1.07
10^{th} decile	8.75	8.75	8.77	9.05
90^{th} decile	11.83	12	11.10	11.53
Experience				
Mean	22.18	21.89	23.92	23.54
Standard deviation	7.03	7.34	4.96	4.30
10^{th} decile	13	12.38	17.54	17.90
90^{th} decile	30.8	31.14	30.12	28.51
Seniority				
Mean	6.96	6.61	8.45	9.32
Standard deviation	4.75	4.73	4.48	4.27
10^{th} decile	1.80	1.75	1.99	2.56
90^{th} decile	13.82	13.72	14.10	14.20
Share of females				
Mean	0.175	0.167	0.225	0.215
Standard deviation	0.212	0.212	0.215	0.190
10^{th} decile	0	0	0.02	0.03
90^{th} decile	0.5	0.5	0.56	0.495

Table 4a: Estimation results, homogeneous returns

Variable	OLS	Topel
Years of schooling	0.0572 (0.0003)	0.0555 (0.0003)
Seniority†	0.0152 (0.0007)	0.0114 (0.0004)
$Seniority^2$ (*10)	-0.0145 (0.0009)	-0.0135 (0.0005)
$Seniority^3$ (*100)	0.0056 (0.0000)	0.0052 (0.0002)
$Seniority^4$ (*1000)	0.0007 (0.0001)	0.0006 (0.0000)
Experience†	0.0374 (0.0009)	0.0521 (0.0008)
$Experience^2$ (*10)	-0.0104 (0.0007)	-0.0233 (0.0006)
$Experience^3$ (*100)	0.0008 (0.0002)	0.0049 (0.0002)
$Experience^4$ (*1000)	0.0000 (0.0000)	-0.0004 (0.0000)
Share of† females	-0.0638 (0.0043)	-0.0582 (0.0044)
Average education†	0.0361 (0.0008)	0.0380 (0.0008)
Average seniority	-0.0073 (0.0005)	-0.0059 (0.0005)
Average $seniority^2$ (*10)†	0.0023 (0.0003)	0.0024 (0.0003)
Average experience	0.0046 (0.0007)	0.0053 (0.0007)
Average $experience^2$ (*10)†	-0.0015 (0.0002)	-0.0016 (0.0002)
log L†	0.0209 (0.0004)	0.0205 (0.0004)
log K/L†	-0.0019 (0.0005)	-0.0019 (0.0005)
R^2	0.5671	0.8832
Sample size	831 127	831 127

Number of additional jobs, industry dummies (two digit ISIC), county dummies, year dummies and dummies for the age of the plant are included in the regressions, but not reported. Standard errors, reported in parentheses, are adjusted for heteroscedastisity and correlated error terms within individuals. For the Topel method estimates, the variance of the parameters estimated in the second step are adjusted for the sampling variance of estimated variables using the procedure in Murphy and Topel (1985). Variables estimated in the second step in the Topel procedure are marked with †. R^2 for the Topel estimation refers to the second step regression.

Table 4b: Estimated experience and seniority profiles, homogeneous returns

	3 years	5 years	10 years	20 years
Returns to seniority				
OLS	0.0340	0.0464	0.0563	0.0621
	(0.0014)	(0.0019)	(0.0021)	(0.0026)
Topel	0.0234	0.0294	0.0249	0.0049
	(0.0008)	(0.0011)	(0.0013)	(0.0021)
Returns to experience				
OLS	0.1032	0.1623	0.2791	0.4024
	(0.0021)	(0.0030)	(0.0040)	(0.0038)
Topel	0.1366	0.2081	0.3329	0.4367
	(0.0021)	(0.0030)	(0.0042)	(0.0043)

The premiums are calculated on the basis of the estimates presented in Table 4a.

Table 5a: Estimation results, heterogeneous returns

Variable	Primary education	Secondary education	Tertiary education
Years of schooling†		0.0398	
		(0.0014)	
Seniority†	0.0054	0.0141	0.0159
	(0.0007)	(0.0005)	(0.0010)
$Seniority^2$ (*10)	-0.0082	-0.0158	-0.0149
	(0.0008)	(0.0007)	(0.0016)
$Seniority^3$ (*100)	0.0030	0.0063	0.0061
	(0.0003)	(0.0003)	(0.0007)
$Seniority^4$ (*1000)	-0.0003	-0.0008	-0.0008
	(0.0000)	(0.0000)	(0.0001)
Experience	0.0440	0.0521	0.0656
	(0.0020)	(0.0011)	(0.0024)
$Experience^2$ (*10)	-0.0175	-0.0273	-0.0307
	(0.0014)	(0.0009)	(0.0022)
$Experience^3$ (*100)	0.0033	0.0065	0.0070
	(0.0003)	(0.0003)	(0.0007)
$Experience^4$ (*1000)	-0.0003	-0.0006	-0.0006
	(0.0000)	(0.0000)	(0.0001)
Share of females†		-0.0707	
		(0.0044)	
Average education†		0.0357	
		(0.0008)	
Average seniority†		-0.0063	
		(0.0005)	
Average $seniority^2$ (*10)†		0.0025	
		(0.0002)	
Average experience		0.0072	
		(0.0007)	
Average $experience^2$ (*10)†		-0.0020	
		(0.0002)	
log L		0.0190	
		(0.0004)	
log K/L†		-0.0028	
		(0.0005)	
R^2		0.8842	
Sample size		831 127	

Model is estimated using Topel's two-step method. Number of additional jobs, industry dummies (two digit ISIC), county dummies, year dummies and dummies for the age of the plant are included in the regressions, but not reported. Standard errors, reported in parentheses, are adjusted for heteroscedastisity and correlated error terms within individuals. The standard errors of the parameters estimated in the second step are adjusted for the sampling variance of estimated variables using the procedure in Murphy and Topel (1985). Variables estimated in the second step are marked with †. R^2 for the Topel method refers to the second step regression.

Table 5b: Estimated experience and seniority profiles, heterogeneous returns

	3 years	5 years	10 years	20 years
Returns to seniority				
Primary education	0.0097^{ST}	0.0101^{ST}	-0.0013^{ST}	-0.0348^{ST}
	(0.0016)	(0.0023)	(0.0034)	(0.0060)
Secondary education	0.0299^{P}	0.0387^{PT}	0.0389^{PT}	0.0320^{PT}
	(0.0011)	(0.0016)	(0.0022)	(0.0042)
Tertiary education	0.0359^{P}	0.0494^{PS}	0.0628^{PS}	0.0783^{PS}
	(0.0022)	(0.0029)	(0.0043)	(0.0097)
Returns to experience				
Primary education	0.1171^{ST}	0.1802^{ST}	0.2959^{T}	0.4064^{ST}
	(0.0049)	(0.0071)	(0.0097)	(0.0089)
Secondary education	0.1334^{PT}	0.1999^{PT}	0.3071^{T}	0.3770^{PT}
	(0.0026)	(0.0037)	(0.0049)	(0.0047)
Tertiary education	0.1709^{PS}	0.2594^{PS}	0.4116^{PS}	0.5358^{PS}
	(0.0054)	(0.0074)	(0.0088)	(0.0064)

The premiums are calculated on the basis of the estimates presented in Table 5a.
P Significantly different from primary level premium at the 1 percent level
S Significantly different from secondary level premium at the 1 percent level
T Significantly different from tertiary level premium at the 1 percent level

Table 5c: Bias assessment

	Primary education	Secondary education	Tertiary education
β_1, Topel	0.0440	0.0521	0.0656
β_1, IV	0.0455	0.0529	0.0652
β_2, Topel	0.0054	0.0141	0.0159
β_2, IV	0.0039	0.0133	0.0163
γ_{XS}	0.1364	0.1936	0.2066
γ_{X0S}	-0.1603	-0.0751	-0.0706
b_1+b_2	0.0052	0.0020	-0.0007
Implied $\gamma_{X\mu}$	0.0001	-0.0002	0.0001
Bias β_2, Topel	$-b_1$ +0.0007	$-b_1$ +0.0003	$-b_1$ - 0.0002

Table 6: Differences in experience and seniority profiles between 1986 and 1995

	3 years	5 years	10 years	20 years
Returns to seniority				
Primary education	0.0169***	0.0299***	0.0682***	0.1703***
	(0.0025)	(0.0039)	(0.0071)	(0.0151)
Secondary education	0.0154***	0.0270***	0.0610***	0.1502***
	(0.0024)	(0.0038)	(0.0064)	(0.0117)
Tertiary education	0.0205***	0.0353***	0.0763***	0.1756***
	(0.0063)	(0.0100)	(0.0188)	(0.0388)
Returns to experience				
Primary education	0.0081	0.0135	0.0270**	0.0543**
	(0.0054)	(0.0088)	(0.0164)	(0.0278)
Secondary education	0.0133***	0.0220***	0.0428***	0.0809***
	(0.0027)	(0.0043)	(0.0075)	(0.0111)
Tertiary education	0.0136***	0.0227***	0.0455***	0.0916***
	(0.0044)	(0.0070)	(0.0124)	(0.0210)

Estimated differences in seniority and experience premiums between workers in 1995 and 1986. The estimates are calculated from a model estimated using Topels two-step method with quartics in experience and seniority and quadratic interaction between a time trend and experience and seniority, separately for each of the three education levels. Other included variables are years of schooling, plant average years of schooling, plant average experience and seniority and their squares, share of females in the plant, log number of employees, log capital per employee, number of additional jobs, industry dummies (two-digit ISIC), county dummies, year dummies and dummies for the age of the plant. Standard errors, reported in parentheses, are adjusted for heteroscedastisity and correlated error terms within individuals. The standard errors of the parameters estimated in the second step are adjusted for the sampling variance of estimated variables using the procedure in Murphy and Topel (1985).

*** denotes significance at the 1 percent level
** denotes significance at the 5 percent level
* denotes significance at the 10 percent level

Table 7: Differences in experience and seniority profiles by manufacturing capacity utilization

	3 years	5 years	10 years	20 years
Returns to seniority				
Primary education	0.0103**	0.0153**	0.0216*	0.0073
	(0.0044)	(0.0071)	(0.0131)	(0.0253)
Secondary education	0.0170***	0.0271***	0.0480***	0.0718***
	(0.0030)	(0.0047)	(0.0080)	(0.0156)
Tertiary education	-0.0101	-0.0164	-0.0306	-0.0525
	(0.0065)	(0.0103)	(0.0188)	(0.0430)
Returns to experience				
Primary education	0.0178***	0.0280***	0.0479***	0.0641***
	(0.0038)	(0.0061)	(0.0104)	(0.0144)
Secondary education	0.0117***	0.0181***	0.0293***	0.0313***
	(0.0034)	(0.0055)	(0.0094)	(0.0133)
Tertiary education	0.0264***	0.0410***	0.0672***	0.0756***
	(0.0061)	(0.0095)	(0.0153)	(0.0174)

The estimates are calculated from a model estimated using Topels two-step method with quartics in experience and seniority and quadratic interaction between an index for capacity utilization (total manufacturing) and experience and seniority, separately for each of the three education levels.
See note to Table 6.

Table 8: Correlations between plant characteristics

	Investment intensity	Capital intensity	High-tech	Plant size	Average experience	Average seniority	Average education
Investment intensity	1.0000						
Capital intensity	-0.2527	1.0000					
High-tech	0.0580	-0.2360	1.0000				
Plant size	0.0067	0.2811	0.1530	1.0000			
Average experience	-0.1823	0.2110	-0.2033	0.0298	1.0000		
Average seniority	-0.1188	0.3107	-0.1554	0.2890	0.3705	1.0000	
Average education	0.1098	-0.0379	0.3415	0.1973	-0.4596	-0.1422	1.0000

Table 9: Differences in experience and seniority profiles by average education

	3 years	5 years	10 years	20 years
Returns to seniority				
Primary education	0.0023	0.0041	0.0099	0.0267
	(0.0154)	(0.0249)	(0.0464)	(0.0088)
Secondary education	0.0220**	0.0325**	0.0445*	0.0071
	(0.0090)	(0.0141	(0.0243)	(0.0463)
Tertiary education	-0.0089	-0.0127	-0.0152	0.0110
	(0.0137	(0.0213)	(0.0372)	(0.0826)
Returns to experience				
Primary education	0.1058***	0.1697***	0.3068***	0.4831***
	(0.0118)	(0.0186)	(0.0316)	(0.0420)
Secondary education	0.1659***	0.2650***	0.4724***	0.7145***
	(0.0086)	(0.0136)	(0.0234)	(0.0327)
Tertiary education	0.0644***	0.1034***	0.1876***	0.2979***
	(0.0112)	(0.0176)	(0.0294)	(0.0391)

Estimated differences in seniority and experience premiums between workers in plants with maximum average education and workers in plants with minimum average education. The estimates are calculated from a model estimated using Topels two-step method with quartics in experience and seniority and quadratic interaction between plant average education and experience and seniority, separately for each of the three education levels. See note to Table 6.

Table 10: Differences in experience and seniority profiles by average experience

	3 years	5 years	10 years	20 years
Returns to seniority				
Primary education	-0.0047	-0.0035	0.0142	0.1136*
	(0.0137)	(0.0218)	(0.0393)	(0.0746)
Secondary education	-0.0046	0.0009	0.0450**	0.2629***
	(0.0089)	(0.0136)	(0.0227)	(0.0445)
Tertiary education	-0.1072***	-0.1631***	-0.2491***	-0.1891*
	(0.0191)	(0.0294)	(0.0512)	(0.1143)
Returns to experience				
Primary education	-0.0868***	-0.1391***	-0.2503***	-0.3896***
	(0.0106)	(0.0166)	(0.0284)	(0.0381)
Secondary education	-0.0821***	-0.1323***	-0.2416***	-0.3915***
	(0.0082)	(0.0129)	(0.0219)	(0.0295)
Tertiary education	-0.0235	-0.0356	-0.0535	-0.0362
	(0.0151)	(0.0234)	(0.0384)	(0.0478)

Estimated differences in seniority and experience premiums between workers in plants with maximum average experience and workers in plants with minimum average experience. The estimates are calculated from a model estimated using Topels two-step method with quartics in experience and seniority and quadratic interaction between plant average experience and experience and seniority, separately for each of the three education levels. See note to Table 6.

Table 11: Differences in experience and seniority profiles by average seniority

	3 years	5 years	10 years	20 years
Returns to seniority				
Primary education	0.0413***	0.0659***	0.1169***	0.1743***
	(0.0109)	(0.0173)	(0.0312)	(0.0584)
Secondary education	0.0390***	0.0621***	0.1095***	0.1600***
	(0.0071)	(0.0110)	(0.0184)	(0.0357)
Tertiary education	-0.0238	-0.0534**	-0.1756***	-0.6266***
	(0.0149)	(0.0231)	(0.0402)	(0.0882)
Returns to experience				
Primary education	-0.0518***	-0.0830***	-0.1497***	-0.2339***
	(0.0079)	(0.0125)	(0.0214)	(0.0291)
Secondary education	-0.0563***	-0.0907***	-0.1654***	-0.2670***
	(0.0066)	(0.0104)	(0.0179)	(0.0250)
Tertiary education	-0.0537***	-0.0821***	-0.1277**	-0.1093***
	(0.0113)	(0.0176)	(0.0291)	(0.0378)

Estimated differences in seniority and experience premiums between workers in plants with maximum average seniority and workers in plants with minimum average seniority. The estimates are calculated from a model estimated using Topels two-step method with quartics in experience and seniority and quadratic interaction between plant average seniority and experience and seniority, separately for each of the three education levels. See note to Table 6.

Table 12: Differences in experience and seniority profiles by investment intensity

	3 years	5 years	10 years	20 years
Returns to seniority				
Primary education	0.0168	0.0246	0.0320	-0.0049
	(0.0126)	(0.0201)	(0.0367)	(0.0704)
Secondary education	0.0476***	0.0730***	0.1142***	0.1014**
	(0.0083)	(0.0130)	(0.0231)	(0.0455)
Tertiary education	0.1051***	0.1686***	0.3040***	0.4061***
	(0.0143)	(0.0222)	(0.0391)	(0.0869)
Returns to experience				
Primary education	0.0141*	0.0228*	0.0420*	0.0693**
	(0.0084)	(0.0131)	(0.0220)	(0.0276)
Secondary education	0.0176***	0.0280***	0.0494***	0.0728***
	(0.0062)	(0.0096)	(0.0158)	(0.0193)
Tertiary education	0.0003	-0.0028	-0.0218	-0.1085***
	(0.0104)	(0.0160)	(0.0259)	(0.0318)

Estimated differences in seniority and experience premiums between workers in plants with maximum investment intensity and workers in plants with minimum investment intensity. The estimates are calculated from a model estimated using Topels two-step method with quartics in experience and seniority and quadratic interaction between investment intensity and experience and seniority, separately for each of the three education levels. See note to Table 6.

Table 13: Differences in experience and seniority profiles by capital intensity

	3 years	5 years	10 years	20 years
Returns to seniority				
Primary education	-0.0035	-0.0034	0.0049	0.0572
	(0.0127)	(0.0205)	(0.0379)	(0.0700)
Secondary education	0.0288***	0.0494***	0.1060***	0.2405***
	(0.0081)	(0.0127)	(0.0218)	(0.0379)
Tertiary education	0.0004	-0.0022	-0.0188	-0.0953
	(0.0148)	(0.0234)	(0.0425)	(0.0884)
Returns to experience				
Primary education	-0.0289***	-0.0457***	-0.0796***	-0.1118***
	(0.0095)	(0.0150)	(0.0255)	(0.0340)
Secondary education	-0.0254***	-0.0410***	-0.0753**	-0.1236***
	(0.0077)	(0.0122)	(0.0208)	(0.0283)
Tertiary education	0.0468***	0.0758***	0.1407***	0.2380***
	(0.0132	(0.0204)	(0.0333)	(0.0411)

Estimated differences in seniority and experience premiums between workers in plants with maximum capital intensity and workers in plants with minimum capital intensity. The estimates are calculated from a model estimated using Topels two-step method with quartics in experience and seniority and quadratic interaction between capital intensity and experience and seniority, separately for each of the three education levels. See note to Table 6.

Table 14: Differences in experience and seniority profiles, high-tech industries vs. other industries

	3 years	5 years	10 years	20 years
Returns to seniority				
Primary education	-0.0119***	-0.0182***	-0.0279***	-0.0222
	(0.0033)	(0.0054)	(0.0100)	(0.0188)
Secondary education	-0.0061***	-0.0092***	-0.0137**	-0.0087
	(0.0018)	(0.0028	(0.0050)	(0.0094)
Tertiary education	-0.0088***	-0.0138***	-0.0236***	-0.0310*
	(0.0029)	(0.0046)	(0.0082)	(0.0175)
Returns to experience				
Primary education	0.0157***	0.0253***	0.0462***	0.0745***
	(0.0022)	(0.0034)	(0.0057)	(0.0070)
Secondary education	0.0152***	0.0244***	0.0439***	0.0684***
	(0.0014)	(0.0021)	(0.0035)	(0.0044)
Tertiary education	0.0117***	0.0189***	0.0344***	0.0550***
	(0.0022)	(0.0035)	(0.0057)	(0.0069)

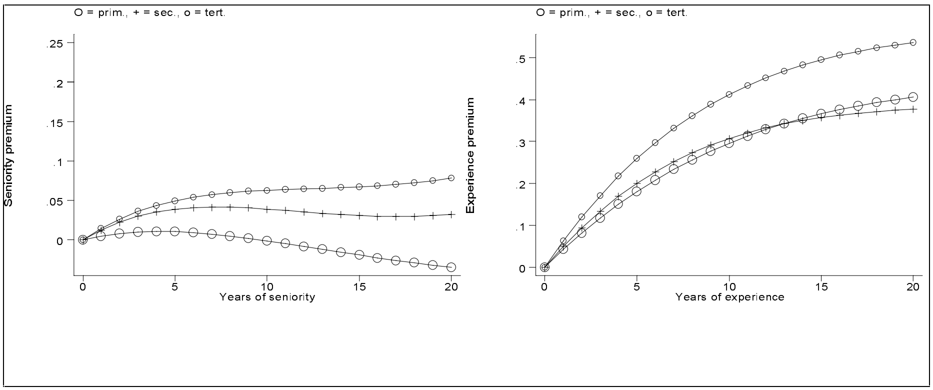
Estimated differences in seniority and experience premiums between workers in high-tech industries and workers in other industries. The estimates are calculated from a model estimated using Topels two-step method with quartics in experience and seniority and quadratic interaction between a high-tech industry dummy and experience and seniority, separately for each of the three education levels. See note to Table 6.

Table 15: Differences in experience and seniority profiles by plant size

	3 years	5 years	10 years	20 years
Returns to seniority				
Primary education	-0.0026	-0.0035	-0.0032	0.0090
	(0.0047)	(0.0075)	(0.0137)	(0.0252)
Secondary education	0.0154***	0.0252***	0.0481***	0.0870***
	(0.0031)	(0.0048)	(0.0081)	(0.0144)
Tertiary education	-0.0038	-0.0095	-0.0348*	-0.1325***
	(0.0070)	(0.0110)	(0.0191)	(0.0395)
Returns to experience				
Primary education	-0.0052	-0.0082	-0.0139	-0.0182
	(0.0038)	(0.0059)	(0.0102)	(0.0142)
Secondary education	-0.0035	-0.0059	-0.0127*	-0.0287**
	(0.0032)	(0.0051)	(0.0110)	(0.0178)
Tertiary education	0.0071	0.1159	0.0219	0.0386*
	(0.0059)	(0.0092)	(0.0153)	(0.0197)

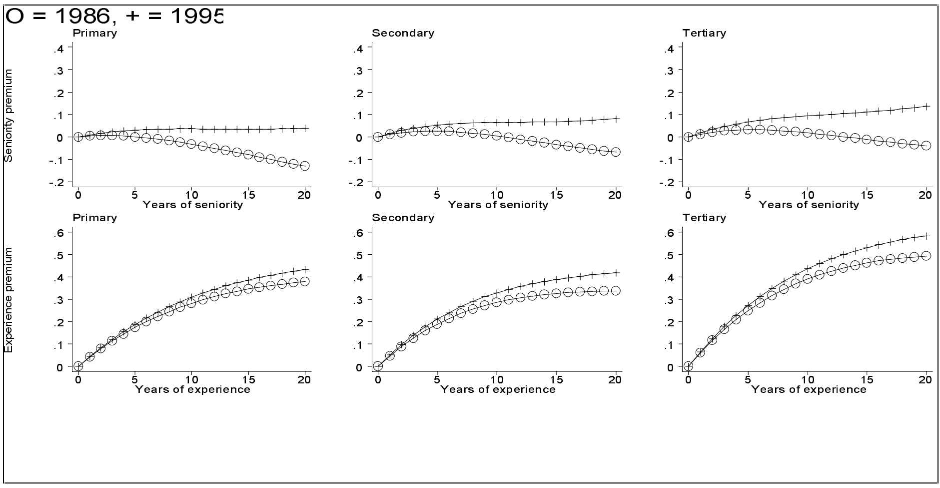
Estimated differences in seniority and experience premiums between workers in plants with maximum plant size and workers in plants with minimum plant size. The estimates are calculated from a model estimated using Topels two-step method with quartics in experience and seniority and quadratic interaction between plant size and experience and seniority, separately for each of the three education levels. See note to Table 6.

Figure 1: Seniority and experience premiums, by education



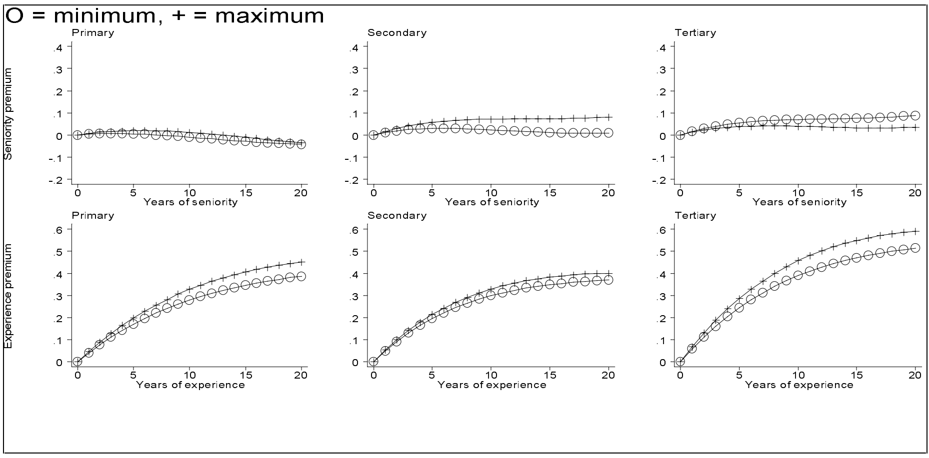
Cf. Table 5b

Figure 2: Seniority and experience premiums in 1986 and 1995



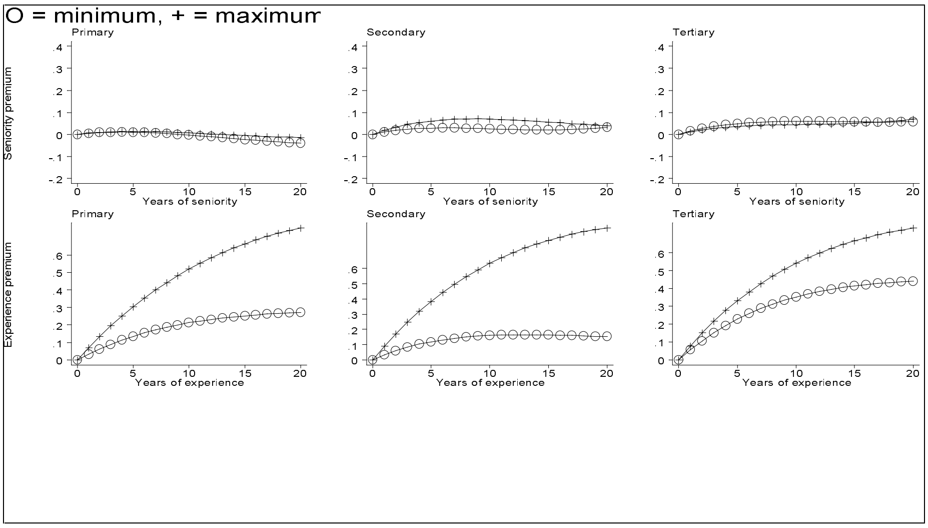
Cf. Table 6

Figure 3: Seniority and experience premiums by manufacturing capacity utilization



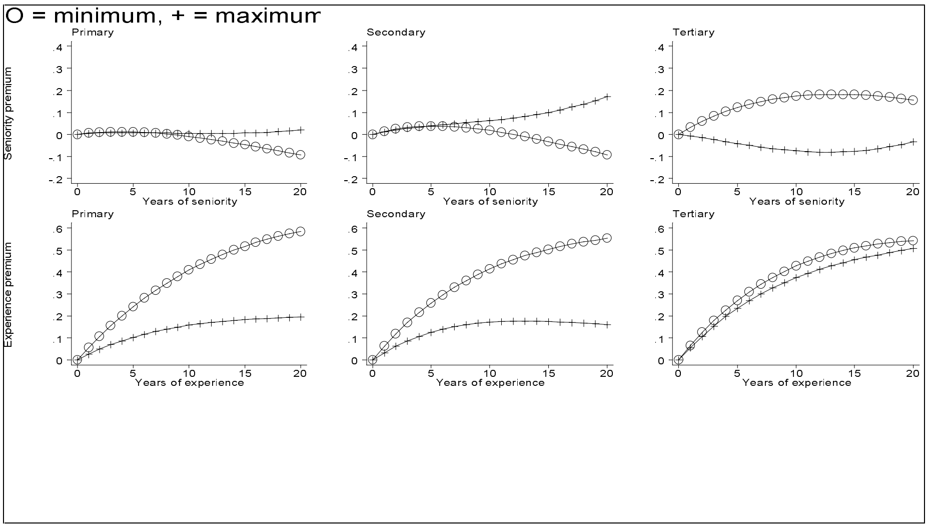
Cf. Table 7

Figure 4: Seniority and experience premiums by plant average education



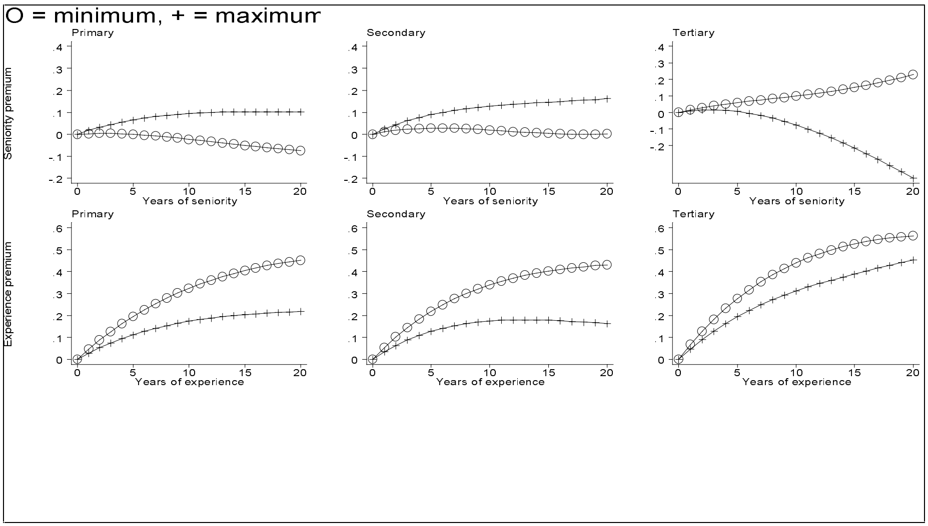
Cf. Table 9

Figure 5: Seniority and experience premiums by plant average experience



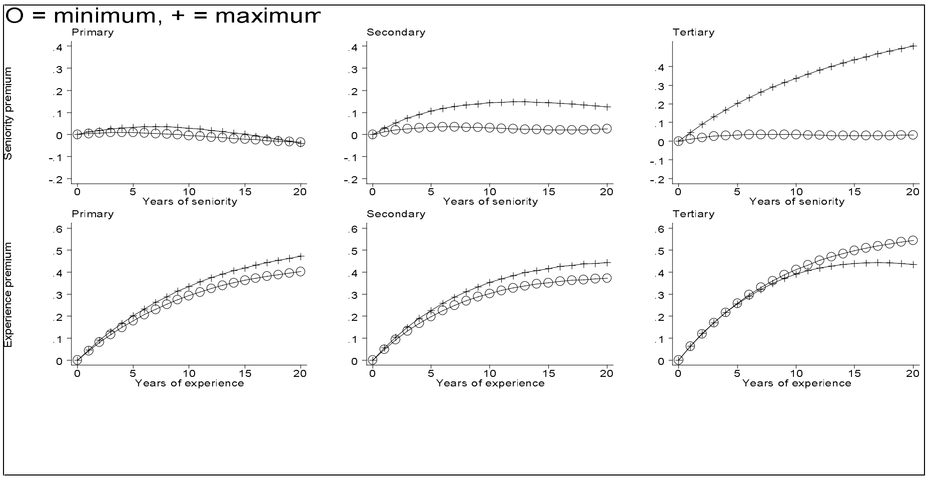
Cf. Table 10

Figure 6: Seniority and experience premiums by plant average seniority



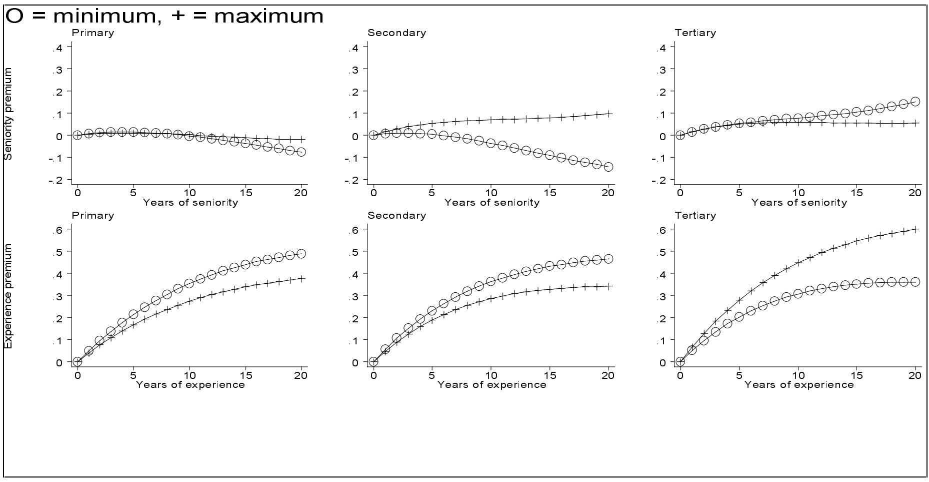
Cf. Table 11

Figure 7: Seniority and experience premiums by investment intensity



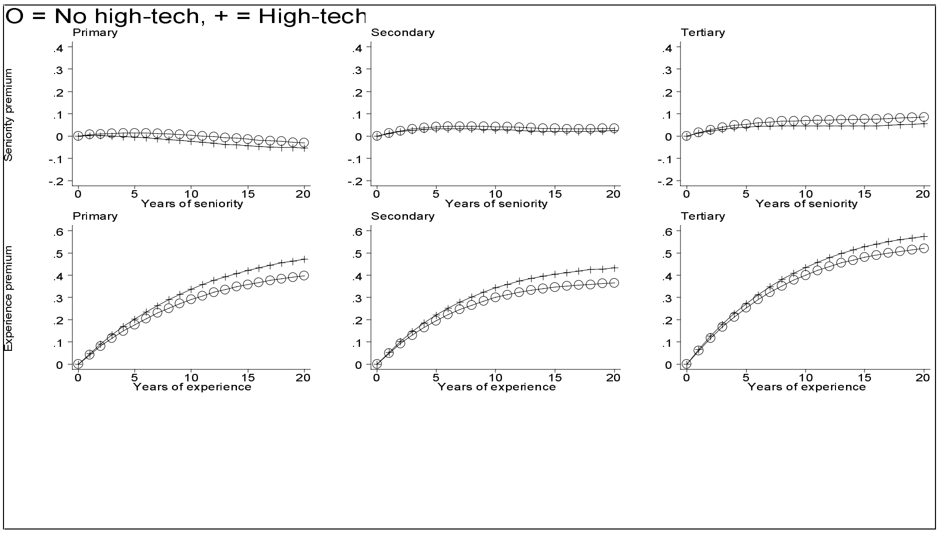
Cf. Table 12

Figure 8: Seniority and experience premiums by capital intensity



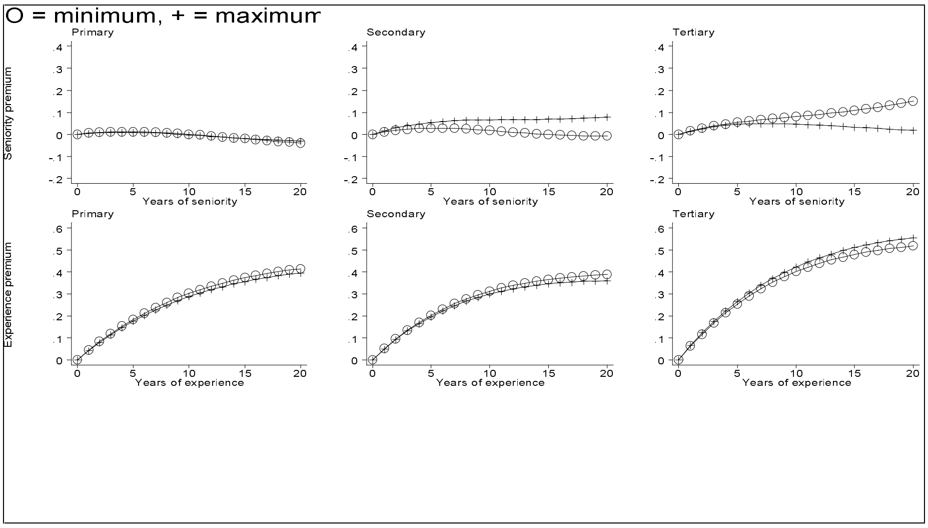
Cf. Table 13

Figure 9: Seniority and experience premiums, high-tech industries vs. other industries



Cf. Table 14

Figure 10: Seniority and experience premiums by plant size



Cf. Table 15

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