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Employer Size - Wage Effect: A Critical Review and an Econometric Analysis

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INTRODUCTION

"The size wage differential is one of the key differentials observed in labour markets. It is particularly interesting because, unlike the union wage differential, it exists in the absence of an obvious agent, one of whose goals is its existence. Hence, if employers of different sizes pay very differently for the same quality of labour working in a similar environment, there is no available deus ex machina to save the day: our knowledge of the labour exchange must ultimately be relied on".

Brown and Medoff (1989)

Many empirical studies have confirmed the existence of a strong positive relationship between employer size, measured as firm or plant size, and wages.

The hypotheses put forth in the attempt to explain why concentrated industries pay high wages and larger firms remunerate workers more than small firms, emphasise different aspects of wage formation: labour quality, efficiency wages and the different organisation of labour across industries, as well as working conditions and the role of unions.

In the empirical literature, the observed positive employer size-wage relationship seems to proxy these determinants, which cannot be analysed directly, given the lack of adequate data.

The size-wage relationship has been reported in various countries. Brown and Medoff (1989), in their seminal paper[1], report a positive and significant employer size-wage effect in the US. Similar results are found in more recent studies in the US, as well as in other countries: Canada (Morissette, 1993), Great Britain (Main and Reilly, 1993), Japan (Rebick, 1993) and Germany (Gerlach and Schmidt, 1990; Schmidt and Zimmerman, 1991).

In particular, the studies investigating the German labour market point to a positive and persistent size wage gap, even after controlling for factors, such as labour quality, seniority, innovative activity, and monitoring costs (Schmidt and Zimmermann, 1991 and Gerlach and Huebler, 1998).

The key issue, therefore, seems to be how, in the long run, large firms can survive despite higher labour costs. Many possible explanations can be found in the literature. However, none of these explanations seems to be completely satisfactory, at least when considered as mutually exclusive as an alternative to the others.

The main purpose of this paper is to explore the size-wage gap by testing the various theories put forth in previous research. This kind of analysis is possible thanks to the unique data set available, namely the *IAB-Beschäfigtenstichprobe*. The dataset covers 1% of the German labour-force from 1975 to 1995. This panel contains both information on different

[1] There were earlier studies, including Moore (1911), Rehn (1954) and Lester (1967). However, in the literature Brown and Medoff (1989) are recognised as the paper of reference.

characteristics of individual workers, and data on the size of the plant in which each worker is currently employed. The independent identification of workers and plants makes available the complete employment and earnings history of each worker and the evolution of size and the educational composition of the workforce for each plant.

The empirical test is conducted using the instruments of regression analysis, including the estimation of fixed effects and first difference models. The starting point will be the formulation of a neoclassical earnings function, which includes the worker's observable characteristics, extended by employer size. Further, to investigate the determinants of wages, the earnings function is stepwise extended to industry and occupation dummies, to plant educational composition variables and to the establishment growth variable. The inclusion of these and more controls, for instance regional dummies, does not seem to have a noticeable effect on the size coefficient.

The second step is the attempt to account for unobservable firm and individual effects through the panel data estimation (within and between firms) of the wage function. In order to conduct this longitudinal analysis, we consider different subsamples from the dataset: "stayers", (i.e. workers who do not leave their plant) and movers. From the latter we isolate those who left their job because of plant closure, since they almost equate to completely exogenous movers.

The findings confirm previous empirical results: for whatever additional information, on demographic characteristics, educational attainment, job duration, educational composition of the plant, industry and regional dummies, is added as control in the regressions even controlling for unobserved worker or firm heterogeneity, the size variable remains significant. The identification of a unique determinant of the size-wage differential is not possible.

The paper is structured as follows:

Section 2 and 3 discuss the main theoretical explanations and results of previous studies. Section 4 describes the data set used. Section 5 outlines the methodology applied in analysing the different aspects of the relationship under study. Section 6 contains the results obtained. The main conclusions are given in Section 7. The appendix presents in more detail a description of the variables used in the estimation and the results obtained.

THEORETICAL EXPLANATIONS

The literature debates many theoretical explanations of why workers of large employers receive higher wages. The rational behind these explanations is that the size-wage effect is due either to differences in measured and unmeasured dimensions of labour quality or to compensating differentials caused by different job and employer characteristics. While there are well-established empirical results pointing to the existence of a wage premium, at a theoretical level there is still much investigation to be done to establish such a phenomenon.

We will explain in more detail some of the hypotheses put forth in the literature, before then, we briefly emphasise the inadequacies that affect all of these explanations.

The analysis of the link between earnings and firm size seems to suffer from the fact that the variable "employer size" is incompatible with a stringent causal concept. It combines a multitude of different determinants. This is a disadvantage since several theoretical interpretations can be adduced to explain the confirmed link between firm size and earnings. On the other hand, an advantage is that firms can be characterised by their size and that scale of production plays an important role in the process of wage determination.

However, generally, it is not possible to differentiate between the competing theoretical interpretations since crucial data are missing. It is probably because of data limitations that several interesting hypotheses relating to the connection between employer size and wages are still largely unexplored.

In fact, it is not reasonable explanations that are lacking, but rather firm evidence linking the size-wage effects observed to the various potential explanations put forth in the literature.

In the sections that follow we will present the potential explanations put forth in the literature following the traditional dichotomization between Neoclassical and Institutionalist explanations.

For the purpose of our empirical analysis, however, the key difference between alternative explanations will be their relying on fixed unobserved worker heterogeneity, compensated by the firm, or rather to unobserved firm's characteristics, for instance firm-specific compensation policies, in the justification of the observed size-wage differential.

Neoclassical Explanations

The Neo-classical approach explains the significant size wage differential within the framework of the standard competitive model, without asymmetries of information about the ability and productivity of workers.

Labour Quality Hypothesis

According to the labour quality hypothesis, large employers hire higher-quality workers for different reasons.

Hamermesh (1980) explains the presence of higher quality workers in larger plants by reference to the relatively greater capital intensity of larger establishments and the capital-skill complementarity. The higher levels of both human and physical capital per worker at larger employers are, in turn, believed to be due to scale economies and/or preferential access to credit in imperfect capital markets.

Oi (1983) and Garen (1985) argue that large plants employ higher quality workers to reduce monitoring costs per unit of labour services. Oi also argues that large firms, being more innovative and more capital intensive, need more qualified and specialised workers, and seek a

lower rate of workforce turnover. Therefore, firm specific human capital accumulation takes place primarily at large firms and plants[2].

According to Lucas (1978), the presence of more able entrepreneurs and of complementarities between entrepreneurial and workers ability imply higher quality workers at larger employers.

Kremer (1993) argues that the greater complexity of tasks induced by the more advanced technology adopted by large employers induces greater skill complementarity between workers and, therefore, higher returns to human capital.

All these hypotheses highlight the fact that big firms use different sorting mechanisms in the choice of the labour force. Underpinning all of them, though, there is a common positive skill-based relationship between employer size and wages.

The labour quality explanation can be tested by controlling for the observed measures of individual human capital. One can proceed with the estimation of a wage equation on cross-sectional data on individuals, using, as measured variables of labour quality, age, schooling, etc. (Brown and Medoff, 1989).

When longitudinal data are available, the estimation of the earning function can be extended in time through the comparison of wages of the same individual when he is working for different-sized employers. Moreover, the use of fixed effect estimation allows wage rate changes to be considered as a function of changes in employer size. If the quality of labour explanation were valid, then larger and smaller employers should pay the same to workers of a given quality. Workers of the same quality would only earn the same wherever they work, if worker's individual characteristics were the only determinants of size-wage differentials. The quit rates and the job tenure in large and small employers would not be significantly different when wages and other fringe benefits are held fixed.

However, coefficients obtained from this type of estimation are not always consistent, since, in studies that convert categorised employers' size data into continuous measures of size, the fixed effect estimator is affected by measurement error, which would worsen the signal to noise ratio and attenuate the estimated coefficients (Albaek et al. 1997).

Regarding measures of employer size, the establishment size can be considered as the relevant measure of scale when analysing the skill-capital complementarity hypothesis, whereas firm size seems the logical measure for testing Oi's model.

Since the correlation between firm and plant size is high, one should obtain similar results when using only one of these two measures, although the inclusion of both would allow a more thorough analysis of the size-wage gap.

[2] If workers with more overall human capital have a comparative advantage in accumulating firm specific skills, this implies a technological source of sorting by workers' skills among different sized employers.

Compensating Wage Differentials Hypothesis

When wage differentials are not explained by labour quality differences, economists have supplied an alternative/complementary explanation; namely, difference in working conditions.

Working conditions in larger workplaces are more likely to be worse than in smaller plants (among others, Masters, 1969). For instance, there is increased work division, a more impersonal work atmosphere, greater reliance on rules, less freedom of action and scheduling, longer commuting. Thus, larger employers have to compensate prospective workers of a given quality, for the unattractive features of the job by paying a higher wage.

To test the compensating differential explanation, ideally, the unattractive aspects of larger workplaces should be isolated and the job characteristic variables should be included in a wage equation, in order to reduce the wage premium associated with employer size.

Therefore, one should estimate an earnings function augmented by firm size and by variables capturing work characteristics following the hedonic wage literature.

Since it is difficult to measure job characteristics, it is reasonable to use detailed industry and occupation characteristics.

According to the hypothesis of equalising wage differences, when wages are held constant, only size should be positively correlated to quit rates, whereas working conditions should not be.

Institutional Explanations

Based on the evidence that, generally, labour and product markets are not perfectly competitive and on the idea that the nature of the employer-employee relationship differs systematically across plants of different sizes, several explanations of the existence of a size-wage premium have focused on the problems of imperfect information and imperfect competition in the labour and product markets.

Internal Labour Markets

The literature on internal labour markets (Doeringer and Piore, 1971) provides a possible explanation for the positive relationship between firm size and wages: internal labour markets would represent a screening device and an incentive for human capital investments.

Internal labour markets facilitate the evaluation of workers' performance, since it is easier to collect information on the employee and ensure a higher return of specific human capital investments. This is thanks to reduced employee initiated turnover and a reduction in any diffidence of older workers in imparting their knowledge to new employees. Larger firms may,

therefore, find it profitable to exploit their inherent size advantage for promoting within-firm job mobility[3].

Efficiency Wages

Efficiency wage models (Akerlof and Yellen, 1986) point to discrepancies in technology and/or product quality as a possible explanation of the differences in wages according to size. Monitoring is more difficult in larger firms than in smaller firms; the cost of turnovers is higher and shirking has great negative effects; and productivity is more sensitive to wages. Larger firms exceed the market wage rate to reduce fluctuations and to offer incentives for a steady and involved work effort. The main problem with this hypothesis is that it is impossible to distinguish between the presence of efficiency wages and unmeasured labour quality.

Union Avoidance Hypothesis

The assumption underlying this strand of the literature is that large employers face a great threat of unionisation and therefore tend to follow a strategy of positive labour relations.

Large non-unionised employers may try to avoid unionisation by conducting a policy of positive industrial relations including, inter alia, higher wages, more benefits and better working conditions. As a result, union wage and benefit differentials should vary inversely with size. A different analysis, using a closely related argument and yielding the same result, is that large employers are more likely to be unionised (Weiss, 1966), since the working conditions and the scale of activity in larger plants are more likely to make workers receptive to unionisation. This results in higher wages.

The conclusion to both the "union avoidance" hypothesis and the "union demands" hypothesis is that the oligopolistic structure allows workers to obtain higher wages.

Job Seniority

Job seniority seems to have a significant positive impact on wages. As stressed by Schmidt and Zimmermann (1991) many collective wage contracts explicitly specify how to reward seniority. This could explain the positive relationship between job seniority and earnings. Bigger firms are more likely to offer contracts designed to keep turnover low and effort high, because of greater internal labour markets.

Market Power

Larger firms are more likely to have monopoly power and they may share some of the monopoly rents with their workers, it being reasonable that excess profits lead to wage premiums when the labour force is organised as it is in large firms.

To test this hypothesis, it is possible to check directly the argument's assumption that the product demand curve of large employers is less elastic. Otherwise, it is also possible to include

[3] Idson (1989) reports evidence on the relationship between plant size and internal mobility for non-union workers in the United States based on individual employee responses.

industry dummies in the wage regression, since the product market power explanation could simply refer to concentrated industries in which firms are typically large.
As reported by Schmidt and Zimmermann (1991), collective bargaining in Germany is mainly organised on an industry level, and thus, firm size can be expected to mirror industry characteristics. Therefore to test for these latter hypotheses (Union Avoidance and Union Demand, Job Seniority and Market Power hypotheses) one can include explicitly industry or sector dummies. Including a variable for individual union status would not have a positive effect on wages in Germany since collective contracts also cover non-members[4].

Imperfect Information Models

Several recent contributions (Greene et al., 1992; Weiss and Landau, 1984; Garen, 1985) model incomplete information about wages, job characteristics and the suitability of applicants as determinants of firm-size wage differentials. Allocating resources and incurring costs can reduce the incomplete information affecting both sides of the labour market. Improved matches can lead to higher wages and increases in productivity. Larger firms are more likely to emphasise formal qualifications and credentials. Schooling should, therefore, be a more important determinant of wages in larger firms than in smaller firms.
Monopsony models of labour markets (Green, Weiss and Landau) assume that large employers face a smaller pool of applicants relative to vacancies (lower applicant-to-job vacancy ratio hypothesis): the number of applicants declines since the number of units of labour to be employed and the size of the available pool do not increase in the same proportion. Therefore at any minimum level of worker quality chosen by the employer, the larger employer will be forced to offer higher wages in order to satisfy the greater labour input requirement [5]. However these models are challenged by the empirical fact that the number of applicants per vacancy is usually very high for large firms.

In the literature, the employer size-wage differential is explained by four separate factors.
As we have seen, the Neoclassical explanations are based on the labour quality differences and on the worse working conditions at larger employers.
The Institutionalist labour economists believe the size-wage differential to be caused by the larger employers' attempts to avoid unionisation of their employees and by product market power.

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[4] Schmidt and Zimmermann (1991): "we investigated the effect of individual union status on earnings that is reported in the US literature. In accordance with the institutional arrangements in Germany we found no such effect. The estimated coefficient was never significant nor did it show the expected positive sign".

[5] Brown and Medoff (1989), though, argue (p.1048): "The model is too complicated to have derivable predictions about the relationship between employer size and quality of worker hired. Thus it is consistent with the positive size-quality relationship …, but it would be consistent with the opposite result."

It is important to note that, in previous studies, the labour quality variables seem best to explain the size-wage differential - they account for 50% of the observed differential, while the other possible factors normally account for only a small proportion of the observed differential.
However, the existing theoretical explanations should be considered not as mutually exclusive but as complementary interpretations of this phenomenon; none of them seems satisfactorily to explain the apparent size-wage gap, but they all help to explain the sizeable and persistent gap.

RESULTS AND METHODS FROM PREVIOUS STUDIES

Since the eighties, several studies have investigated the empirical evidence on the existence of a size-wage gap. We will refer to few studies: Brown and Medoff (1989) since it is considered the work of reference for most of the literature, Abowd Kramarz and Margolis (1999) and Gibbons and Katz (1992) for their innovative insights on methodological issues. We also report results and methods of previous studies on the German labour force.
Brown and Medoff, find evidence that, even when union status is the same, large employers pay higher wages. Their results underline the independent effect on pay of both company and establishment size[6]. Of the hypotheses explored in their study, it is only the difference in quality of workers across firm size categories that is corroborated by their empirical tests. This accounts for roughly one half of the observed size-wage differentials.
Thus, Brown and Medoff findings indicate that nearly one half of the observed mean wage differential by employer size remains unexplained.[7]
In their longitudinal data analysis they test whether unmeasured quality dimensions of labour, assumed fixed over time can account for the size-wage gap. In fact, if changes in worker characteristics are used to estimate changes in wages, unmeasured labour quality should not cause any bias. Their findings highlight a significant size differential among movers, but also show that firm size has essentially no impact on wages in the fixed effect estimates for job stayers, where changes in size, for stayers, represent downsizing or upsizing of the plant.
In their analysis, Abowd, Margolis and Kramarz (1999) conduct a study on a large matched employer-employee sample from France and isolate fixed individual and fixed firm effects from workers moving between employers. They find that individual heterogeneity rather than firm heterogeneity explains most of the wage gap across size categories.

[6] In fact, whether firm size or plant size is more important in explaining the wage premium remains open. Brown, Medoff and Mellow find that for the US both measures of employer size are significant.

[7] Comparing two workers with observationally equivalent qualifications and jobs working at different sized employers, the size of one employer being double the size of the other, they estimate that the one employee working for the larger employer receives a wage premium of 1.5% to 3.8%.

One objection that can be raised against these studies in particular, and against fixed effects estimates in general, is that they assume exogenous worker mobility. If this hypothesis is not verified, the fixed effect estimate is inconsistent.
The literature, in particular Gibbons and Katz (1992), suggests two possible methods to solve this potential self-selection bias: the use of estimation methods that try to correct for self-selection (two-stage estimation) or the selection of a subsample that attempts to isolate exogenous movers, so as to minimise the incidence of endogeneity.
Gibbons and Katz use the latter method in a study on inter-industry wage differentials, their findings do not support a pure unmeasured ability model.
Researchers in Germany have only recently engaged in the investigation of the firm size-wage relationship, but the results of these studies confirm the existence of size-wage differentials.
In their comprehensive study, Schmidt and Zimmermann (1991) utilise a random survey of currently employed individuals in West Germany and West Berlin using 891 observations. The authors estimate a neoclassical earnings function incorporating a firm size variable, and include in successive steps additional information in the regression, this being tenure, innovative activities of firms, sectoral dummies, demographic variables and work characteristics variables. The main result they obtain is that wages increase with firm size, and the magnitude and significance of the size variables coefficients are not reduced by the addition of control variables.
In a more recent study, Gerlach and Huebler (1998), making use of the German Socio-Economic Panel for the years 1984-1993, investigate the evolution of the size-wage differentials. Their empirical investigations show widening size-wage differentials during the period under study. They find that large firms increasingly attract more qualified workers.

DATA AND VARIABLE CONSTRUCTION

The empirical analysis uses the *IAB* (the *Institut für Arbeitsmarkt und Berufsforschung*) Employment sample for the period 1975-1995. The *IAB* Employment Sample is based upon the *Beschäftigungsstichprobe* (BS), a dataset that represents the 1% sample from the German Social Security records, supplemented by information from unemployment records.
The dataset contains the size of plants as a continuous variable; this is a notable advantage in respect to other studies of the employer-size wage relationship. Since information on the precise number of employees in each plant is generally not available, many studies only report estimated coefficients for various size classes. This means that our study does not incur in the potential measurement errors problems when converting categorised employer-size data into a continuous size measure, which was the method applied in previous studies (e.g. Brown and Medoff, 1989). Unfortunately, the dataset does not allow us to investigate the joint effects of firm and plant size on wages, since information on firm size is not available.

The subsample used for the analysis consists of full-time[8] male workers who were not older than 15 in 1975, who went through the apprenticeship system by 1988 and were not older than 22 when finishing their apprenticeship education. Pre-1980 data on plant size is not available. Therefore we have been forced to drop those observations. In addition, in earnings regressions and in descriptive statistics concerning wages, only observations after 1983 have been included, since it was only from 1984, that employers were required to report additional payments (Christmas or holiday money) to the authorities.

The endogenous variable in the earnings regressions is the natural logarithm of the daily wage deflated by the Consumer Price Index. The set of explanatory variables ranges from demographic characteristics (age, marital status) to human capital earnings determinants (schooling, experience, job specific experience and current job tenure). As regards workers, information on past and current occupation is available. This makes past and present participation decisions available. This also allows the construction of measures of mobility of workers between firms.

The main advantage of this dataset for the purpose of the present investigation is that it includes not only the complete employment and earning history of the worker but also, independent from the individual, both a continuous measure of the plant size and its evolution. Data on the average level of education of employees at establishment levels is also made available through the aggregation of information about individuals (percentage of employees without education, with education and with a university degree).

It was therefore possible to exploit information on size differentials in quit rates, company tenure, and "job tenure" to characterise further the size effect.

METHODOLOGY

The data set contains information on plant size measured as the exact number of employees in each individual plant. This allows measuring size-wage effects using, in the wage equation, plant size as a continuous variable. Therefore, estimation results will be reported in terms of size-wage elasticity. To account for a non-linear relation we also conduct further investigation using an earnings regression where size enters as a categorical variable[9].

The basic wage equation estimated is of the form:

$$w_{i(j)t} = \alpha_0 + \alpha_1 X_{it} + \alpha_2 S_{j(i)t} + \varepsilon_{it} \qquad (1)$$

Where $\varepsilon_{it} \sim N(0,\sigma^2)$

[8] For a detailed description of variables and for summary statistics we refer to Appendix

[9] We consider 6 size categories: 0 to 5; 6 to 20; 21 to 50; 51 to 150; 151 to 500; 501 to 2000; and more than 2000 employees, so that each comprises roughly the same proportion of workers in the sample.

Where $w_{i(j)t}$ is the logarithm of the real daily wage of worker $i=1...N$ in plant j at date $t=1,...,T$.
The vector of explanatory variables X_{it} includes a set of observable time variant exogenous individual characteristics: a categorical variable indicating educational qualification, experience, represented by the total years of work experience, and its square; occupation specific experience, measured as years spent in the occupation, including those of apprenticeship, and its square; tenure, defined in terms of the length, in years, of the current employment relationship, and its square; a dummy indicating the worker's marital status.
$S_{j(i)t}$ is the logarithm of the size of plant j where worker i is currently employed and α_2, the coefficient of interest, is the coefficient of the firm size variable representing the size-wage elasticity.
In the wage regression we also include time dummies for the years from 1984 to 1995.
Apart from this basic wage model we also run regressions for various extended models, the limits of which being dictated by the information on various plant size-wage relevant variables available in the dataset.
Definitions of key variables used in the estimations and sample means for relevant variables are given in the Appendix.
The meaning of differences in pay across employees has to be considered. In market models, these necessarily represent omitted human capital (clustered within firm or industry) or omitted job characteristics (compensating differentials). In fact, to maintain the market model's predictions, it must be the case that pay differences across firms are explained variously by assertions that employees are not homogeneous (omitted human capital), or that employers are not homogeneous (compensating differentials). The alternative is that the labour market is not perfectly competitive.[10]
The estimation goes through various steps to test the various hypotheses put forth in the literature.
The starting point is a standard earnings function enriched by the size measure, which confirms the existence of a significant size-wage gap.
To test for the persistence of this size-wage differential, control variables, proxying labour quality and working conditions are introduced. These are only partly represented by the human capital variables used in the basic earnings specification, since it is likely that there are unobserved components still omitted from the regression.
The following steps all try to proxy these unobserved components in different ways.

[10] Failures of the assumptions required for competitive markets may involve imperfect information concerning employers and employees or imperfect mobility.

We first investigate to what extent wage differences can be explained by intersectoral differences or occupational characteristics. Thus, controls for industry affiliation and for occupation are introduced.
Controlling for the individual industry affiliation means estimation on the basis of within-industry variation only. Large firms are more likely to exist in concentrated industries. Whether the documented size-wage effect is an expression of monopoly rent from less competitive industries, as predicted by Institutionalist theories, or in concentrated industries employers hire higher quality workers - effects that we could not control for using observable individual characteristics - incorporating our information on firm types or industry group should cause a deterioration of the estimated size premium.
Controls for occupation should approximate working conditions and should help in studying the impact of job characteristics.
Given the information available in the dataset, it is possible to test the labour quality theory, in particular Kremer (1993), since plant educational composition should account for the presence of skill complementarities within the plant. We include as explanatory variables plant characteristics, such as percentage of worker with/ without educational qualification.
We, also, introduce a variable indicating plant growth. This variable should indicate whether and how downsizing or upsizing of the plant affects wages directly and indirectly through its effect on the size wage elasticity coefficient.

Panel data methods are used to investigate the role of unobserved worker and firm characteristics in explaining the observed size-related variation in wages.
The theories explored above make distinctive predictions about the persistence of wage components across employees and employers.
The labour quality explanation of persistent wage differences among observationally equivalent workers relies on unmeasured differences in ability of workers; these are not captured in level estimations.
Models relying on compensating differences, rent sharing and efficiency wages, on the other hand, predict the existence of size-wage differentials even for identical workers, when they are employed in different plants. Rent sharing models predict no persistence of the pure firm component of a previous employer's wage premium at a new employer.
To test the theories about the distribution of wages across employers, we, therefore, use the evidence derived by following employees across identified employers.
Whether or not a wage premium paid generally or individually to workers at one firm persists as these workers move to another employer depends on whether the “match components” are common across firms. Match components that are specific to a firm do not persist as the worker moves across firms. Match components that are specific to the worker are unlikely to yield strong common firm effects.

In the attempt to provide empirical assessment of these two different strands of the theory we, therefore, use first difference and fixed effect estimation on the whole sample and on particular subsamples containing respectively "movers" and "stayers".
If match effects represent omitted general human capital, movers should retain their premium. Wage differentials should survive intact the transition to a new employer. Such unmeasured human capital would account for persistent wage premiums.
Firm differentials that represent the firm's sharing of economic rent should not survive a transition. Such rents follow the firm irrespective of the workers, rather than following the worker irrespective of the firm.
The first type of tests conducted follow workers and asks whether they maintain their previous firm's wage component as they change employer.
The second type of test follows firms and asks whether each firm's wage differential remains unchanged over time as it slowly changes its workforce composition.
In fact, we want to examine the variation in wage rates holding firm effects constant and variation in firm wage rate holding person effect constant.
We, therefore, conduct various analyses, beside the, already mentioned, OLS estimation on the whole sample, on stayers and on movers.
We estimate wage growth equations between/within firms, including step by step additional regressors, like, for instance, skill mix differences and industry affiliation.
For movers, we investigate the effect on wages not only of the current plant size but also of the previous employer's size. The results of this estimation could support the existence of unmeasured quality of the worker as well as possible signalling phenomena. Having worked in a bigger plant could, in a world of imperfect information, allow a worker to be identified as high quality by new potential employers and thus paid more, irrespective of the size of the current plant.
Given the problem of self-selection biases, arising from the endogeneity of mobility choices, we attempt to design a subsample of exogenous movers by selecting from the dataset only those workers displaced by plant closing and we compare the results obtained from the investigation on the subsample of all movers.

We, then attempt to investigate the effect of firm unmeasured heterogeneity. This is possible only for a small subsample of the dataset, mainly composed by medium sized and big firms (Table A.8 in Appendix) since we need to have more individuals working in the same plant.
Fixed effect analysis on this subsample allows us to eliminate firm specific effect and to keep fixed individual effects.
We assume that in equation 1 the error term ε_{it} can be decomposed as follows:

$$\varepsilon_{it}=\xi_I+f_{ij}+\eta_{it}+r_t \qquad (2)$$

i.e. we decompose real compensation per worker into components related to observable individual characteristics, personal heterogeneity, firm heterogeneity and residual variation.
We then get to the following wage equation:

$$w_{i(j)t} = \alpha_0 + \alpha_1 X_{it} + \alpha_2 S_{j(i)t} + \xi_i + f_{ij} + \eta_{it} + r_t \qquad (3)$$

where $w_{i(j)t}$ is the log of daily wage of individual i in period t in firm j, X_{it} are time variant individual specific and observed characteristics, $S_{j(i)t}$ is the log size of plant j where individual i works at time t, as before.
ξ_i is the pure individual specific (unobservable and not time varying personal characteristics) effect, and f_{ij} is a match specific firm-individual effect. Finally, r_t are time effects, η_{it} is an idiosyncratic shock, that presents the following error structure:
$E[\eta_{it} \mid i, t, J(I,t), x_{it}]=0$

and

$$Cov\left[\eta_{it}, \eta_{ns} \middle| i, t, n, s, J_{(i,t),} J_{(n,s)}, x_{it}, x_{ns}\right] = \begin{Bmatrix} \sigma_\varepsilon^2 \forall i = n, t = s \\ 0 \end{Bmatrix}$$

In matrix notation:

$$W = \alpha_1 X + \alpha_2 S_{j(i)t} + \Gamma\xi + \Psi f + \Phi r + \eta \qquad (4)$$

Equations 3 and 4 can be interpreted as the conditional expectation of worker's wage given information on the observable characteristics, the date of observation, the identity of the worker and the identity of the employing plant.
The omission or aggregation of one or more of the effects in equation 3 can change the meaning of the other effects significantly, giving rise to omitted variable biases.
The parameter of interest is α_2, the effect of firm size, conditional on observed and unobserved firm specific and individual specific characteristics.
Given the "matched" person and firm longitudinal nature of the data, we are able to control for both measured and unmeasured heterogeneity in the workers and their employing firms.
We observe workers both as he moves firm and as he stays with the current employer.
Given the underlying assumption that unmeasured productive ability is time-invariant, both fixed effect and first difference methods eliminate the impact of unmeasured ability on the measured size effects. The first difference and the fixed effect on the whole sample estimates the size effect both from “stayers” with a changing firm size and from “movers” between

differently sized plants, we, then, also, conduct the estimation on the two subsamples, separately.

Within-differencing, (on stayers):

$$w_{ijt} - w_{ijt-1} = \alpha_1 \Delta X_{it} + \alpha_2 \Delta S_{jt} + \Delta \eta_{it} + \Delta r_t \qquad (5)$$

This identifies α_2, i.e. it allows analysis of simultaneous individual and firm level unobserved heterogeneity; α_2 estimates the effects of upsizing or downsizing of the employing firm on the wage variation.

Between-differencing (on movers):

$$w_{ijt} - w_{ikt-1} = \alpha_1 \Delta X_{it} + \alpha_2 \left(S_{jt} - S_{kt-1}\right) + \left(f_{ij} - f_{ik}\right) + \Delta \eta_{it} + \Delta r_t \qquad (6)$$

The problem with the estimation of the regression in 6 is:

$$E\left(w_{ijt} - w_{ikt-1} \middle| \Delta X_{it}, \left(S_{jt} - S_{kt-1}\right)\right) = \alpha_1 \Delta X_{it} + \alpha_2 \left(S_{jt} - S_{kt-1}\right) + E\left[\left(f_{ij} - f_{ik}\right) + \Delta \eta_{it} \middle| \Delta X_{it}, \left(S_{jt} - S_{kt-1}\right)\right] + \Delta r_t$$

Clearly, $E([f_{ij}-f_{ik}]|[S_{jt}-S_{kt-1}]) \neq 0$ if firm effects are correlated with firm size (even if $f_{ij}=f_j$[11]).
Moreover, if mobility were a random event, individual unmeasured wage component could be identified using movers, but mobility may not be a random reallocation of workers across firms. We, therefore, try to implement an empirical strategy to reduce the importance of biases arising from the endogeneity of job reallocations.
Consider the model 3 and let assume that $f_{ij}=f_j$ for all workers employed in plant j, so that f_j represents the pure firm effect.
Using movers, we can identify the unobserved individual and firm fixed wage components, ξ_i and f_j:

$$(w_{ijt}-w_{ikt-1}) = (f_j - f_k) + \Delta \eta_{it} \qquad (7)$$

The individual component is differenced out leaving the difference in firm effects and the change in errors. The latter term is mean zero and uncorrelated with (f_j-f_k) only if moves are

[11] However, the parameter α_2 is not necessarily the parameter of interest. There is no real story why the size alone should have any impact on wages. All explanations for firm size differentials do actually refer to f_{ij} the individual-firm match effect (or the firm effect). Firm size effects in this sense is the extent to which firm size can represent the firm-individual specific effect, conditional on fixed individual effects. If 3 represents the correct structure, then the effect in 6 should capture exactly this.

random reallocations. If the assumption of exogenous mobility, i.e. that the design matrix for the firm effects, *f*, is orthogonal to the error process η, is verified, then the estimated coefficient is unbiased.

This hypothesis is unlikely to hold in practice. Unbiased estimates are more likely to be obtained from job changes that are exogenous rather than endogenous to the wage distribution.

We, therefore, look at movers displaced from dying firms; the subsample is constituted by workers who leave a plant that closes down within two years of their departure.

It is important to isolate exogenous job losses since models of size effects as pure firm effects predict that first difference regression estimates of size-wage differentials on such a sample should be similar to level estimates.

Unmeasured ability models yield this result only for endogenous movers, but not for exogenous plant switchers.

On this subsample we estimate a level wage regression, as in (3). We then estimate for movers, both endogenous and exogenous, an extended earnings functions that includes as independent explanatory variable the pre-displacement size:

$$w_{i(j)t} = \beta_0 + \beta_1 X_{it} + \beta_2 S_{j(i)t-1} + \xi_i + f_{ij} + \eta_{it} + r_t \qquad (8)$$

The coefficient of interest is β_2, which now measures the impact of pre-displacement size on post-displacement earnings.

Thirdly, we estimate the difference equation 6 on this subsample: if the effect estimated in the level regression is entirely due to the sorting of workers across plants by unmeasured ability then in the first difference equation the coefficient α_2 should be virtually zero; on the other hand, if the level coefficients are entirely due to firm effects the α_2 in 6 should be virtually identical to the coefficient obtained by level estimation.

We, then, consider a subsample of workers employed in the same plant to isolate the unobserved firm effect and estimate its effect on the size-wage coefficient.

Since we estimate a fixed effect model only on workers belonging to the same plant we obtain:

$$w_{ijt}^{*} = \alpha_1 X_{it}^{*} + \alpha_2^{*} S_j^{*} + \xi_i^{*} + \upsilon_{it}^{*} + r^{*}_{t}$$

where the variable are considered as deviation from the plant mean. We attempt to isolate the pure firm effect component. If the size-wage differential is to be attributed to the pure firm effect, then α^{*}_{2} should virtually drop to 0. If the main component is the unobserved worker heterogeneity, however, α^{*}_{2} should not be significantly different from the level estimates.

EMPIRICAL FINDINGS

Descriptive statistics

The sample includes, from the year 1980 to the year 1995, 186424 observations, 16399 individuals, who have finished their apprenticeship and are full time workers, and 37065 plants. Small firms account for a substantial share and medium size firms for a relatively large share of the total number of firms in the sample; 51% of the plants in the sample employ less than 20 employees and only 11% more than 500, so that the distribution of size through the years is skewed to the left (a shown by figure 1).

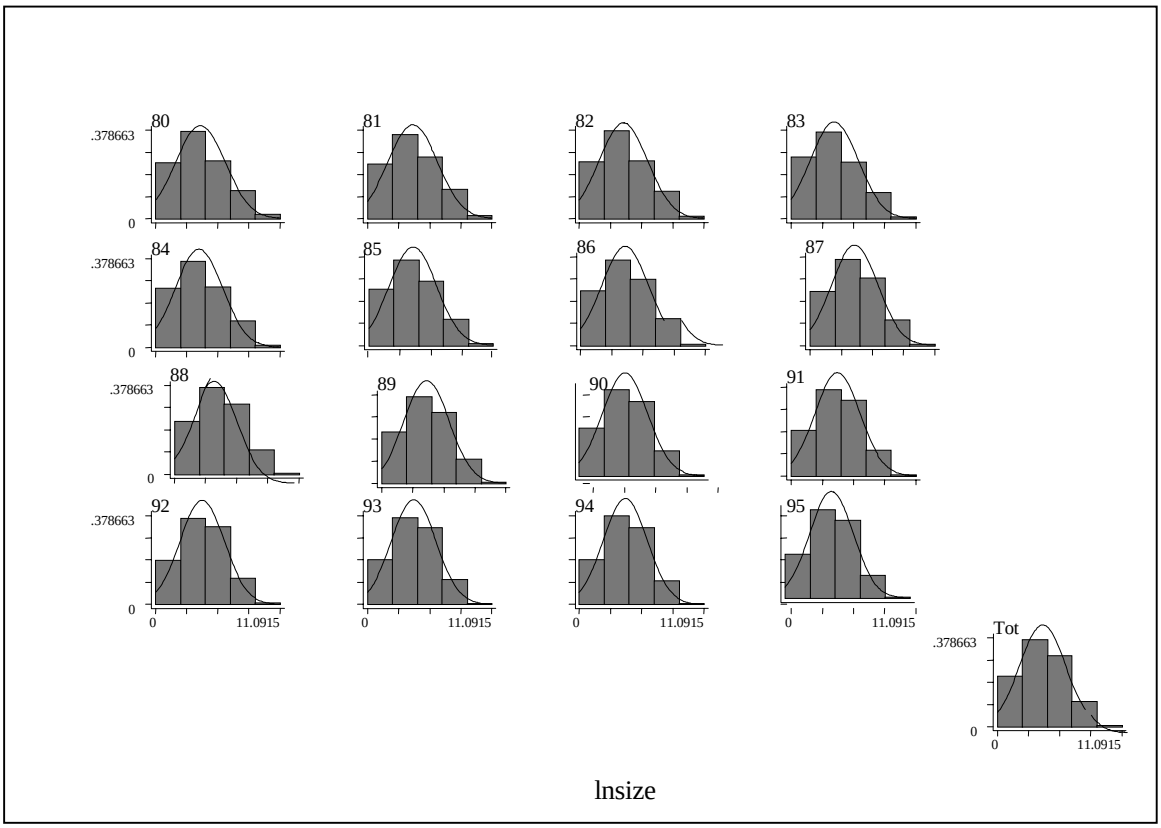

Figure 1: Distribution of size through the years

As shown by table 1 and 2, the criterion chosen to divide the continuous variable available as measure of plant size in categories has been to include roughly an equal employment share, rather than the same number of plants, in each size category.

Size Category (number of workers)	Frequency	Percent	Cumulative
Less than 5	7252	19.57	19.57
6-20	9501	25.63	45.20
21-50	6328	17.07	62.27
51-150	6127	16.53	78.80
151-500	4856	13.10	91.90
501-2000	2531	6.83	98.73
More than 2000	470	1.27	100
Total	37065	100	100

Table 1: Distribution of plants by size category

Size Category (number of workers)	Frequency	Percent	Cumulative
Less than 5	1951	11.9	11.9
6-20	2698	16.45	28.35
21-50	2154	13.13	41.48
51-150	2451	14.95	56.43
151-500	2666	16.26	72.69
501-2000	2535	15.46	88.15
More than 2000	1944	11.85	100
Total	16399	100	100

Table 2: Distribution of total employment by size category

For the purpose of our investigation it is important to consider the dimensional differences across industries since several hypotheses can be tested adding controls for industry affiliation in the regressions.

The sectoral breakdown (table 3) shows that small and medium sized firms dominate the primary and construction sectors, while the Mining, Energy and Manufacturing sectors is mainly composed by large firms.

Sector	Size Category							
	0-5	***6-20***	***21-50***	***51-150***	***151-500***	***501-2000***	***More than 2000***	***Total***
Primary	436 59.89%	162 22.25%	83 11.40%	42 5.77%	3 0.41%	2 0.27%	0 0%	728
Energy	9 3.33%	31 11.48%	36 13.33%	54 20%	72 26.67%	50 18.52%	18 6.67%	270
Mining	3 3.12%	5 5.21%	10 10.42%	7 7.29%	17 17.71%	26 27.08%	28 29.17%	96
Manufacturing	2175 15.26%	3179 22.31%	2191 15.38%	2410 16.91%	2541 17.83%	1511 10.6%	243 1.71%	14250
Construction	1646 25.01%	2370 36.01%	1245 18.92%	873 13.26%	377 5.73%	68 1.03%	3 0.05%	6582
Trade and Transport	1714 20.68%	2260 27.26%	1570 18.94%	1450 17.49%	887 10.70%	375 4.52%	34 0.41%	8290
Industry Services	420 19.91%	559 26.51%	386 18.30%	313 14.84%	250 11.85%	136 6.45%	45 2.13%	2109
Consumer Services	148 13.19%	199 17.74%	246 21.93%	347 30.93%	134 11.94%	42 3.74%	6 0.53%	1122
Public Services	701 19.38%	736 20.34%	561 15.51%	631 17.44%	575 15.89%	321 8.87%	93 2.57%	3618
Total	7252 19.57%	9501 25.63%	6328 17.07%	6127 16.53	4856 13.10%	2531 6.83%	470 1.27%	37065

Table 3: Dimensional composition of industries (9 categories):number of plants and percentage by size categories.

Some of the hypotheses described above assume that larger plants present a different educational composition of the workforce in respect to that of smaller plants. Given the skill complementarities between workers, larger plants should be characterised by a higher percentage of workers with higher educational attainments:

The empirical evidence from the sample confirms this hypothesis. Table 4 shows that the percentage of workers without any educational qualification increases from being on average 26% in plants with less than five employees to 31.5% in firms with more than 2000 employees, as well as that the proportion of university graduates jumps from 1.2% in the lowest size category to 8.7% in the highest. Thus, there seems to be a substitution between “skilled” workers and graduates.

	0-5	*6-20*	*21-50*	*51-150*	*151-500*	*501-2000*	*More than 2000*
Without Education	26.12	30.13	29.62	30.83	32.19	32.20	31.52
With Education	72.65	68.42	68.41	66.14	63.82	62.05	59.74
University Degree	1.23	1.45	1.97	3.03	3.99	5.75	8.74

Table 4: educational composition of plants by size category (%)

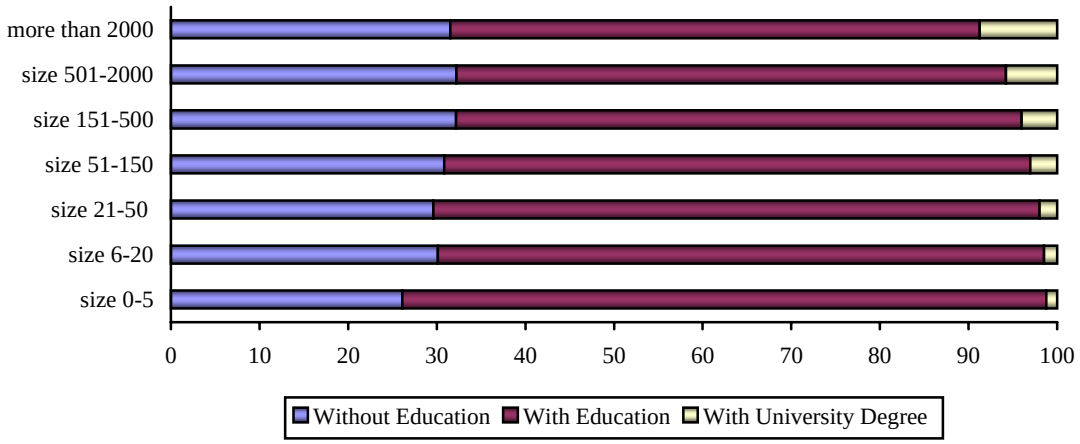

Figure 2: Educational Composition by size category

To investigate the higher internal mobility and lower external mobility in bigger plants, we construct a dummy variable that assumes value 1 in the event of a quit and value 0 otherwise. Similarly we look at occupation[12] switches, independent from employer switches.

We, therefore, report tables showing the quit rates analysis and the relation between quit rates and occupation switches, respectively, within each size category.

Table 6 makes evident that the quit rate is lower in bigger firms: it goes from roughly 25% in small establishments down to 6% in firms with more than 2000 employees.

[12] Where occupation switches are considered on the categorical variable represented by 14 dummies (Appendix).

	0-5	*6-20*	*21-50*	*51-150*	*151-500*	*501-2000*	*More than 2000*	*Total*
No quit	75.33	76.92	79.38	81.73	85.80	89.86	93.70	83.17
Quit	24.67	23.08	20.62	18.27	14.20	10.14	6.30	16.83

Table 5: Quit rates by size category (%)

Further analysis of mobility and its direction, show that the greater the discrepancy in the number of employees, the less mobility of workers between size categories. Of the workers who leave an employing firm with less than 6 employees, e.g., almost 25% moves to a plant in the same size category and only 3.41% to very large firms. On the other hand, of the workers currently employed in a very small plant only 4.34% come from a plant where more than 2000 individuals where employed.

As shown by table 5 only 6.3% of the workforce employed in very large plants quits its job, this supports the predictions of the internal labour market theory. As shown by table 6 and 7, 6% of the workers who do not change employers change occupation and of those who change occupation 66% change also employers.

	Does not change occupation	*Change Occupation*	*Total*
Does not quit	93.66	6.34	100
Quit	38.39	61.61	100
Total	84.36	15.64	100

Table 6: Occupation switches and quits (%)

	Does not change occupation	*Change Occupation*	*Total*
Does not quit	92.34	33.69	83.17
Quit	7.66	66.31	16.83
Total	100	100	100

Table 7: Quit rates and occupation switches (%)

If we look at a distribution of workers who do not quit their firm the share of those who do change occupation increases with plant size as expected if one believes in the internal labour market predictions (table 8).

Size Category	*0-5*	*6-20*	*21-50*	*51-150*	*151-500*	*501-2000*	*more than 2000*	*Total*
Does not change occupation	94.63	95.11	94.69	94	93.21	93.19	91.10	93.66
Change Occupation	5.37	4.89	5.31	6	6.79	6.81	8.90	6.34

Table 8: Internal mobility: occupation switches for "stayers" (%)

The distribution of real wages has changed through the years, maintaining an increasing profile along size of establishment (Figure 3).

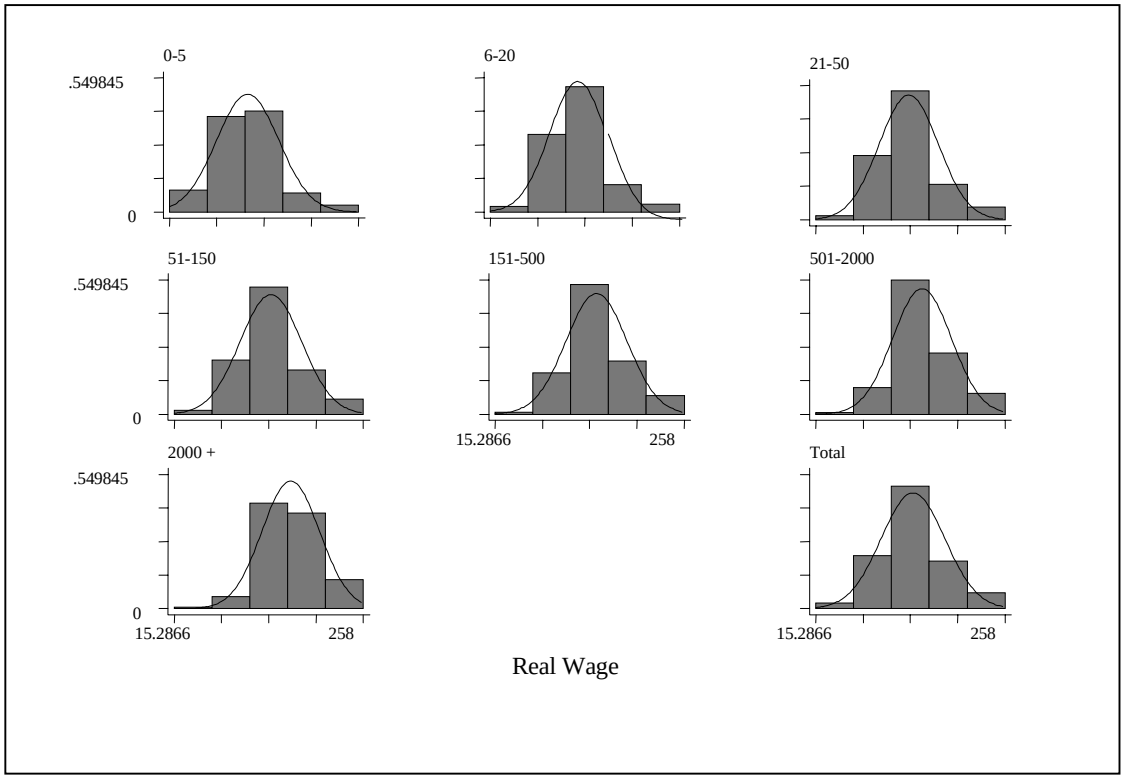

Figure 3: distribution of real wages by size category

Within industries wages grow with size of the firm:

Sector	Size Category							
	0-5	*6-20*	*21-50*	*51-150*	*151-500*	*501-2000*	*More than 2000*	*Total*
Primary	75.81	112.95	129.83	126.31	145.81	122.72	0	93.49
Energy	175.66	159.6	158.8	161.5	174.92	164.9	174.12	168.31
Mining	135.09	149.47	152.07	145.62	154.26	149.86	155.51	153.90
Manufacturing	118.40	125.46	135.60	141.33	148.52	153.63	167.24	146.41
Construction	122.10	130.42	135.48	143.69	152.35	162.49	149.77	134.57
Trade and Transport	116.63	126.63	132.07	134.52	136.11	141.89	157.16	131.30
Industry Services	138.41	151.55	157.44	167.43	163.93	171.23	180.49	159.88
Consumer Services	92.48	1055.46	106.79	109.65	132.11	141.34	170.76	115.51
Public Services	109.17	113.41	122.87	124.72	126.31	132.98	129.87	122.85

Table 9: Within industry mean wage by size category

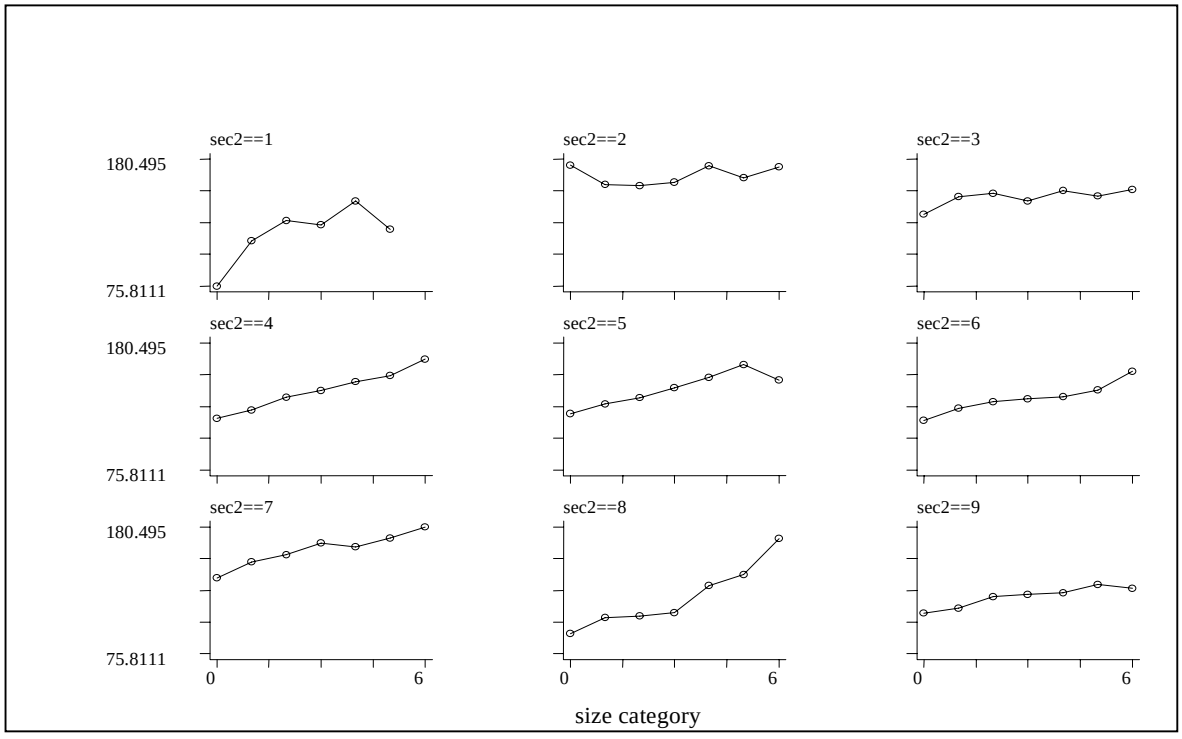

Figure 4: Average real wage by sector and size category

Within some occupations (agriculture and miner) the behaviour of wages is not as smooth as within sectors, but the wages normally increase with size:

	Size Category							
Occupation	***0-5***	***6-20***	***21-50***	***51-150***	***151-500***	***501-2000***	***More than 2000***	***Total***
1.1	73.60	110.69	126.50	119.34	115.30	129.24	134.54	97.10
1.2	141.03	141.43	135.95	110.29	163.79	157.02	152.95	152.49
1.3	124.37	126.89	131.61	131.23	141.01	147.54	161.74	145.74
1.4	103.92	110.23	124.82	126.59	133.77	144.11	148.61	123.09
1.5	120.11	129.69	132.54	139.52	144.42	149.11	159.57	133.34
1.6	118.45	126.67	131.61	136.53	145.80	147.91	161.21	138.82
2.1	124.41	136.73	144.37	149.88	155.89	165.26	181.57	150.99
2.2	114.33	117.58	118.76	122.56	129.45	138.06	152.19	133.05

Table 9: Average Real Wages by occupation (Appendix) and Size Category

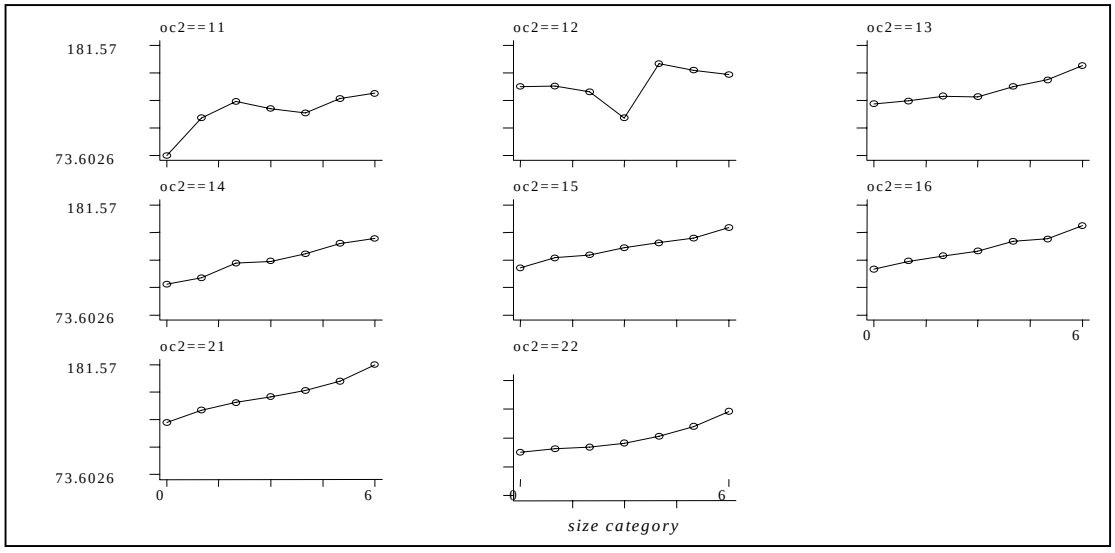

Figure 5: Average Real Wage by occupation and Size Category

Estimation Results

Table 10 and 11 report the estimated plant-size elasticity. Apart from plant size, the basic wage equation includes standard human capital variables (educational qualification, experience and its square, job specific experience and its square, tenure and its square, a marriage dummy and year dummies).

6-20	*21-50*	*51-150*	*151-500*	*501-2000*	*More than 2000*	*Size-wage elasticity*
0.1164	0.1543	0.1792	0.2142	0.2475	0.3283	0.0379
(.0024)	(.0026)	(.0025)	(.0025)	(.0025)	(.0026)	(.00027)

Table 10: Size Coefficients

We consider not only the size wage elasticity, but also the coefficient on size category dummies. Table 10 presents estimated pooled size wage differentials relative to the reference class in the estimation, namely the lowest plant size class (0-5 employees) and the size wage elasticity. The estimated size wage differentials are substantial in magnitude and all statistically significant.

	Whole Sample	*Stayers*	*Movers*	*Exogenous Movers*
OLS	0.0379 (.0002)	0.0398 (.0003)	0.0314 (.0005)	0.0292 (.0024)
Fixed Effect	0.0261 (.0038)	0.0271 (.0005)	0.0231 (.0008)	0.0239 (.0023)
First Difference	0.0249 (.0006)	0.0259 (.0029)	0.0218 (.0012)	0.0175 (.0029)

Table 11: Estimated size coefficients

The size elasticity coefficients (table 11) are obtained from regressing log daily wages on log plant size and the aforementioned individual-specific variables. The results point to a significant, strongly positive plant-size elasticity ranging from 3.8% to 3%, depending on the controls included in the regression, as shown in detail by table A.2 in the Appendix.

In Appendix, we report the size-wage differentials obtained when also controlling for the individuals' industry affiliation. The figures reported are estimated on the basis of within industry variation only. Adding industry dummies to the basic wage model reduces the plant size elasticity. In particular it is noticeable that the size elasticity coefficient decreases from 3.8% to 3.1% when including the industry dummies at a more detailed level (85 categories). The inclusion of controls for occupation (269 categories) has a smaller effect on the coefficient, but still significant.

The estimation results obtained when further adding regional dummies (329 categories) to the basic model specification already augmented with industry dummy variables have also been estimated. The addition of regional dummies appears to reduce the estimated size-wage effects only very slightly, and, therefore, have not been reported.

From our results, we may, therefore, conclude that substantial plant size-wage effects exist within industries and occupations.

We estimate the same wage regressions using two different subsamples: one of stayers and one of movers: for the latter, the size elasticity coefficient drops to 2.7%, when we control for industry affiliation and educational composition of the plant, but the coefficient still remains significant.

Looking at the empirical findings, it, therefore, seems that we can rule out differences in observable individual characteristics, such as formal education and work experience, as major factors behind the size-related variation in wages observed across plants.

A Neoclassical explanation for the estimated positive relationship between employer size and wages is the hypothesis of a more frequent use of pay compensations for unobserved working conditions and unobserved worker abilities in large plants.

In order to provide a better test of the individual heterogeneity hypothesis, we also report results from panel data estimations. More precisely, in order to test the hypothesis whether unmeasured heterogeneity is the main reason behind the size-wage effect, we estimate fixed effect and first difference models from the panel.

Since these unmeasured characteristics are constant over time, a fixed effect (similarly first difference) estimation controls for them and thereby provides consistent measures of the size-wage premium. We can sweep out all fixed unobserved individual heterogeneity and thus restrict the plant size-wage gap to depend only on individual variation over the time period under study. This means, inter alia, that the variation in the plant-size variable arises only from two sources: from growth of the organisation within which an individual works and/or from individual's shifts between plants.

The fixed effect model produces a plant-size wage elasticity amounting to roughly 2.6%, the first difference estimate amounts to 2.5%, as can be seen from the Table 11.

We, therefore, use first difference and fixed effect regression to determine the role of unmeasured individual heterogeneity on movers and on stayers. The size coefficient is still significant and presents only a minor reduction in magnitude. For movers, the elasticity is roughly 2.3%.

The fixed effect estimation on movers would eliminate biases originated by unmeasured productive ability, as long as mobility choices are not endogenous.

To tackle the problem of endogeneity, we approximate a sample of exogenous movers considering only those workers displaced by closing plants[13].
We find that both longitudinal estimation and cross sectional analysis give similar results, even for this subsample of approximately exogenously displaced workers.
These findings imply that pure unmeasured worker characteristics cannot be considered as the unique determinants of the observed size-wage differential.
For movers we estimate the effects on current earnings of previous employer's size. We report the estimated effects in table 12.

	Current Size	***Previous Size***
Movers	0.0314 (.0005)	0.0124 (.0003)
Exogenous Movers	0.0292 (.0024)	0.0260 (.0034)

Table 12: coefficients from regression on current and previous employing plant of job movers.

The results reported in table 12 suggest that pre-displacement plant-size, both for all movers and for exogenous job movers plays a fairly significant role in determining a worker's post-displacement wage. These substantial differentials maintained by workers displaced by plant closing are inconsistent with models in which the level differentials solely reflect pure firm effects.
We decided, therefore, to investigate further the incidence of firm effects and, as anticipated in the methodology, we estimate fixed effect on workers employed by the same firm to isolate the pure firm effect. The coefficient, in this case, drops to 1.3%, but it is still significant, as shown in the Appendix and in table 13.

OLS	**Fixed Effect**
0.0334 (.0005)	0.0132 (.0026)

Table 13: fixed effect on subsample of co-workers

This latter result point to the existence of a quite noticeable pure firm effect, in contrast with the results, reported above in Table 12.
Thus, when we look at fixed effect estimates, both on workers and on plants, our findings do not seem to support unmeasured quality models, rather they seem more consistent with the interpretation of size effect as pure firm effect. The opposite is true when we consider the estimation of previous plant size on present earnings.

[13] We consider those workers who quit the plant in the time period of two years before the plant closes down.

CONCLUSIONS

The purpose of this study has been to examine the evidence of the size-wage relationship using a unique data set on 1% of the German labour force. This has been done using Panel data estimation methods.

The results indicate that there is a positive significant plant size-wage effect in the sample under study.

Moreover, the plant size-wage effects estimated remain roughly unchanged even after controlling for a broad set of individual and job-related characteristics, such as labour quality, industry affiliation and region.

In sum, the various individual and job related variables added to the basic equation do not seem to have a significant independent effect on the magnitude of the plant size elasticity.

Estimations based on fixed effect and first difference models seem to indicate that unmeasured individual heterogeneity contributes only in part to the existence of a positive and significant plant size-wage gap.

Contrary to previous studies, we find, using a particular subsample of workers employed in the same plant, that firm unobserved heterogeneity account for a significant part of the observed size-wage differentials. This result is corroborated by longitudinal estimation - fixed effect and first difference - on movers, but is not consistent with the estimated significant effect of previous employer's size on current wages, for the same subsample.

From the evidence presented in this research, we draw the following conclusions.

The plant size-wage effect in the sample under study is positive and significant.

Movers experience wage changes that are of the same sign and of similar magnitude to the size differentials estimated in the level regressions. This evidence is quite consistent with the true firm effect playing an important role in explaining the size-wage structure.

Furthermore, this same evidence leads us to reject the simplest unmeasured ability explanations: the size wage differentials cannot be entirely explained by unmeasured productive ability that is time invariant.

We can, therefore, conclude that the size-wage effect remains partly unexplained even after our attempts of accounting for observed and unobserved firm and worker characteristics.

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APPENDIX

Definitions of key variables used in the estimations

Real Wage; daily wage deflated by the Consumer Price Index (source: Datastream, see Table A1.2).

Establishment size; The size of an establishment measured by the number of employees.
The continuous variable has been reclassified in 6 categories:
size category 0: 0-5 employees
size category 1: 6-20 employees
size category 2: 21-50 employees
size category 3 :51-150 employees
size category 4: 151-500 employees
size category 5: 501-2000 employees
size category 6: more than 2000 employees

Marital status: Married=1, otherwise 0.

Employment Status. This variable includes the following categories:
0 Apprentice
1 Unskilled blue collar
2 Skilled blue collar
3 Foreman
4 White collar
7 Home-worker
8 Part-time worker with less than 19 hours per week
9 Part-time worker with more than 19 hours and less than 35 hours per week

Qualification level of an employee
This variable includes seven categories:
1 No formal education
2 With vocational education, without A-levels (no high-school)
3 Without vocational education, with A-levels (with high-school)
4 With vocational education, with A-levels (with high-school)
5 Polytechnic
6 University
7 Qualification unknown

Industry Classification

This variable defines the specific industry to which the employing establishment belongs to; at a very detailed level, it includes (85 categories).

These are classified at a more aggregated level as follows:

1 Primary

2 Energy

3 Mining

4 Manufacturing

- 4.1 Manufacturing Primary Goods
- 4.2 Manufacturing Investment Goods
- 4.3 Manufacturing Consumption Goods
- 4.4 Manufacturing Food

5 Construction

- 5.1 Building Trade
- 5.2 House Building

6 Distributional Services

- 6.1 Trade
- 6.2 Transport and Communications

7 Industry Services

8 Consumer Services

9 Public Services

Occupational groups

This variable describes the field of occupational specialisation of an employee. These include at a very detailed level 269 categories at a more aggregated level 13 categories:

1) Production and Maintenance
   - 1.1 : Agricultural
   - 1.2 : Miners
   - 1.3 : Row Materials and Intermediate Goods Producers
   - 1.4 : Consumption Goods Producers
   - 1.5 : Builders
     - 1.5.1 Main Building
     - 1.5.2 Renovation
   - 1.6 Installation and maintenance of machinery

2) Services, Infrastructural Tasks
   - 2.1 Services

2.1.1 Planning and Organisation, Laboratory Technicians
2.1.2 Administration
2.1.3 Qualified Administrative and Managers
2.1.4 Qualified Services
2.1.5 Simple Services
2.2 Infrastructural tasks

Region; categorical variable - 329 dummies - indicating the West German Administrative districts.

Experience; calculated as years spent actively on the labour market, after having finished the apprenticeship period.

Occupational specific experience; calculated as years of experience practicing the current occupation – considered as 14-categorical variable - including the apprenticeship period.

Tenure; length in years of the current employment relationship.

Table A.1: Summary statistics

Variable	***Mean***	***Standard Deviation***
Size	1842	6569
Real Wage	137.12	40.99
Age	25.76	3.88
Experience	6.33	3.93
Occupational Experience	5.81	4.02
Tenure	3.88	3.69
Married workers (%)	25.5	43.5
Percentage without education	30.54	22.07
Percentage with Education	65.75	21.95
Percentage with hjgher Degree	3.73	7.58
Employment Growth (%)	2.42	3.49

Table A.2: Employer size-wage effects: OLS Estimation.

	Whole Sample	Stayers	Movers
Observations	170674	142220	28452
Simple Human Capital Earning Function	0.0379 (.0002)	0.0398 (.0003)	0.0314 (.0005)
Industry (85)[§]	0.0309 (.0003)	0.0317 (.0005)	0.0271 (.0005)
Occupation (269) [§]	0.0324 (.0003)	0.0327 (.0003)	0.0283 (.0005)
Industry (14) and Occupation (13) [§]	0.0314 (.0003)	0.0321(.0005)	0.0279 (.0005)
Educational Composition	0.0372 (.0003)	0.0380 (.0003)	0.0301 (.0005)
Educational Composition, Industry (14) and Occupation (13)[§]	0.0304 (.0004)	0.0326 (.0003)	0.0267 (.0008)
Growth	0.0374 (.0003) -0.0091 (.0018)	0.0383 (.0003) -0.0102 (.0021)	0.0332 (.0007) -0.0004 (.0039)*
Growth & Educational Composition	0.0366 (.0003) -0.0083 (.0018)	0.0374 (.0003) -0.0092 (.0021)	0.0326 (.007) -0.0008 (.0038)*
Growth Industry (14) and Occupation (13)[§]	0.0312 (.0004) 0.0067 (.0017)	0.0326 (.0003) -0.0085 (.0019)	0.0271 (.0008) 0.0019 (.0036)*
Growth, Educational Composition, Industry (14) and occupation (13)[§]	0.0301 (.0004) -0.0055 (.0017)*	0.0324 (.0003) -0.008 (.0019)	0.0263 (.0008) 0.0024 (.0037)

NOTE: Dependent variable is log real wages.

Additional explanatory variables include educational qualifications, general and occupational specific experience and its square, tenure, dummy indicating marital status and year dummies.

Standard Errors are in parentheses.

[§]: Numbers in parentheses are the number of dummy variables representing categories of these variables.

***: not significant.**

Table A.3: Employer size-wage effects: estimation of a fixed effect model, on the whole sample, on stayers and on movers.

	Whole Sample	Stayers	Movers
Observations	170674	142220	28452
Simple Human Capital Earning Function	0.02610 (.0038)	0.0271 (.0005)	0.0231 (.0008)
Industry (85)[§]	0.0259 (.0004)	n.a.	0.0233 (.0009)
Occupation (269) [§]	0.0267 (.0004)	0.0263 (.0005)	0.0236 (.0009)
Industry (14) and Occupation (13) [§]	0.0267 (.0004)	n.a.	0.0244 (.0009)
Educational Composition	0.0261 (.0004)	0.0271 (.0005)	0.0232 (.0008)
Educational Composition Industry (14) and Occupation (13) [§]	0.0266 (.0004)	0.0262 (.0005) -0.0048 (.0016)	0.0242 (.0009)
Growth	0.0258 (.0004) -0.0059 (.0014)	0.0262 (.0005) -0.0043 (.0016)*	0.0225 (.0008) -0.00277 (.0042)*
Growth and Educational Composition	0.0258 (.0004) -0.0054 (.0014)	0.0262 (.0005) -0.0043 (.0016)	0.0227(.0009) -0.0029 (.0042)*
Growth, Industry (14) and Occupation (13)[§]	0.0266 (.0004) -0.0047 (.0014)	0.0269 (.0005) -0.0052 (.0016)	0.0241 (.0009) 0.0015 (.0041)*
Growth, Educational Composition, Industry (14) and Occupation (13) [§]	0.0266 (.0004) -0.0042 (.0014)	0.0270 (.0005) -0.0048 (.0016)	0.0242 (.0010) 0.0015 (.0041)*

NOTE: Additional explanatory variables include educational qualifications, general and occupational specific experience and its square, tenure, a dummy indicating marital status and year dummies.

Standard Errors are in parentheses.

[§]: Numbers in parentheses are the number of dummy variables representing categories of these variables.

***: not significant**

Table A.4: Employer size-wage effects: First Difference Estimation.

	Whole Sample	Stayers	Movers
Observations	97343	81114	16227
Simple Human Capital Earnings Function	0.0249 (.0006)	0.0259 (.0029)	0.0218 (.0012)
Industry (85)[§]	0.0250 (.0007)	n.a.	0.0224 (.0012)
Occupation (269) [§]	0.0253 (.0007)	0.0237 (.0029)	0.0234 (.0012)
Industry (14) and Occupation (13) [§]	0.0252 (.0007)	n.a.	0.0232 (.0012)
Educational Composition	0.0243 (.0007)	0.0249 (.0029)	0.0217 (.0012)
Educational Composition Industry and Occupation	0.0247 (.0007)	0.0239(.0029)	0.0227 (.0013)
Growth	0.0239 (.0007)	0.0279 (.0039)	0.0236 (.0012)
Growth & Educational Composition	0.0238 (.0007)	0.0266 (.0039)	0.0218 (.0013)

NOTE: Dependent variable is difference in log real wages.

Additional explanatory variables include educational qualifications, general and occupational specific experience and its square, tenure, a dummy indicating marital status and year dummies.

Standard Errors are in parentheses.

[§]: Numbers in parentheses are the number of dummy variables representing categories of these variables.

Table A.5: Employer size-wage effects: OLS Estimations on movers

	On current plant size	On previous plant size	On previous and current plant size
Observations	28452		
Simple Human Capital Earning Function	0.0314 (.0005)	0.0124 (.0003)	0.0239 (.0008) 0.0084 (.0008)
Industry (85)[§]	0.0271 (.0005)	0.0078 (.0005)	0.0200 (.0009) 0.0071 (.0007)
Occupation (269) [§]	0.0283 (.0005)	0.0006 (.0005)	0.0234 (.0008) 0.0046 (.0007)
Industry (14) and Occupation (13) [§]	0.0279 (.0005)	0.0065 (.0004)	0.0215 (.0009) 0.0056 (.0008)
Educational Composition	0.0301 (.0005)	0.0104 (.0005)	0.0234 (.0008) 0.0077 (.0008)
Educational Composition Industry and Occupation	0.0267 (.0008)	0.0056 (.0005)	0.0209 (.0009) 0.0054 (.0007)
Growth	0.0332 (.0007) -0.0004 (.0039)*	0.0157 (.0005)	
Growth & Educational Composition	0.0326 (.007) -0.0008 (.0038)*	0.0133 (.0005)	
Growth Industry and Occupation	0.0271 (.0008) 0.0019 (.0036)*	0.0128 (.0005)	
Growth, Educational Composition Industry and occupation	0.0263 (.0008) 0.0024 (.0037)	0.0214 (.0009)	

NOTE: Additional explanatory variables include educational qualifications, general and occupational specific experience and its square, tenure, a dummy indicating marital status and year dummies.

Standard Errors are in parentheses.

[§]: Numbers in parentheses are the number of dummy variables representing categories of these variables.

***: not significant**.

Table A.6: Employer size-wage effects: OLS Estimation on the subsample of exogenous movers

	Fixed Effect	OLS	OLS using previous plant size	First difference using pre and post closure spells
Observations		7353		
Workers		3122		
Firms		6700		
Human Capital Earnings Function	0.0239 (.0023)	0.0292 (.0024)	0.0260 (.0034)	0.0175 (.0029)
Industry (85)[§]	0.0227 (.0024)	0.0207 (.0028)	0.0172 (.0034)	0.0187 (.0032)
Occupation (269)[§]	0.0221 (.0024)	0.0251 (.0027)	0.0162 (.0034)	0.0189 (.0032)
Industry (14) and Occupation (13)[§]	0.0222 (.0024)	0.0205 (.0029)	0.0170 (.0034)	0.0185 (.0032)
Educational Composition	0.0241 (.0024)	0.0294 (.0025)	0.0207 (.0038)	0.0184 (.0030)
Educational Composition Industry (14) and Occupation (13)[§]	0.0222 (.0025)	0.0215 (.0030)	0.0129 (.0036)	0.0195 (.0033)
Growth	0.0238 (.0028) -0.0202 (.0059)	0.0269 (.0026) -0.0030 (.0105)*	0.02066 (.0039) -0.0013 (.0122)*	
Growth and Educational Composition	0.0238 (.0029) -0.0198 (.0059)	0.0270 (.0027) -0.0037 (.0104)*	0.0192 (.0039) -0.0008 (.0121)*	
Growth, Industry (14) and Occupation (13)[§]	0.0226 (.0030) -0.0172 (.0058)	0.0168 (.0032) 0.0025 (.0103)*	0.0113 (.0038) 0.0035 (.0119)*	
Growth, Educational Composition, Industry (14) and Occupation (13) [§]	0.0224 (.0031) -0.0169 (.0058)	0.01772 (.0033) 0.0028 (.0103)*	0.0110 (.0038) 0.0044 (.0119)*	

NOTE: Additional explanatory variables include educational qualifications, general and occupational specific experience and its square, tenure, a dummy indicating marital status and year dummies.

Standard Errors are in parentheses.

[§]: Numbers in parentheses are the number of dummy variables representing categories of these variables.

***: not significant**

Table A.7: Employer size-wage effects: Fixed effect Estimation on firms using workers employed in the same plant.

	Fixed Effect	*OLS*
Observations	63052	63052
Workers	9123	9123
Firms	4290	4290
Human Capital Earnings Function	0.0132 (.0026)	0.0334 (.0005)
Occupation (269)	0.0138 (.0025)	0.0328 (.0005)
Educational Composition	0.0149 (.0026)	0.0318 (.0005)
Educational Composition and Occupation (13)	0.0150 (.0026)	0.0339 (.0005)

NOTE: Additional explanatory variables include educational qualifications, general and occupational specific experience and its square, tenure, a dummy indicating marital status and year dummies.

Standard Errors are in parentheses.

§: Numbers in parentheses are the number of dummy variables representing categories of these variables.

Table A.8: Size of plants that employ more than a worker in the sample

Size of plants that employ more than a worker in the sample									
Number of observations					4329				
Mean					947.78				
Standard Deviation					2462.68				
Percentiles	1%	5%	10%	25%	50%	75%	90%	95%	99%
Mean Size	2	13	27	89	324	929	2119	3668	8926