Employer Size and Hierarchy: Evidence from Britain

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We argue that the employer size effect reflects the role of hierarchy. Using matched employer-employee data and individual longitudinal data, we show that the establishment size effect for supervisors is approximately twice that for non-supervisors. We confirm sorting on supervisor ability and present evidence of additional match specific returns for supervisors. We demonstrate that spans of control influence the establishment size return for supervisors but not for non-supervisors. Talented supervisors sort into larger establishments taking a talent premium with them but they also receive a match-specific return on that talent only when matched with a larger establishment.

Keywords: Supervisor; Hierarchy; Size Wage Effect

JEL Codes: M52, D22

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1. Introduction

Economists have long debated why larger employers pay higher wages. Many theoretical explanations have been tested including rent sharing, compensating differentials, returns to increased specialization and simple ability sorting. Often these have not found empirical support (Oi and Idson 1999; Brown and Medoff 1989; Groshen 1991; Belfield and Wei 2004). Indeed, Fox (2009 pp. 83-84) argues "our failure to explain firm-size wage gaps means economists do not understand key features of how firms and labor markets work". This paper hopes to improve that understanding by returning to the vein of theory explored by Fox suggesting that the size effect is largely a hierarchical phenomenon. Larger employers typically have both deeper hierarchies and wider spans of control. The return to supervisory talent is larger for these employers and so efficient assignment argues that more talented supervisors should match with larger employers (Tervio 2008; Gabaix and Landier 2008). Moreover, talented supervisors receive match-specific returns in larger employers, simply not present in smaller employers. We provide a series of tests of these hypotheses.

This is the first paper using British data to focus on the difference in establishment (workplace) size effects for supervisors and non-supervisors. We examine both matched employee-employer data and individual longitudinal data. While the exact questions identifying those with supervisory duties differ, both data sources demonstrate substantially larger returns to employer size for those with such duties. This pattern survives our efforts to control for establishment level heterogeneity in the first data source and individual worker heterogeneity in the second data source. Instrumental variable exercises also confirm that the returns to size are highly concentrated among supervisors in both data sources.

This concentration of returns and its pattern support hierarchy theory. The fact that the return to size for those with supervisory duties persists but shrinks in the face of individual fixed effects means that unobserved but time invariant ability is not the complete story. The

remaining return may at first be thought to reflect effort, learned skills or match quality, but is not simply an ability return (Idson and Feaster 1990). We further support the implications of hierarchy theory by examining the role played by larger spans of control, typical in larger establishments. We find that larger spans of control increase wages for supervisors far more than non-supervisors. Moreover, we show that the span of control interacts with establishment size in ways sensibly informed by hierarchy theory. In addition, we demonstrate a tie between establishment size and skill matching that is unique for supervisors and supportive of the importance of hierarchy. We then carefully examine the timing of the wage increase associated with changing jobs to a larger employer and show that the increase for supervisors appears concentrated at the time of the change in a way that is not true for non-supervisors. These last two results suggest that there is, indeed, a return to match quality for supervisors. Thus, we suggest that the size premium reflects both that larger establishments hire more talented supervisors (sorting on ability) and that talented supervisors receive a larger return on that talent only in larger establishments (a match specific return).

In what follows, the next section reviews the literature on size effects with an eye towards the importance of hierarchical explanations. The third section presents the data and variables from our two data sources. The fourth section describes the methodology. The fifth section presents our key results, provides complementary evidence on three extensions and describes robustness checks. The sixth section concludes.

2. The Role of Hierarchy in the Literature

For more than a century, economists have observed that larger firms pay higher wages (Moore 1911). The extent, size and source of this correlation has been extensively studied. Brown and Medoff (1989) show that holding worker characteristics constant, doubling firm

size is associated with a wage increase from 1.5% to 3.8%. Troske (1999) emphasizes the distinction between establishment size and firm size showing that the former is typically larger. Moving workers from a standard deviation below to one standard deviation above the mean establishment size generates 13% higher wages while a similar move around the mean firm size generates 11% higher wages. In related work, Bayard and Troske (1999) confirm significant and positive establishment size wage premia for manufacturing, retail trade and service industries. Moreover, they emphasize the similarity of the magnitude of the establishment size wage premia across all three of these broad sectors. Thus, in contrast to the differences they find in the firm size wage premium, they claim that broad industrial differences do not account for the size, persistence and regularity of the establishment size wage premium. This emphasis on establishment size follows Mellow (1982) who earlier found an unexplained wage effect of 14% associated with moving an otherwise equal (in observables) worker from an establishment with 25 employees to one with more than 1,000 employees.

While these results come from the United States, similar evidence exists for many countries. An unexplained establishment size effect has been found for the UK (Main and Reilly 1993; Green et al. 1996; Manning 2003), for Canada (Morissette 1993; Reilly 1995), for Germany (Schmidt and Zimmerman 1991; Gerlach and Schmidt 1995; Andrews et al. 2012), for Austria (Winter-Ebmer 2001; Gruetter and Lalive 2009), for France (Abowd et al. 1999; Fakhfakh and Fitzroy 2006), for Switzerland (Winter-Ebmer and Zweimuller 1999), for Italy (Brunelllo and Colussi 1998; Scoppa 2014), for Nordic countries (Albaek et al. 1998; Pehkonen et al. 2017), for a cross-section of five European countries (Lallemand et al. 2007), for a cross-section of nine OECD countries (Gibson and Stillman 2009)[1], for Latin-American

[1] Gibson and Stillman (2009) do not find a firm-size wage premium for Belgium and Poland after controlling for basic worker characteristics.

countries (Mizala and Romaguera 1998), and for developing African countries (Strobl and Thornton 2004).

The establishment size effect on earnings proves both important in magnitude and persistent across time and location. The magnitude of the firm size effect has, however, been shown to be declining in the United States for reasons other than changing industrial composition (Bloom et al. 2018) but increasing in Germany and Sweden and stable in the UK (Colonnelli et al. 2018). More fundamentally, the cause of the size effect (both establishment and firm) has been highly disputed. It may reflect differential costs of turnover or monitoring, rent sharing, compensating wage differentials, the strength of unions or higher levels of specialization (Kruse 1992; Oi and Idson 1999; Belfield and Wei 2004; Molina-Domene 2018). While these and related theories suggest a size effect broadly spread across workers and types of jobs, hierarchical theory suggests otherwise. Hierarchy theory suggests that size is largely relevant only for those in supervisory positions and argues both for ability sorting and match specific returns within those positions.

Hierarchy theory differs because the supervisor-subordinate relationship generates productivity not suggested by other theories. Those further up the hierarchy are in potentially high productivity jobs largely because of their control of subordinates. Thus, wage levels jointly reflect worker skills and the jobs in the hierarchy that workers hold (Meagher 2001). It is this inter-relationship between position and skill that argues for both ability sorting and match specific returns.

Larger employer size typically brings greater spans of control, more non-supervisors to supervise, also deeper hierarchies, and thus more layers of supervisors. The extent to which each are associated with larger size reflects the trade-off between the greater scale economies associated with larger spans of control and the associated loss of monitoring quality. Similarly, improving monitoring quality requires smaller spans of control but more

layers of supervisors in a larger firm and runs the risk of loss of communication and control (Van Zandt 1999). Administrative and supervisory tasks in an environment with larger spans of control and more layers of supervisors are anticipated to influence profit to a greater extent, and importantly require greater responsibility and skill. Yet, exemplary supervisor talent can be utilised fully only with larger employers.

Meagher and Wilson (2004) test an implication of this theory. They examine a cross-section of Australian workers showing that the establishment size effect is significantly larger among those with supervisory duties. Moreover, the difference in the returns is not explained by the other available controls. While a valuable contribution, it remains potentially consistent with the earlier observation that larger employers hire workers with greater researcher unobserved ability (Abowd et al. 1999). In particular, the relevant unobserved ability could be mostly the ability to supervise. In this view, the larger premium for supervisors reflects larger employers simply hiring supervisors with greater ability, and the resultant wage effect reflects sorting on ability. Thus, they confirm the sorting but not the match specific return.

Fox (2009) adds to this by showing that in both the United States and Sweden size wage gaps increase with job responsibility. This proves consistent with a hierarchical model in which white-collar employees advance with age in hierarchies and supervise more workers, both lower level supervisors and non-supervisors (Garicano and Rossi-Hansberg 2004, 2006). Indeed, the wage-gaps of white-collar workers increase with age because supervisors at larger firms supervise increasingly more workers as they age.

In an important case study, Smeets and Warzynski (2008) and Smeets et al. (2019) find that large spans of control are associated with higher wages within a large high-tech European firm. Caliendo et al. (2015) use data from French manufacturing firms and find that growing firms add hierarchical levels that increase pay dispersion.

More generally, and supportive of Fox (2009), Mueller et al. (2017) use proprietary pay surveys matched to administrative data to examine pay inequality within firms. They show that pay differentials between jobs that involve no supervisory responsibility are invariant to firm size. At the same time, the pay disparity between jobs with supervisory responsibility and those without grows dramatically with firm size. This hints that there may be more going on than a return to ability alone, as the supervisory jobs in larger establishments and the skills required for them differ as reflected by internal wage setting independent of who fills those jobs.[2] Thus, while both an examination of employees and of jobs argues for the importance of hierarchy theory, open questions remain about the extent to which sorting on unchanging ability drives the results.

We provide the first British examination contrasting supervisors and non-supervisors and using both matched employer-employee establishment data and longitudinal worker data. We show that the return to establishment size for those with supervisory duties is roughly twice as large as for those without. This difference is statistically significant, not explained by other controls and an important determinant of the difference in earnings between supervisors and non-supervisors. Instrumental variables exercises suggest that exogenous variation in establishment size influences the wages of supervisors far more than non-supervisors. The longitudinal data presents a statistically larger return to establishment size for supervisors. Importantly, it continues to do so when holding constant individual worker fixed effects. Thus, a given supervisor moving to a larger workplace has a larger percentage increase in earnings than a given non-supervisor moving to a larger workplace. We confirm ability sorting but show a return beyond that ability.

This suggests two potential (and not mutually exclusive) possibilities. Either there is a rapid learning by doing that happens for supervisors at larger workplaces that is rewarded or

[2] This also seems compatible with Barron et al. (1987) who show that larger employers face larger monitoring problems, do more intensive screening and provide greater training. These differences suggest the return for supervisory ability may be greater in larger establishments.

there do exist match specific returns to skilled supervisors in larger workplaces. We shed light on these possibilities by first showing that the size effect for supervisors is largest when there is an exact match between job requirements and self-reported supervisor ability. This importance of the match does not carry over to non-supervisors. We then focus on those moving from a smaller to a larger establishment in a modified event study. We show that the supervisors have a larger wage increase at the time of change than the non-supervisors. The latter show a more gradual increase after the change. This suggests that the larger increase for supervisors may, indeed, reflect match specific returns. The general idea of match specific returns is common in labour economics having been used to explain inter-industry earnings structures (Kim 1998) and returns to degrees (Belman and Heywood 1997) among other labour market phenomena. The point from hierarchy theory is that skilled supervisors are only able to use that skill and be fully rewarded for it in a larger employer. We see this as an integral part of understanding hierarchies and as consistent with the empirical evidence we present.

The larger size effect for supervisors than non-supervisors seems to argue against some theoretical causes of the size effect. Thus, if unions are stronger in larger workplaces, it is difficult to explain why supervisors are the primary beneficiaries. Yet, it can certainly be argued that theories other than hierarchy might generate larger returns to workplace size for supervisors.[3] Thus, supervisors in larger organizations may be more difficult to monitor. Firms might respond by providing incentive payments to supervisors that prevent shirking. These payments may not be needed for non-supervisors if the payment to supervisors are effective. This could imply higher rent sharing for supervisors in larger workplaces. Yet, absent in this emphasis on the difficulty of monitoring supervisors is the crucial role of ability

[3] We credit an anonymous reviewer for suggesting the following alternative theoretical explanations.

from hierarchy theory. Our evidence of strong sorting on ability as well as match specific returns is not easily generated from differential monitoring difficulties.

Similarly, greater specialization in larger companies might imply that supervisory input becomes more productive. The productivity associated with specialization again differs from the productivity associated with ability. Specialization makes otherwise less productive workers more productive but our evidence is that larger employers attract inherently more productive supervisors as well as providing match specific returns. Moreover, it is unclear why the benefits of specialization should be so concentrated among supervisors. In the end, we cannot rule out all other possible theories but the emphasis of hierarchy theory on the unique match of high ability supervisors with high potential productivity positions generates predictions on sorting and match quality. These predictions are not immediately evident from other theories.[4]

3. Data and Variables

Our first data source is the 2004 and 2011 Workplace Employment Relations Survey (WERS), a stratified sample of British workplaces (Van Wanrooy et al. 2013). Within the establishments for each year is a shared sample of establishments that creates a panel. We focus exclusively on this panel. WERS matches establishment level questions asked of senior managers with questionnaires from 25 randomly selected employees in each establishment, or from all employees in establishments with fewer than 25.[5] While individual employees are not followed over time, this dataset is nonetheless ideal as it provides a richer vector of establishment–level control variables. To correct for sample design and any observable non-response bias we use weights as provided by the survey data throughout our analysis (see Forth and Freeth, 2004).

[4] We thank an anonymous reviewer for encouraging us to contrast our results and past theories.
[5] The management questionnaire response rate in 2004 (2011) was 64% (46%) while the employee questionnaire response rate in 2004 (2011) was 60% (54%).

Each employee is asked "*Do you supervise any other employees? A supervisor, foreman or manager is responsible for overseeing the work of other employees on a day-to-day basis*" Yes/No. Employees are also asked "*How much do you get paid for your job here, before tax and other deductions are taken out? If your pay before tax changes from week to week because of overtime, or because you work different hours each week, think about what you earn on average*". Thus, in our results we contrast "supervisors" with "non-supervisors." In robustness tests we will also use occupational codes identifying managers in the WERS to better match the question from the BHPS.

In the 2011 WERS survey respondents report within 14 bands representing income ranging from "less than £60 per week/£3,120 per year" to "£1,051 or more per week/£54,061 per year".[6] Since wages are only observed within ranges we use mid-points across the ranges where we set the bottom interval equal to the mid-point of the lower bound and set the top interval equal to 1.5 times the lower bound of this top category.[7]

The survey provides the respondents' usual weekly working hours including overtime (continuous measure). To reduce participation issues, we restrict the sample to full-time employees (>=30 hours per week) aged 18-65 years although we experiment with the treatment of hours. The employer size variable comes from the establishment level questionnaire and identifies the total number of employees in the establishment (matching Meagher and Wilson 2004). After dropping observations with missing data, we have 10,227 employees matched in 577 workplaces.

Our second data source is the combined British Household Panel Study and Understanding Society data (US). The BHPS is a random sample of approximately 10,000 individuals in 5,500 households, later, in 1999, increased to 16,000 individuals in 9,000

[6] In WERS 2004 the corresponding pay bands were ranged from "less than £50 per week/£2,600 per year" to "£871 or more per week/£45,241 per year".
[7] Bryson et al. (2018) confirm the reliability of the banded WERS earnings. They report a correlation of 0.99 between the WERS earnings and payroll records from the Annual Survey of Hours and Earnings.

households. US is the follow-on survey covering the period 2009 onwards covering approximately 100,000 individuals in 40,000 households. BHPS households comprise a subset of the US sample and can be followed, except for in the first wave of US where the unique BHPS identifier is unavailable. In our main estimates, we use the full sample of respondents from the BHPS and US. We stress that our results are materially unaffected by including only the individuals from the BHPS and going forward we will refer to the combined series as simply the BHPS. We focus on the employed and exclude the self-employed. We follow the same additional sample selection decisions as for WERS including focusing on full-time employees aged 18-65 years.

Every wave each employee is asked *"Do you have any managerial duties or do you supervise any other employees?"* Individuals provide mutually exclusive responses that they are a manager, a foreman/supervisor, or that they are neither a manager nor a supervisor. We note that taking both positive responses as supervisors may include some managers without supervisory responsibilities and recognize this as a potential source of measurement error. Excluding managers also seems likely to be in error as many managers will have supervisory duties and as the question combines supervisor with foreman and perhaps implies very limited supervisory duties. This may cause many higher-level supervisors to identify as a manager. Thus, we present the results separately for "managers" and for "supervisors/foreman" and for those that are neither. We will call the last group "line workers."

The BHPS has a range of information on wages and hours worked from which we can compute hourly wages for each respondent-year observation. The employer size question is asked of individual respondents and the responses are in bands. It asks "*How many people are employed at the place where you work?*" The answers are given in intervals, 1-2; 3-9; 10-24; 25-49; 50-99; 100-199; 200-499; 500-999; and 1000 or more. Some small number of

individuals answer either "don't know but fewer than 25" or "don't know but 25 or more". We exclude these individuals from our analysis. As a result of our restrictions, we are left with an estimating sample of 167,342 observations from 1991 to 2016.

Appendix Tables A1 and A2 present descriptive statistics according to supervisory status for WERS and the BHPS, respectively. The supervisors and non-supervisors look relatively 'balanced' across key workplace/employment characteristics even as they differ in obvious personal characteristics such as education, wages and age.

4. Methodology

Our ideal estimating equation would be estimated separately for different worker types (for example supervisors and non-supervisor) and take the following form:

$$y_{ijt} = \beta_0 + \beta_1 Size_{ijt} + \varphi' \mathbf{X}_{ijt} + \gamma' \mathbf{W}_{ijt} + \phi_i + \lambda_j + \theta_t + \varepsilon_{ijt} \quad (1)$$

Where the dependent variable y_{it} is log hourly pay of individual *i* in establishment j at time *t*. *Size* is the log number of employees at the establishment *j* where individual *i* works at time *t*. The coefficient β_1 is the estimated size elasticity for worker type and $\boldsymbol{x}$ and $\boldsymbol{w}$ are vectors of individual and workplace characteristics, respectively. Critically, ϕ_i and λ_j are unobserved fixed effects over time that vary by individual and by establishment. Estimating such an ideal model requires panel data that follows *both* establishments and matched employees over time. We use the BHPS which follows workers over time but does not match establishments. We also use the WERS which follows establishment's overtime but does not follow the workers in those establishments over time. Instead, it randomly samples workers in each time period within the establishments it follows.

When estimating pooled ordinary least squares (POLS) as baselines, these imperfections do not present a problem. We estimate this simplified version of (1) separately for supervisors and non-supervisors in WERS and for managers, supervisor/foreman and line-

workers in the BHPS. We also estimate a fully interacted specification where size, $\boldsymbol{X}$ and $\boldsymbol{W}$ are all interacted with the relevant employee type dummy. This allows us to formally test the statistical difference in the size coefficients, β_1, between, for example, supervisors and non-supervisors. We recognize that in these estimates the error equals $\phi_i + \lambda_j + \varepsilon_{ijt}$ and may bias estimates of β_1.

Exploiting the advantages of each data source moves us closer to (1). In the BHPS we use FE(*i*) to control for the extent to which the establishment size elasticity reflects sorting across establishments on unmeasured fixed individual characteristics such as ability. Thus, we estimate:

$$y_{ijt} = \beta_0 + \beta_1 Size_{ijt} + \varphi' \mathbf{X}_{ijt} + \gamma' \mathbf{W}_{ijt} + \phi_i + \theta_t + \varepsilon_{it}, \quad \text{where } \varepsilon_{it} = \varepsilon_{ijt} + \lambda_j \tag{2}$$

We recognize that correlations between λ_j and the size variable may mean that these estimates retain bias relative to (1) but have also corrected for one source of bias relative to POLS.

A mirror image of (2) would use WERS to exploit the repeated observations within workplace.

$$y_{ijt} = \beta_0 + \beta_1 Size_{ijt} + \varphi' \mathbf{X}_{ijt} + \gamma' \mathbf{W}_{ijt} + \theta_t + \lambda_j + \varepsilon_{it}, \quad \text{where } \varepsilon_{it} = \varepsilon_{ijt} + \phi_i \tag{3}$$

Again, this eliminates one source of potential bias but the error term retains the potentially correlated individual fixed effects. As the individual workers are not followed over time, FE(*j*) in (3) cannot be run at the individual level. The variation in establishment size within firm is completely co-linear with the establishment indicator and the wave indicator. Thus, we aggregate all individual level variables to their establishment means and estimate on the resulting establishment level panel of $t = 2$.

While WERS and the BHPS contain similar information, several differences exist. The most notable relate to the dependent variable and the key independent variables of interest. While hourly wages are available as a continuous variable in the BHPS, as discussed early, they are reported in intervals in WERS. This leads us to estimate the main WERS models using midpoints of the intervals for comparison with BHPS. While this is our preferred specification and used throughout, we do confirm the WERS results via maximum likelihood interval regression (Stewart 1983) and match this with BHPS interval regression using the same intervals as reported for WERS.

The second key difference is that while WERS reports establishment size continuously, BHPS reports it in intervals. We again use midpoints of the size categories to generate a (quasi) continuous size variable. This allows more direct comparison with the WERS data. As we discuss later, this choice does not in practice change the tenor of our results.

A further, general, issue is how to specify the relationship between establishment size and wages. The main choice is between log-log and log-linear models. We use log (wage) – log (establishment size) as our main specification throughout the paper. This fits the data better (improved goodness of fit), is free of unit of measure and so readily interpretable, and comparable across models. It also allows us to easily compare with previous studies.

We endeavour to keep the vector of controls (both $\boldsymbol{X}$ and $\boldsymbol{W}$) as similar as possible across data sets. Remaining differences reflect the respective workplace and individual/household focus of each. WERS has more detailed information on, for instance, workplace composition, the BHPS has more information on personal characteristics. In practice, this leads to modest variation in the specific control vectors but we stress that our main estimates of interest are largely unchanged when we use common, more parsimonious, control vectors. Specific control vectors are explained as notes to the tables of estimates. The

vector of individual controls $\boldsymbol{x}_{it}$ includes employee age and its square, tenure and its square, dummies for gender, married or cohabitating, seven educational qualification dummies and one vocational qualification dummy, two dummies capturing a permanent or temporary job (vs. 'fixed period' job), union membership and eight occupational dummies.[8] Workplace controls $\boldsymbol{w}_{jt}$ include dummies for being part of a larger organization or a single independent establishment (vs. 'sole UK establishment of a foreign organisation'), the percentages of the eight occupational groups, the percentages female, and union, eleven industry dummies and nine region dummies and year dummies.

An additional concern is that wage patterns may be driven by time-varying unobservable factors. Thus, unobserved negative demand shocks could hurt profitability, reduce employment size and reduce wages. In response to the possibility of such time varying unobservables, we adopt an identification strategy based on industrial aggregation (examples include Fisman and Svensson (2007), Lai and Ng (2014) and Bilanakos et al. (2017). The strategy posits that unmeasured characteristics of an industry help define the size of workplaces within that industry. In our case, these industry characteristics stand as exogenous influences that make it more or less likely that establishments within the industry will be large employers. These unmeasured characteristics may reflect the nature of the product and the underlying technology including potential scale economies.

The empirical implementation generates an identifying variable that aggregates a lagged size indicator. This aggregate uses the earlier WERS waves. The 1998 wave is used to create the 2004 instrument and the 2004 wave is used to create 2011 instrument. Thus, using a lagged and largely different set of establishments helps improve the exogeneity of the instrument.[9] The identifying variable is the lagged average size of workplaces in industry cell

[8] We had difficulties developing a measure of tenure in the US years to match that in the BHPS years. We show in the on-line appendix (Table OA3) that our exact handling of this proves immaterial.
[9] The 1998 wave does not have a panel element that connects to 2011.

at the 2-digit industry level. The underlying assumption is that the aggregated instrument introduces independent variation that allows the identification of the individual size effect. In the case of the BHPS, we adopt a matching strategy where we use 7-year lagged 2-digit industry cells of establishment size as the source of exogenous variation. This naturally leads to a loss of observations (the period 1991-1997) where we do not have this information. The IV estimation uses two stage least squares that adjusts standard errors and takes establishment size as endogenous. We ultimately present both cross-sectional and fixed-effect versions of the IV estimation.

5. Results

Table 1 presents initial results. These are pooled estimates within each data source. The first two columns contrast the positive relationship between log size and log earnings for supervisors and non-supervisors within the WERS. These are individual level observations. The point estimates for supervisors, a 0.037 elasticity, is much larger than that for non-supervisors, 0.024. This difference is statistically significant as shown by a fully interacted specification available upon request (t-stat = 2.46).[10] As our estimate of FE(*j*) requires aggregation, we mimic the pooled estimate by averaging the individual level variables to the establishment for both supervisors and non-supervisors. Columns 3 and 4 of Table 1 show that these estimates are virtually identical to the individual level estimates. The point estimate for supervisors, a 0.037 elasticity, remains larger than that for non-supervisors, 0.023, a difference of 0.014.[11]

Columns 5, 6 and 7 produce similar relationships within BHPS. The estimated size elasticity coefficient is largest for managers, next largest for supervisors and smallest for line

[10] Using maximum likelihood interval regression (Stewart 1983) rather than midpoints generates nearly identical point estimates of 0.037 and 0.025 (available upon request).

[11] The aggregated estimate does not immediately allow a measure of significance for the difference. Yet, a variation that uses the average difference in supervisor and non-supervisor wages as the dependent variable returns a virtual identical 0.0147 elasticity difference that is statistically significant. Available upon request.

workers. The estimate for supervisors is significantly larger than that for line workers (the difference in a fully interacted specification has a t-statistic of 3.38) but the coefficient for managers is by far the largest and more than twice as a large as that for line workers, 0.069 vs. 0.031 (the difference in a fully interacted specification has a t-statistic of 17.52).[12] Complete estimates showing all the control variables are reported in Tables OA1 and OA2 in the on-line appendix for the WERS and the BHPS samples respectively.

INSERT TABLE 1

We emphasize that the general magnitudes we report are close to those reported by others. Bayard and Troske (1999) report log establishment size coefficients of around 0.04 for the US although they are not concerned with the role of supervisors. Indeed, similar magnitudes are also reported in the original work by Brown and Medoff (1989). A common way to understand the resulting premium from our estimates is to project the wage change of employees as they move from a standard deviation below the mean log size to a standard deviation above the mean log size (again, see Bayard and Troske 1999). In the WERS, this imagined move generates a wage premium of 16.2 percent for supervisors but only 8.9 percent for non-supervisors. These compare with Bayard and Troske who find US size premiums of 14 percent in manufacturing, 10 percent in retail sales and 11 percent in services. Similar projections using the BHPS are larger, but the pattern is similar. They indicate a premium of 26.9 percent for managers, 14.4 for supervisors and 11.5 percent for line-workers.

Thus, the initial evidence suggests a much larger size elasticity for supervisors than non-supervisors in the WERS and for managers and supervisors than for line workers in the BHPS. This is the paper's first evidence supporting hierarchy theory and the first evidence of its sort for Britain. It matches the Australian cross-sectional evidence of Meagher and Wilson

[12] We re-estimated our BHPS specification replicating the dependent variable for WERS (midpoints of the WERS wage categories). The OLS estimates were remarkably similar, 0.074 (managers), 0.040 (supervisors) and 0.032 (line-workers). Nearly identical results followed from maximum likelihood interval regression on this data.

(2001). We now examine what remains of this pattern when we control for FE(*j*) or FE(*i*). Such establishment or individual fixed effects might generate the apparent pattern that both we and Meagher and Wilson present.

In estimating FE(*j*) we use the aggregated establishment data in the two-year panel. The first two columns of Table 2 show FE(*j*) results directly analogous to the pooled results in columns 3 and 4 of Table 1. The coefficient for supervisors maintains its size at 0.037 while that for non-supervisors is essentially zero. The Hausman tests for both supervisors and non-supervisors clearly reject the hypothesis that the correct specification should be POLS instead of fixed effects.[13] Overall, the estimates suggest that the bias in the size elasticity from failing to estimate FE(*j*) is essentially absent for supervisors but very large for non-supervisors. Moreover, when estimating FE(*j*), the establishment size influence is limited to supervisors.[14]

INSERT TABLE 2

The remaining columns in Table 2 show the FE(*i*) estimates using the BHPS. Here the variation comes from changes in establishment size within worker over time. The coefficients drop relative to the pooled estimates in Table 1. For instance, the elasticity coefficient on establishment size for managers declines from 0.069 to 0.028. To the extent that the managerial worker fixed effect reflects ability, this argues two points. First, managers are sorted and sort into larger establishments. Conforming with hierarchical theory this would be anticipated if greater managerial talent is required in larger establishments.[15] Second, there

[13] The relevant test for WERS is between the POLS in columns 3 and 4 of Table 1 and FE(*j*) in Table 2 (columns 1 and 2) and for BHPS is between the POLS in columns 5, 6 and 7 of Table 1 and the FE(*i*) in Table 2 (columns 3, 4 and 5). Following a reviewer's suggestion these tests are conducted on specifications containing only the establishment size variable of interest.

[14] A very similar pattern emerges when we use the individual data in a first stage and average residuals by establishment for the aggregated FE(*j)* (results available upon request).

[15] We recognize that the diminution of the establishment-size wage effect could reflect attenuation bias. This would be more marked when employees do not change establishment and so changes in establishment size across time may reflect measurement error by respondents. We re-estimated our FE(*i*) models for a sub-sample who did not change jobs. The establishment size estimates were essentially the same as those reported in Table 2. A comparison of those who change jobs and those who do not is in the on-line appendix – see Table OA4.

remains a return independent of that sorting. This suggests that a talented manager receives a match specific return to a larger establishment that he or she will not receive at a smaller establishment. We take these two points as further support for the implications of hierarchy theory.

It also remains the case that the FE(*i*) estimate for managers is significantly larger than that for line workers and for that of supervisors. The return to size for supervisors now appears insignificantly different than that for line workers. This may support the notion that some supervisors such as team leaders remain in the same occupation and at more nearly the same level of hierarchy as line workers.[16]

The pattern of results across the two data sources continue to provide evidence of the importance of hierarchy. Indeed, if the influence of FE(*j*) and FE(*i*) were additive, they would suggest no decline from estimating FE(*j*) on the size elasticity for supervisors so that the gap in elasticities would remain even correcting for both FE(*j*) and FE(*i*).[17]

We next recognize the concern with endogeneity driven by time-varying unobservable factors. We utilise the industrial aggregation identification strategy described earlier. Here the identifying assumption is that there are likely industry specific factors that influence establishment size, for instance the nature of the product and underlying technology, but that these factors (as reflected in historical average industry level average establishment sizes) should not have an independent effect on current wages. Specifically, the identifying variable in the WERS is the average size of workplaces in the industry cell at the 2-digit level lagged by one survey. Thus the 2011 instrument comes from the 2004 survey and the 2004

[16] Further support for this view is provided by returning to the original WERS estimate. We required that supervisors also be identified as "managers" in the occupational codes. This causes the coefficient on establishment size for supervisors to increase from 0.037 to 0.041.

[17] The differences in coefficients between POLS and FE(*j*) and between POLS and FE(*i*) can be converted to correlations, $r = d/(\sqrt{(d\text{^}2 + a)}$, where *d* is the standardized mean difference between coefficients and $a = \frac{(n_1+n_2)^2}{n_1 n_2}$. The correlations indicate the continued importance of the estimated size elasticities: -0.0002 for supervisors and 0.0175 for non-supervisors in the WERS and 0.0202 for managers, 0.0120 for supervisors, and 0.0062 for line workers in the BHPS.

instrument comes from the WERS 1998 survey.[18] The underlying assumption is that the aggregated and lagged instrument introduces independent variation that allows the identification of the individual size effect. We match our approach as closely as possible for the BHPS. Thus, for the BHPS we use the same lag, 7 years, and draw average establishment size within the 2-digit industry cell.

The first two columns of Table 3 present the results for WERS using the pooled individual data. The lower panel of Table 3 indicates that the instrument is not weak. The resulting estimates continue to indicate a large and significant size elasticity for supervisors and a much smaller and only weakly significant elasticity for non-supervisors. The coefficient for supervisors is larger than those without instrumenting (see column 1 of Table 1) and the supervisor coefficient is now twice as large as the largely unchanged coefficient for non-supervisors.

INSERT TABLE 3

The remaining columns of Table 3 use an equivalent IV for the individual worker BHPS. Here we aggregate the establishment size from the lagged individual observations. This results in a loss of sample size as we give up seven years of data. The F-statistics again indicate the absence of a weak instrument. The measure of establishment size takes a statistically significant elasticity coefficient in all three estimates. The relative sizes of the estimates remain. The estimate for managers continues to be nearly twice as large as that for line workers. The sizes of the coefficients are larger than in the POLS in Table 1. This may reflect a larger local average treatment effect or the fact that the IV is unaffected by measurement error in establishment size. To the extent it reflects the former, it suggests that the influence of correcting for endogeneity may offset the influence of estimating FE(*i*). We

[18] Establishments that participated in the 1998 WERS cannot be linked to those in 2011.

emphasize that the original POLS estimate and both corrections to the BHPS show the size elasticity to be larger for managers.

While recognizing the data demands, we further estimated FE(*j*)-IV and FE(*i*)-IV models as reported in Table 4. The critical point is that the pattern across worker types remains evident. The WERS estimates in the first two columns look very similar to the estimates without FE(*j*) in Table 3. The elasticity for supervisors is twice that of non-supervisors. Similarly, the BHPS estimates in the columns 3 to 5 look very similar to those without FE(*i*) in Table 3. The decline evident from the FE(*i*) and FE(j) corrections in Table 2 when compared to Table 1 is not replicated when correcting for endogeneity.

INSERT TABLE 4

This section has tested the prediction from hierarchy theory that managers have larger returns to establishment size. The conclusion we draw from the series of presented estimates is that corrections for FE(*j*), FE(*i*) and endogeneity do not likely threaten our basic result that, indeed, supervisors and managers have larger size elasticities.

5.1 Extensions

We move from here to examine several hypotheses that are necessarily unique to each data source. In looking at those associated with the WERS we keep the instrumental variables approach used in Table 3 and examine issues of hierarchy in more detail. First, we explore a constructed measure of span of control. Within each establishment we use the individual data to create the share of all employees who are supervisory. We divide this into three categorical variables. More workers per supervisor implies a larger span of control and a smaller share of supervisors for a given hierarchy. If span of control is important, our constructed measure may both take a role itself and influence the return to size for supervisors and non-supervisors.

To examine the possible interaction of establishment size and our constructed span of control measure we instrument these interactions using our aggregated IV as in Table 3.

Table 5 isolates the importance of span of control with the IV continuing to perform reasonably well. The span of control dummy variables for supervisors attain negative and significant coefficients. The point estimates indicate that categories indicating smaller span of control have smaller wages as one would anticipate. The estimates make clear that the largest span of control category is associated with statistically significantly larger earnings. Imprecision in the non-supervisor estimates makes them insignificantly different from zero. Yet, the point estimates are substantially smaller suggesting span of control is less important for non-supervisors.

In addition, the span of control influences the estimated size elasticity much more for supervisors. Focusing on the three span of control categories, we generate three size effects. When the span of control is large the estimated coefficient for establishment size is approximately 0.07. This becomes 0.11 for the medium span of control and becomes approximately 0.22 for the smallest span of control. Each of these estimates are significantly different from zero and all of them are substantially larger than those implied for non-supervisors. Those for non-supervisors are 0.04, 0.08 and 0.07 and, again, insignificantly different from zero because of imprecision. On balance, the estimation makes clear that controlling for the span of control does not change the basic point that the size elasticities are larger for supervisors.

INSERT TABLE 5

The pattern of estimates for supervisors deserves careful interpretation. It indicates that an equal size increase in establishment size plays a smaller role when the span of control is large. When spans of control are large, an increase in size can come largely from additional increases within a level of the hierarchy or a division within that level. When spans of control

are small, the same increase in size necessarily comes mostly from increasing the height or number of divisions within the hierarchy. A large firm with a small span of control is a complex hierarchy. This complexity brings the requirement for exemplary communication and supervisory talent. Thus, both span of control and size matter independently and the interaction suggests the importance of hierarchy complexity. Thus, the pattern of an increased role for size in smaller spans fits well with hierarchy theory.

Our second extension with the WERS also keeps the instrumental variables estimation and explores the idea of a match specific return. WERS asks all respondents an interesting question about skill matching: "*How well do the work skills you personally have match the skills you need to do your present job?*" The resulting five-point scale allows workers to identify that their skills match perfectly or provides two categories of being over-matched (their skills exceed those needed) or two categories of being under-matched (their skills fall short of those needed). As we hope to shed light on the importance of match-specific returns, we divided the sample of workers into three categories, matched, over-matched and under-matched. For each category we continue the division between supervisor and non-supervisor. This resulted in six log-earnings equations in which employer size was the critical instrumented independent variable.

The results are presented in Table 6. When examining supervisors, the largest employer size elasticity clearly exists among those perfectly matched. The estimate shows a highly significant coefficient of 0.09. Those supervisors that are under matched show essentially no meaningful elasticity. This suggests that among those who simply do not have the required skills, there is no advantage to being in a larger employer. Those that are over matched show a far smaller and insignificant estimated elasticity. This pattern makes clear that the appropriate skill match is important in determining the size elasticity for supervisors providing additional supportive evidence for match-specific returns.

INSERT TABLE 6

The contrast with the non-supervisors is dramatic. The non-supervisors show no strong pattern of returns for those matched, over-matched or under-matched. The elasticity point estimates are all essentially the same. This suggests the return to size for non-supervisors has much less to do with skill match than that for supervisors and so hints at the importance of matching and hierarchy theory in explaining the employer size effect.

We now use the BHPS (and its consistent measure of tenure) to further explore issues of match specific returns. We emphasize that hierarchy theory argues for both ability sorting for managers and supervisors/foreman but also for unique match specific returns available only in larger establishments. Yet, the fixed effect estimates could instead reflect unique opportunities for training and investment at larger employers. To provide additional scrutiny, we select a specific sample and imagine an event study focused on taking a new job at a different sized establishment. Again, we emphasize that these likely represent a selected sample of workers and employers who will benefit from the job change. We take that as given. At issue is whether the changes for managers, supervisors or line workers appear to include a discrete jump in earnings or whether it seems dominated by a period of growth in earnings in the periods immediately after the moving event. The latter would be more supportive of larger employers providing opportunities for skill formation and learning by doing that smaller employers do not provide.

We limit our sample to those job changers who move to a larger workplace. We split our sample according to whether the individual is manager, supervisor or line worker in the year prior to this move. To help isolate the impact of size, we remove any individuals who change type of worker over the job change. We limit the observation window to no more than 3 years before and 2 years after the job change. This results in 2,589, 1,543 and 5,885 person-year observations for managers, supervisors and line workers, respectively. All models

include individual fixed effects, the earlier standard controls and a series of year dummies. This produces three sets of estimates which provide within individual effects of moving to a larger workplace. We plot establishment size wage effects by year centred on the year of job change (t=0), where 3 years before provides the base category.

INSERT FIGURE 1

Figure 1 shows the summary of these estimates. The first panel focuses on the managers. The year from -1 to zero shows the pay change associated with the job change and it demonstrates that the increase in wages for managers is essentially concentrated in this period. There is no evidence of pre-change trends in wages that might suggest selection on trends in worker earnings or productivity. Similar patterns are observed for supervisory workers. When combined with the inclusion of individual fixed effects, this hints that the size wage effect for managers and supervisors results largely from more productive use of given supervisory ability.

This can be contrasted with the line-workers who change jobs. In panel 3, the immediate wage increase from a job change is far more modest. It then continues to increase but never reaches the size of that for managers or supervisors. This fits with, for instance, the common human capital explanations. Opportunities to train and learn may be greater in larger workplaces suggesting the size effect reflects a stronger relationship between tenure and wages in larger workplaces. Our point is not to investigate this directly but to show the difference between managers and supervisors and those who are line workers.

To be sure, this is not only a selected sample but the nature of the selection may differ across the three groups of workers. Yet, the dramatic increase associated with the move and relatively modest increase after, suggests the return to managers and supervisors moving may not reflect greater opportunity for human capital investment. One would anticipate that such

opportunities would persist after the immediate job change. Instead, the large increase associated with the change (especially when compared with non-supervisors) puts the spotlight on capturing the return to a valuable match where ability matters but only with a large employer. Thus, these results fit with the evidence from the fixed effect estimates and the examination of match quality using the WERS to argue for a match specific return to size for those with supervisory duties not present for those without such duties.

5.2 Further Robustness Examinations

We now briefly describe estimate modifications aimed at evaluating the robustness of our main and preferred results.

First, as an alternative to using log hourly wages we re-estimated our main models using log weekly wages while controlling for hours worked. This slightly more flexible specification leaves key estimates essentially unchanged (available upon request). Likewise, as an alternative to using log size we re-estimated our models using number of employees (divided by 1000). While naturally, the magnitude of the estimates change, the establishment size – wage premium remain and these are larger for supervisors than for non-supervisors (WERS), and for managers compared to line-workers (BHPS). We present the original pooled estimates in the on-line Appendix (see Table OA5) and the FE and IV are available upon request.

While these different functional forms tell the same basic story, we also explore a substantial change in sample. Although establishment size effects have been confirmed in governmental and non-profit sectors (Belman and Heywood 1990), we limited the WERS sample to only those establishments trading goods in markets. The pattern remains with the coefficient for supervisors being 0.041 and that for non-supervisors being 0.029. In a similar spirit, we re-estimated the BHPS pooled models excluding public sector workers. This also revealed modestly higher establishment size wage premiums. Crucially, the pattern of size

elasticities clearly remains: elasticity coefficients of 0.079 of managers; 0.052 for supervisors; and 0.038 for line-workers.

While we have also used a relatively sparse control vector, in part to best match controls across the two data sources, there may be still some concerns that some remaining controls could be viewed as 'bad' controls. To investigate this, we re-estimated our main models with a vector of controls consisting only of age, age squared, regional dummies, gender and marital status. These results are presented in the on-line appendix (see Table OA6). The estimates are larger as would be anticipated but the pattern of elasticities remains.

6. Conclusions

The results we present confirm that the employer size wage effect in Britain is substantially larger for supervisors than for non-supervisors in the WERS and for managers than for line workers in the BHPS. The robustness of this result argues against many of the theories of the wage effect but supports the view that it reflects hierarchy. We emphasize that our results are consistent with the returns to supervisory talent being a critical component of the employer size effect. Yet, the result is not only a simple consequence of inherently more productive managers who would be highly rewarded anywhere moving toward larger employers. There also appears to be a match specific component in which supervisors with greater talent earn a return on that talent only with the larger employers where it is valuable. This combination of the importance of position and ability is an additional important implication of hierarchy theory and the ability to confirm both ability sorting and match specific returns helps support that theory.

Specifically, we saw that controlling for worker fixed effects causes the return to size to diminish for managers but not vanish. We also saw in the WERS the importance of skill match for the size effect. Moreover, our event study showed that the returns to changing

employer size were large and more immediate for managers than for line-workers. Thus, consistent with hierarchy theory, a portion of exemplary supervisory skill is utilized only in larger establishments. A variant on this match specific return could be that particularly valuable supervisory skills generate greater revenue but, again, only at a larger employer. In such a variant the assignment resembles that in the theory of "superstars" (Rosen 1981). A small increment of ability is multiplied in this case by more workers and/or layers of hierarchy generating a return (and potentially even a convex return) to size.

In further support of hierarchy theory, we found that larger spans of control are associated with greater earnings increases for supervisors than for non-supervisors. Span of control is one element of size. When we hold that element constant, we found that size interacted with span of control in interesting ways. Specifically, for those supervisors with a small span of control, a given increase in establishment size brings greater earnings than for those supervisors with a large span of control. We think this also potentially fits with hierarchy theory. An increase in establishment size for those establishments with a small span of control necessarily brings far greater layers of hierarchy and complexity. Thus, the size of the organization and span of control introduce the possibility that exemplary supervisory skills will be used and rewarded in ways that simply cannot happen in smaller and flatter organizations.

Finally, we note that the extensive literature on organizational change argues that hierarchies are becoming increasingly flat (Caroli and Van Reenen, 2001; Guadalupe and Wulf, 2010; Lindbeck and Snower, 2000). The modern firm now delegates more decision-making to workers, has shorter chains of command and has increased flexibility in tasks. To the extent that this organization change continues, an implication of our study would be that the wages (and especially those of supervisors) may show smaller size effects as hierarchy is

no longer as pivotal. Indeed, the evidence by Bloom et al. (2018) argues this is already happening in the United States.

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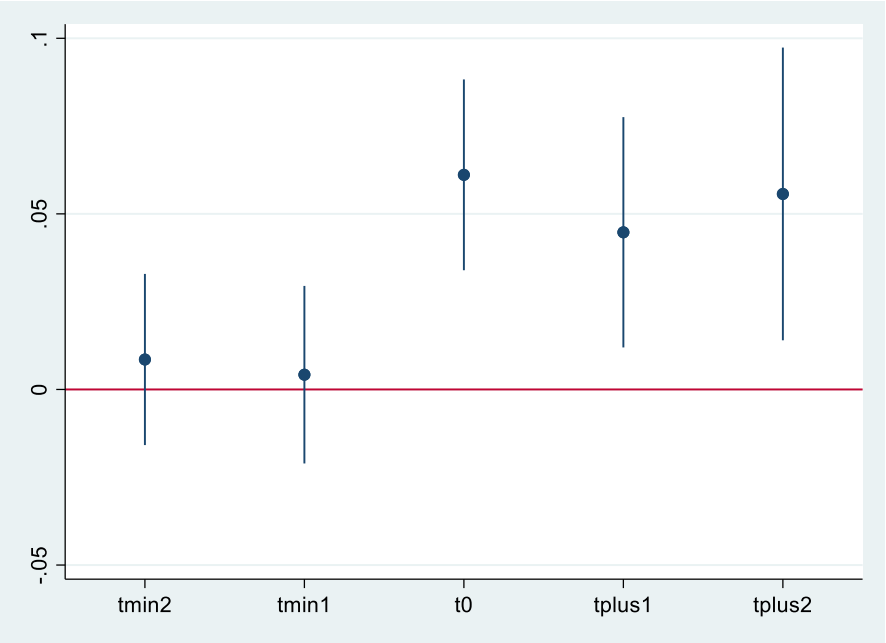
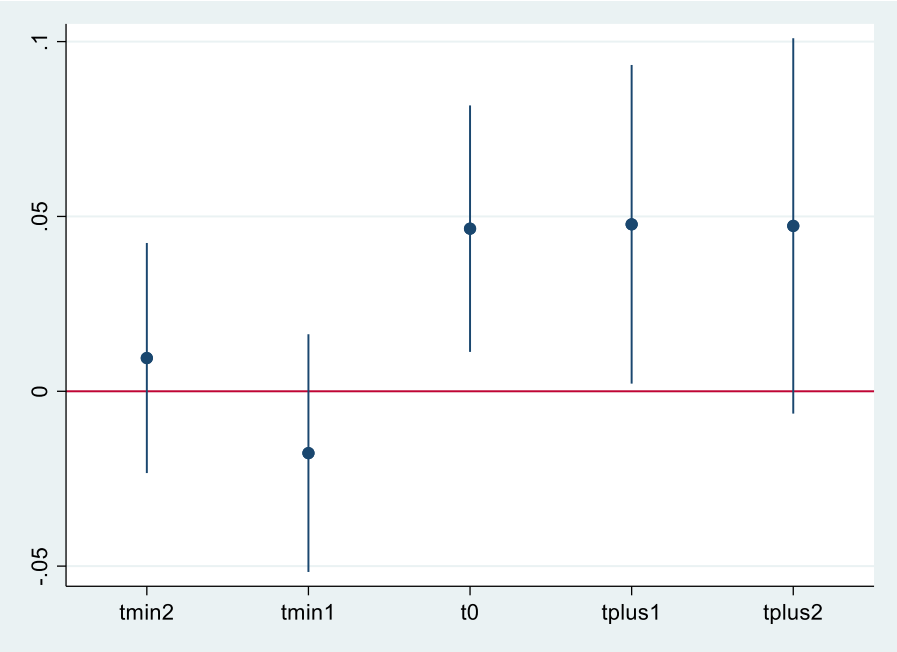
Figure 1. Estimated Wage Effects of Moving to a Larger Employer: Event Study for Job Changers in the BHPS

Panel A - Managers



Panel B – Supervisors



Panel C – Line Workers

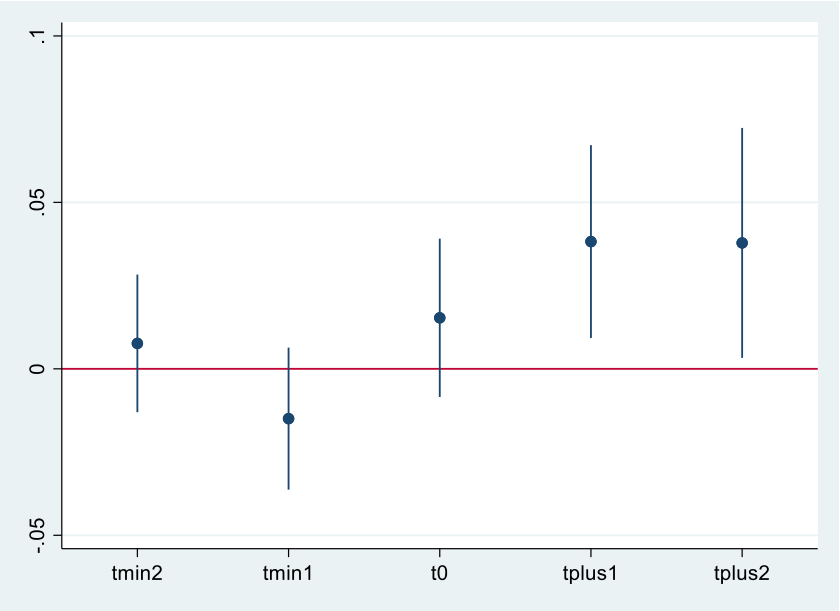


Table 1. Establishment Size and Log Hourly Wages, WERS and BHPS - POLS Estimates

	WERS: Individual Level Sample		WERS: Panel Level Sample		BHPS		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Supervisor	Non-supervisor	Supervisor	Non-supervisor	Manager	Supervisor	Line Worker
Log size	0.0366***	0.0243***	0.0367***	0.0227***	0.0685***	0.0385***	0.0314***
	(0.0065)	(0.0048)	(0.0069)	(0.0054)	(0.0019)	(0.0019)	(0.0011)
Observations	3,759	6,468	1,154	1,154	44,737	27,541	95,064

Notes. In columns 1 and 2 the individual level sample is restricted to a balanced panel sample of 577 establishments observed twice (columns 3 and 4). For reasons of brevity we only report estimates for Log size. Individual controls present for WERS and the BHPS are age and its square, tenure and its square, female dummy, married/cohabiting dummy, union membership dummy, seven educational dummies (in WERS, two in the BHPS), vocational qualification dummy, temporary or permanent job dummies, and eight occupational dummies. For WERS, establishment controls include two dummies if the establishment is part of a larger organization or a single independent establishment, percentages of eight occupational groups, percentages of female, and trade union members, eleven industry dummies and nine region dummies. The BHPS models use 11 region dummies and 8 industry dummies. Robust standard errors are in parentheses. WERS estimates cluster standard errors at the establishment level. BHPS estimates cluster standard errors at the individual level. Levels of significance: *** p<0.01.

Table 2. Establishment Size and Log Hourly Wages, WERS FE(*j*) and BHPS - FE(*i*) Estimates

	WERS: Panel Level Sample		BHPS		
	(1)	(2)	(3)	(4)	(5)
	Supervisor	Non-Supervisor	Manager	Supervisor	Line Worker
Log size	0.0371**	-0.0124	0.0280***	0.0143***	0.0189***
	(0.0176)	(0.0129)	(0.0012)	(0.0016)	(0.0007)
Observations	1,154	1,154	44,737	27,541	95,064
Hausman Test	5.67**	21.26***	620.83***	181.14***	78.65***
p-value	(0.017)	(0.000)	(0.000)	(0.000)	(0.000)
Number of establishments	577	577			
Number of workers			12,455	10,413	28,576

Notes. For reasons of brevity we only report estimates for Log size, all other controls as reported in the Notes of Table 1. Full estimates are available upon request. WERS estimates include workplace fixed effects and BHPS estimates include worker fixed effects. Robust standard errors are in parentheses. WERS estimates cluster standard errors at the establishment level. BHPS estimates cluster standard errors at the individual level. Levels of significance: *** p<0.01, ** p<0.05.

Table 3. Establishment Size and Log Hourly Wages, WERS and BHPS - Instrumental Variables Estimates

	WERS			BHPS	
	(1)	(2)	(3)	(4)	(5)
	Supervisor	Non-Supervisor	Manager	Supervisor	Line Worker
			2nd stage		
Log size	0.0508***	0.0277*	0.1441***	0.1208***	0.0843***
	(0.0192)	(0.0156)	(0.0143)	(0.0154)	(0.0088)
			1st stage		
Instrument	0.6536***	0.5101***	0.1848***	0.1933***	0.1714***
	(0.0927)	(0.0765)	(0.0122)	(0.0145)	(0.0078)
F-Test Weak Instruments	49.61	44.41	227.29	177.19	475.87
Observations	3,759	6,468	25,866	14,958	54,227

Notes. The instrument in WERS is the log average size of workplaces constructed from the 1998 and the 2004 cross sections at the 2-digit level industry cells. The instrument in the BHPS matches this aggregation but uses individual data and a seven-year lag. All other controls as reported in the Notes of Table 1. Full estimates are available upon request. Robust standard errors are in parentheses. WERS estimates cluster standard errors at the establishment level. BHPS estimates cluster standard errors at the individual level. Levels of significance: *** p<0.01, ** p<0.05, *p<0.01.

Table 4. IV-FE(*j*) WERS and FE(*i*) BHPS Estimates: Establishment Size and Log Hourly Wages
WERS Panel (2004-2011) and BHPS (1991-2016) - Instrumental Variables Estimates

	WERS		BHPS		
	(1)	(2)	(3)	(4)	(5)
	Supervisor	Non-Supervisor	Manager	Supervisor	Line Worker
			2nd Stage		
Log size	0.0688***	0.0387**	0.1498***	0.1065**	0.8910***
	(0.0211)	(0.0185)	(0.0588)	(0.0457)	(0.0216)
			1st Stage		
Instrument	0.8304***	0.8304***	0.0434***	0.0657***	0.0736***
	(0.0842)	(0.0842)	(0.0100)	(0.0132)	(0.0074)
F-Test Weak Instruments	97.31	97.31	19.05	24.78	97.82
Observations	1,154	1,154	22,123	11,387	45,572
Number of establishments	577	577			
Number of workers			5,217	3,162	11,098

Notes. The instrument in WERS is the log average size of workplaces constructed from the 1998 and the 2004 cross sections at the 2-digit level industry cells. The instrument in the BHPS matches the WERS aggregation but uses individual data and a seven-year lag. All other controls as reported in the Notes of Table 1. Full estimates are available upon request. Robust standard errors are in parentheses. WERS estimates cluster standard errors at the establishment level. BHPS estimates cluster standard errors at the individual level. Levels of significance: ***p<0.01, ** p<0.05.

Table 5. Span of Control and Log Hourly Wages, WERS Pooled (2004-2011) - Instrumental Variables Estimates

	(1)			(2)		
	Supervisor			Non-Supervisor		
			2nd Stage			
Log size		0.0682***			0.0401	
		(0.0195)			(0.0289)	
Log size * Span of control dummy 2		0.0445*			0.0351	
		(0.0255)			(0.0518)	
Log size * Span of control dummy 3		0.1465**			0.0289	
		(0.0671)			(0.0602)	
Span of control dummy 2		-0.3861**			-0.2141	
		(0.1903)			(0.1925)	
Span of control dummy 3		-0.4257*			-0.1621	
		(0.2290)			(0.2543)	
			1st Stage			
Instrument	0.8268***	0.0862*	0.0417	0.5125***	0.0269	0.0062
	(0.1634)	(0.0491)	(0.0254)	(0.1442)	(0.0679)	(0.0049)
Instrument * Span of control dummy 2	0.3542*	0.757***	0.0439	0.3842*	0.8524***	0.0053
	(0.1924)	(0.1215)	(0.0285)	(0.1945)	(0.1243)	(0.0086)
Instrument * Span of control dummy 3	0.5168*	0.0245	1.0045***	0.3148	-0.0105	0.8437**
	(0.2893)	(0.1479)	(0.3547)	(0.2457)	(0.0957)	(0.3425)
F-Test Weak Instruments	32.45	28.27	21.59	25.21	19.46	18.98
Observations		3,759			6,468	

Notes. The instrument is the log average size of workplaces constructed from the 1998 and the 2004 cross sections at the 2-digit level industry cells. The span of control dummies reflect ranges in the total number of supervisors divided by the total numbers of employees in the establishment. These are defined as follows: 0%≤x≤30%, 30%<x≤75%, 75%<x≤100. The omitted category is share 0%≤x≤30%. The two interaction coefficients in column 1 of the second stage are significantly different from each other: F=12.27, p.val=0.0008. For brevity we only report estimates of the variables of interest. All other controls as reported in the Notes of Table 1. Full estimates are available upon request. Robust standard errors are in parentheses. Standard errors are clustered at the establishment level. Levels of significance: ***p<0.001, **p<0.05, *p<0.10.

Table 6. The Returns to Establishment Size by Skill Match and Log Hourly Wages, WERS Pooled (2004-2011) Instrumental Variables Estimates

	Supervisor			Non-Supervisor		
	2nd Stage					
	(1)	(2)	(3)	(4)	(5)	(6)
	Over matched	Exactly matched	Under matched	Over matched	Exactly matched	Under matched
Log size	0.0287	0.0924***	0.0145	0.0447	0.0412	-0.0402
	(0.0222)	(0.0218)	(0.1311)	(0.0293)	(0.0289)	(0.0940)
	1st Stage					
Instrument	0.7201***	0.8457***	0.4241*	0.5686***	0.5757***	0.3387**
	(0.1166)	(0.0979)	(0.2236)	(0.0836)	(0.0927)	(0.1502)
F-Test Weak Instruments	38.09	74.60	14.59	36.21	35.88	11.93
Observations	1,958	1,584	217	3,431	2,585	452

Notes. The instrument is the log average size of workplaces constructed from the 1998 and the 2004 cross sections at the 2-digit level industry cells. For reasons of brevity we only report estimates of the variables of interest. All other controls as reported in the Notes of Table 1. Full estimates are available upon request. Robust standard errors are in parentheses. Standard errors are clustered at the establishment level. Levels of significance: ***p<0.001, **p<0.05, *p<0.10.

APPENDIX

Table A1. Summary Statistics (WERS Pooled 2004-2011)

	Supervisor		Non-Supervisor	
	mean	st.dev	mean	st.dev
Individual level variables				
Log hourly pay	2.510	0.589	2.185	0.477
Personal characteristics				
Age	42.835	10.355	40.668	11.978
Age sq/100	19.420	8.805	17.973	9.847
Male	0.567	0.496	0.566	0.496
Married	0.742	0.437	0.655	0.475
Academic qualifications				
GCSE grades D-G	0.265	0.442	0.269	0.443
GCSE grades A-C	0.597	0.491	0.531	0.499
1 GCSE 'A'- level grades A-E	0.121	0.326	0.092	0.288
2 or more GCE 'A' levels grades A-E	0.283	0.451	0.217	0.412
First degree, BSc, BA, Bed	0.360	0.48	0.241	0.428
Higher degree, MSc, MA, MBA, PGCE, PhD	0.117	0.321	0.075	0.263
Other academic qualification	0.283	0.45	0.227	0.419
Vocational/professional qualification	0.660	0.474	0.559	0.497
Job characteristics				
Tenure (years)	6.418	3.509	5.421	3.596
Tenure sq/100	0.535	0.41	0.423	0.403
Permanent job	0.962	0.191	0.933	0.250
Temporary job	0.009	0.095	0.022	0.147
Union membership	0.373	0.484	0.401	0.49
Over matched	0.524	0.500	0.517	0.500
Exactly matched	0.434	0.496	0.437	0.496
Under matched	0.039	0.194	0.040	0.196
Occupations				
Manager	0.293	0.455	0.043	0.202
Professional staff	0.181	0.385	0.120	0.326
Technical	0.172	0.378	0.165	0.371
Clerk	0.105	0.306	0.192	0.394
Craft	0.071	0.257	0.101	0.302
Service	0.055	0.228	0.080	0.271
Sales	0.029	0.167	0.040	0.196
Operative	0.049	0.215	0.126	0.332
Establishment level variables				
Number of employees	742.477	1667.065	780.998	1780.332
Log number of employees	4.992	1.859	5.174	1.79
Multi firm	0.733	0.442	0.757	0.429
Single firm	0.243	0.429	0.215	0.411
Span of control (30%<x≤75%)	0.703	0.457	0.483	0.499
Span of control (75%<x≤100)	0.026	0.161	0.008	0.088
Occupational group (shares)				
Managerial and senior administrator	0.115	0.13	0.098	0.114
Professional	0.171	0.216	0.140	0.201
Technical	0.121	0.184	0.106	0.179
Sales	0.074	0.193	0.074	0.187
Operative and assembly	0.073	0.194	0.119	0.250
Clerical and secretarial	0.170	0.197	0.165	0.214
Craft and skilled service	0.084	0.174	0.093	0.188
Protective and personal service	0.091	0.214	0.066	0.190
Workforce characteristics (shares)				
Share female	0.487	0.279	0.426	0.278
Trade union density	0.285	0.302	0.335	0.328
Industry				
Manufacturing	0.143	0.35	0.210	0.407

Continued

Continued

	Supervisor		Non-Supervisor	
	mean	st.dev	mean	st.dev
Utilities (electricity, gas, water)	0.003	0.055	0.003	0.056
Construction	0.070	0.255	0.048	0.213
Wholesale and retail	0.090	0.286	0.095	0.293
Hotels and restaurants	0.027	0.163	0.019	0.136
Transport and communication	0.046	0.209	0.101	0.301
Financial services	0.037	0.188	0.035	0.184
Other business services	0.133	0.34	0.125	0.331
Public administration	0.095	0.293	0.115	0.319
Education	0.139	0.345	0.098	0.297
Health	0.175	0.38	0.126	0.332
Region				
North	0.056	0.23	0.073	0.26
North West	0.138	0.345	0.158	0.365
East Midlands	0.055	0.227	0.074	0.262
West Midlands	0.084	0.277	0.084	0.277
East Anglia	0.029	0.168	0.032	0.177
South East	0.291	0.454	0.243	0.429
South West	0.082	0.274	0.070	0.256
Wales	0.046	0.21	0.042	0.201
Scotland	0.142	0.349	0.144	0.352
Instrument (log)	4.519	0.961	4.668	1.024
Employee-waves	3,759		6,468	
Employee-waves 2004	1,995		3,425	
Employee-waves 2011	1,764		3,043	

Notes. The WERS sample includes full-time workers (>=30 hours per week) in the age group 18-65. There are 577 workplaces in each wave.

Table A2. Summary Statistics, BHPS (1991-2016)

	Managers		Supervisors		Line Workers	
	mean	st.dev	mean	st.dev	mean	st.dev
Individual variables						
Log Hourly Pay	2.582	0.477	2.271	0.422	2.115	0.427
Log number of employees	343.523	513.919	342.263	505.125	327.738	485.424
Male	0.590	0.492	0.546	0.498	0.561	0.496
Age	41.987	10.078	39.247	11.172	38.223	12.231
Married	0.637	0.481	0.555	0.497	0.488	0.500
A Level	0.342	0.474	0.370	0.483	0.325	0.468
Degree or Higher	0.411	0.492	0.235	0.424	0.205	0.404
Temporary Job	0.017	0.129	0.023	0.151	0.060	0.238
Covered Union Member	0.321	0.467	0.381	0.486	0.358	0.479
Tenure	6.591	7.003	6.576	6.885	6.074	7.053
Occupations						
Manager	0.539	0.498	0.070	0.256	0.021	0.142
Professional	0.188	0.391	0.135	0.342	0.115	0.319
Associate Professional/ Technical	0.140	0.347	0.222	0.416	0.152	0.359
Administrative	0.052	0.222	0.141	0.348	0.180	0.384
Skilled Trade	0.024	0.154	0.131	0.338	0.128	0.334
Services	0.023	0.149	0.083	0.276	0.102	0.302
Sales	0.016	0.124	0.060	0.237	0.064	0.245
Operatives	0.009	0.096	0.089	0.285	0.130	0.336
Labourers	0.009	0.094	0.068	0.252	0.110	0.313
Industry						
Mining and Forestry	0.028	0.164	0.041	0.199	0.044	0.206
Manufacturing	0.058	0.234	0.067	0.250	0.074	0.262
Utilities	0.046	0.210	0.062	0.242	0.071	0.257
Construction	0.122	0.328	0.136	0.343	0.144	0.351
Trade	0.084	0.278	0.080	0.271	0.081	0.272
Transport and communication	0.138	0.345	0.100	0.300	0.116	0.320
Financial services	0.102	0.303	0.074	0.261	0.091	0.287
Public administration	0.305	0.460	0.305	0.460	0.277	0.448
Education and Health	0.116	0.320	0.134	0.341	0.101	0.301
Region						
North East	0.032	0.176	0.039	0.193	0.038	0.191
North West	0.105	0.307	0.087	0.281	0.100	0.300
Yorkshire and the Humber	0.067	0.250	0.071	0.257	0.076	0.266
East Midlands	0.064	0.244	0.072	0.259	0.072	0.259
West Midlands	0.070	0.256	0.072	0.259	0.073	0.261
East of England	0.085	0.279	0.075	0.263	0.075	0.263
London	0.112	0.315	0.091	0.288	0.098	0.297
South East	0.140	0.347	0.116	0.320	0.107	0.310
South West	0.071	0.257	0.076	0.264	0.069	0.254
Wales	0.072	0.258	0.104	0.306	0.098	0.298
Scotland	0.109	0.311	0.142	0.349	0.127	0.333
Northern Ireland	0.073	0.260	0.055	0.229	0.065	0.246
Worker Observations	12,455		10,413		28,576	
Worker-Year Observations	44,737		27,541		95,064	

Notes. The BHPS sample includes those individuals observed in the BHPS who are also followed in the US sample. It includes only those individuals in paid employment (exclude self-employed) who work full-time (>=30 hours per week) and are in the age group 18-65.