Within-Firm Wage Compression and Job Skills in the National Compensation Survey

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Abstract: Using nationally-representative data that provide detailed information about the specific skills required of individual jobs, we study how the distributions of skills and wages vary with firm type, as defined by a firm's median wage. Low wage firms have a more compact distribution of wages, and at such firms skills are more likely to predict wages. High wage firms have a more-leftward skew to the wage and skill distributions; asymmetry in the distribution of wages is characterized by more significant differences between the lowest-wage workers and the median worker rather than unusually large differences between high and low wage workers. We replicate the finding of prior studies, which show that the residual variance in wages is higher for firms with higher median wages. We show that this relationship is not uniform across all workers within a firm and that a single estimation masks these underlying differences. Residual variance is most strongly linked to firm median wage among a firm's low wage workers.

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Skills and wages are central to the study of labor economics. However, there are still surprisingly large gaps in what we know about the distribution of both skills and wages within economies. Until the recent availability of matched data sets, it was not possible to compare the within-firm distributions of either skills or wages across various types of firms. Even with new data, the fact that observable measures like education are poor proxies for the skills actually used in a job makes it difficult to generate a very deep understanding of how skills and wages are related across firms. This paper studies the distribution of wages and skills for a nationally representative sample of US firms. The data used here provide very detailed information about the types of skills required for specific jobs. We show that the wage and skill distributions differ markedly across firm types. At low wage firms both wages and skills are less dispersed than at any other type of firm. Within these firms, dispersion exists mainly between the firm's highest-wage workers and its median worker. At high wage firms, on the other hand, the distribution of both wages and skills are more dispersed overall, and particularly between the lowest-wage workers and the median worker. Furthermore, at the lowest wage firms, skills are most closely linked to wages.

In order to understand how the distribution of wages differs across different types of firms, this work presents both descriptive results and uses a regression analysis based on the literature studying the topic of wage compression. In both types of analyses we derive results by first sorting firms according to median wage. We use this sorting to identify low and high wage firms.

The descriptive analysis starts by depicting the overall distribution of wages for all workers in the economy as well as looking at the wage distribution for those working in

specific types of firms (with the type defined by median firm wage). This approach, inspired by similar depictions in Lazear and Shaw (2009), highlights some regularities in the data that guide the remainder of our analysis. Although average wage, by definition, changes with firm type, the shape of the distribution of wages and skills looks surprisingly similar across firm types for firms at the middle or top of the wage distribution. Firms in the lower half of the wage distribution (again sorted by median wage) look substantially different. For these firms, the distribution of wages is very compact.

We then highlight further differences in the wage distribution by type of firm. In addition to reporting skewness, we also give a visual representation of the within-firm wage differentials—focusing on a top to middle differential as well as a middle to bottom wage differential—by median wage percentile of the firm. At low wage firms, within-firm dispersion is most starkly observed in the upper tail of the distribution. The relative difference between the wages of the median worker and those of the highest-wage worker is greatest for low wage firms. At high-wage firms the opposite pattern becomes apparent; the wage difference between the low-wage workers and the median wage worker is high relative to other firms.

Once we establish that the wage distribution differs systematically by firm type, we turn to asking how the distribution of wages relates to the distribution of skills. In other words, are these observed wage differences due to firms simply having different types of workers, with different distributions of skills (as opposed to some institutional factors that affect the wage-skill relationship)? Again, we start with a descriptive analysis that uses data from ten different skills required for jobs. A visual representation of the data shows that, similar to the pattern for wages, the pattern of skill distribution for the low-wage

firms is much more compact than for other firms: workers have much more homogeneous sets of skills in these firms. High-wage firms have much greater diversity of skill sets among their workers, especially in the left tail of the distribution. Additionally, within high-wage firms, the skill differential is highest between those with the least skill and those with average skills, whereas among low-wage firms, it is the differential between the highest skill set and the average skill set that is greatest.

The last portion of our analysis links the distribution of skills to the distribution of wages. Our regression analysis builds on work done in the wage compression literature, which asks if the degree that skills predict wages varies with the productivity (sometimes proxied by median wage) of a firm.[1] Most papers studying wage compression argue that higher productivity (or higher wage) firms have a less compressed wage structure. In other words, at such firms skills are less likely to predict wages. On the basis of our findings, we argue that that much of this effect is driven by the lower tail of the distribution within firms. When we partition the data into the firms' upper tails and their lower tails, we show that the positive relationship between skills and wages is much stronger for estimations focused specifically on low-wage workers. A number of institutional factors, which are typically not discussed in the literature on wage compression, may explain this result.

The remainder of this paper consists of four sections. First, we discuss background and describe the literature on wage compression. Section 2 describes the data. Section 3 presents descriptive results focusing on how the distribution of wages and skills vary for

[1] As Booth and Zoega (2004) show, definitions of "compression" vary across studies. We use the term as a general description of the degree that skills can explain wages. To avoid confusion, when comparing the shapes of the underlying distributions of wages or skills, we use the term "dispersion" to identify instances when one distribution is more dispersed than another.

particular types of firms. Section 4 uses a two-stage regression analysis to link wage compression to firm productivity, as proxied by typical wages.

1. Background and Literature

The simplest and most commonly used model of a labor market characterizes the market as a competitive spot market with perfect information. A labor contract represents the renting of certain human capital characteristics, which can be observed perfectly. With a competitive market, wages equal the value of marginal product. If human capital can be effectively measured by education, experience, or observable job-related skills, then the returns to different types of human capital can be estimated precisely with a variation of the Mincer wage regression (Mincer,1974). Since the market is assumed to be perfectly competitive, these returns are identical across firms, which implies that the distribution of firm-level skills will map directly to the distribution of wages within the firm and that this relationship will be stable across firms.

While the spot-market view of labor markets may offer a general characterization of labor markets, it does not explain why the returns to skill vary across firms or industries in a way that cannot be explained by individual-level characteristics (e.g. Abowd et al, 1999; Davis and Haltiwanger, 1996). The spot market model may ignore institutional factors that might determine the relationship between skills and wages: for example, the role of collective bargaining agreements, implicit or explicit minimum wages, monopsony power or hierarchical wage setting. Most pertinent for our study, a simple model of spot markets fails to explain why the ability of skills to predict wages varies systematically by type of firm.

To explain why the ability of skills to predict wages may vary in a systematic way, economists often turn to models of firms facing incomplete information about the effort made by employees. Such firms might want to offer either a more compressed or more expanded distribution of wages. A more expanded distribution of wages is consistent with a tournament-style pay scheme where increased effort is encouraged by offering additional rewards to the most productive workers (Lazear and Rosen, 1981). Some firms may find it profitable to compress the distribution of wages if equitable treatment increases effort (Akerlof and Yellen, 1990), encourages cooperation (Levine, 1991) or discourages competitive, but counter-productive behavior among workers (Lazear, 1989). Frank (1984) and Zoega and Booth (2005) both argue that highly-productive firms are able to underpay the highest-skilled workers (relative to marginal product) because those workers either value status or because those firms have (monopsonist) market power.

2. Data

Our empirical analyses use a novel dataset that contains information on hourly wages and job skill requirements from a nationally representative sample of establishments in the U.S. The National Compensation Survey (NCS) is a restricted-use dataset collected by the Bureau of Labor Statistics. It covers the non-agricultural, non-federal sectors of the U.S. economy. Our data are from 1999. The data were collected by field economists who visited sampled establishments and randomly selected 5-20 workers from the site's personnel records, depending on establishment size. Interviews with human resources representatives provide detailed information about the jobs that those workers hold. The dataset contains 137,181 jobs at 15,349 firms.

No demographic information about the worker is collected and these data do not include information on benefits. For salaried workers, an hourly wage is imputed. The skill requirements for each job are measured through "generic leveling factors," which are intended to measure various job requirements consistently across occupations. These factors are based on the federal government's Factor Evaluation System, which is used to set federal pay scales.[2] There are ten different leveling factors, or job design attributes: Knowledge; Supervision Received; Guidelines; Complexity; Scope & Effect; Personal Contacts; Purpose of Contacts; Physical Demands; Work Environment; and Supervisory Duties. Here we provide a description of each variable, with the possible Likert values indicated in parentheses.

1. Knowledge (1-9): This measures the nature and extent of applied information that the workers are required to possess to do acceptable work. 1-2 correspond roughly to skills required to do simple, routine or repetitive tasks. 5 is at the level of a college graduate who has mastered the basic principles, concepts and methodology of a professional or administrative occupation, and/or who can solve unusually complex problems; and so on. Thus, larger values imply greater knowledge.

2. Supervision Received (1-5): This measures the nature and extent of supervision and instruction required, the extent of modification and participation permitted by the worker, and the degree of review of completed work. Larger values correspond to *less* Supervision. Values of 1-2 indicate substantial supervisory control with minimal employee input. 3 implies some autonomy for the employee to handle problems and deviations. 4-5 indicate

[2] For a detailed description of the NCS, see Pierce (1999).

that general objectives are set by the supervisor while the worker has more responsibility for implementation and there is little review of the completed job.

3. Guidelines (1-5): Measures how specific and applicable the guidelines are for completing the work, and the extent of judgment needed to apply them. As with Supervision Received, larger numbers correspond to *less* use of Guidelines. 1-2 signify that detailed guidelines are available that are applicable in most situations that are likely to arise. 3 indicates that, while guidelines are available, the worker must judge whether or not they are applicable, and how to adapt them. 4-5 indicate that few guidelines are available or applicable to completing this job.

4. Complexity (1-6): This covers the nature, number, variety, and intricacy of tasks, steps, processes, or methods in the work performed; the difficulty in identifying what needs to be done; and the difficulty and originality involved in performing the work. A lower number indicates *less* complexity—1 indicates that tasks are clear-cut and directly related, with little choice to make in deciding what needs to be done; 4 indicates various duties involving different and unrelated processes and methods; 6 signifies broad functions are performed, with substantial decision-making regarding what needs to be done.

5. Scope & Effect (1-6): Scope & Effect covers the relationship between the nature of the work, i.e., the purpose, breadth, and depth of the assignment, and the effect of work products or services both within and outside the organization. Higher values of Scope & Effect imply larger impacts. This measures the interdependence of a job with other processes and jobs in and beyond the organization.

6. Personal Contacts (1-4): Personal Contacts is based on what is required to make the initial contact, the difficulty of communicating with those contacted, and the setting in which the

contact takes place. It specifically applies to non-supervisor communications. A level of 1 indicates contacts are with other employees in the immediate organization only, and with the general public in very structured situations. At the level of 3, personal contacts are with individuals or groups from outside the employing establishment in a moderately unstructured setting. 4 indicates that the personal contacts are with high-ranking officials from outside the employing establishment at national or international levels in highly unstructured settings

7. Purpose of Contacts (1-4): Ranges from factual exchanges of information to situations involving significant or controversial issues and differing viewpoints, goals, or objectives. A value of 1 indicates the purpose is to obtain, clarify, or give facts or information; 2 is to plan, coordinate, or advise; 3 is to influence, motivate, convince, or question persons or groups or to interrogate or control persons or groups who may be fearful, uncooperative, or dangerous; and 4 is to justify, defend, negotiate, or settle matters involving significant or controversial issues.

8. Physical Demands (1-3): Covers the requirements and physical demands placed on the employee by the work assignment. 1 represents a sedentary job; 3 requires considerable and strenuous physical exertion.

9. Work Environment (1-3): This measures the risks and discomforts in the employee's physical surroundings or the nature of the work assignment and the safety regulations required. A value of 1 indicates everyday risks or discomfort, and normal safety precautions; 3 involves high risks with exposure to potentially dangerous situations or unusual environmental stress which require a range of safety and other precautions.

10. Supervisory Duties (1-5): Describes the amount of supervisory responsibility in the job. 1 represents no supervisory duties; 2 is a group leader or team leader; 3, 4 and 5 indicate increasing hierarchical levels of supervising.

3. Descriptive Results

This section graphically depicts how wages and skills vary in the US economy. To do so, we construct distributions of both wages and skills, both within the firm and within the entire economy.

Distribution of Wages

Figures 1 shows the distribution of wages across the US economy and for "typical" firms in the economy, i.e. those that have a median wage close to the median for the entire economy. The solid line depicts the distribution of log hourly wages for all workers in the data. The dotted line shows the distribution of log hourly wages for only those workers who work at a firm whose median wage is in the 45th to 55th percentile of all firms. Figure 2 compares the distribution of log hourly wages for those working in high wage firms, whose median wage is above the 80th percentile, to those working in low wage firms, below the 20th percentile of all firms.

The figures show a pattern that is similar to the European countries studied in Lazear and Shaw (2009). First, the degree that firms sort is surprisingly modest. Although wages within a given firm are more similar than those of the entire economy, as evidenced by the more compact distribution of the wages for subsamples of firms than for the whole economy, there is still significant dispersion even within firms. The ratio of the average within firm standard deviation of wages divided by the full-sample standard deviation is

.66, which means that the wage dispersion within firms is more than 60% of the total wage dispersion. Lazear and Shaw find values between .6 and .8 for European countries.

Additionally, while the average wage is obviously higher for workers in high-wage firms than for those in low-wage firms, there are many workers in low-wage firms who earn the same log hourly wage as a worker in a high-wage firm, and vice versa. It should also be noted that neither the distribution for high-wage firms nor the distribution for low-wage firms is well described by a normal distribution. Low-wage firms have a very narrow distribution, especially at the bottom tail, and a much more skewed right tail. High-wage firms are more similar to a normal distribution, but are still much more compact, with a left skew.

Figures 1 and 2 cannot reveal the great deal of heterogeneity in the *within firm* wage distributions across different types of firms. We now turn to comparing, within firms, the wage differentials between high, median and low-wage workers. This is done in Figure 3, which plots the relative 90/10, 90/50 and 50/10 within-firm log wage differentials of workers, sorted by the firm's median wage percentile. Thus, a single point on the 90/10 line represents the average 90/10 log wage differential for workers in one given type of firm, identified by the firm's median wage percentile among all firms. The picture highlights that firms are surprisingly similar according to a common measure of wage dispersion: the difference between log wages at the 10^{th} and 90^{th} percentile; regardless of whether the firm is a high-wage firm, a low-wage firm or somewhere in between, workers at the top of their firm's wage distribution earn 0.35 log points higher than those at the bottom of their firm's wage distribution.

Differences across types of firms are only apparent when wage dispersion is measured as the difference from the median to the top or the difference from the bottom to the median. At lower-wage firms, the wage of the lowest-wage worker is likely to be close to the wages of the median worker (relative to other firms). As the median wage rises, the disparity between the low and median-wage workers grows. At the top of the within-firm distribution, the pattern is reversed. As median wage increases, the disparity between high-wage workers and median-wage workers diminishes. These patterns are reflected in the overall skewness of the wage distribution, which moves from a longer, fuller right tail to a longer, fuller left tail as median wage increases, consistent with Figure 2.

Distribution of Skills

One purpose of this paper is to see whether patterns in the distribution of skills match the patterns observed for the distribution of wages and to see if the degree that skills predict wages differs in a systematic way across firms. Therefore, we take the same three subsets of firms defined in Figures 1 and 2 and examine whether the patterns over the distribution of skills mimic the pattern observed in the distribution of wages.

Table 1 shows the distribution for all workers of each of the individual leveling factors, and the correlation between the factors. In general, a lower value correlates with a lesser skilled job—one that requires more supervision, more guidelines, is less complex and requires less knowledge and fewer personal communications; in the case of physical demands and work environment, however, a higher amount of that "skill" indicates a more strenuous, risky job. The median value of the factors is often the lowest or next lowest value. The correlation is especially high between knowledge, supervision received, guidelines and complexity, between the two personal contacts variables and between

physical demands and work environment. The physical demands and work environment variables are negatively correlated with the other factors.

In our analysis, it is not convenient to use all ten factors simultaneously; thus we first create an additive index of the factors.[3] This ranges, by design, from ten to fifty, and has a median of nineteen. Although we use this variable in our analysis, we also recognize that the high correlation between the variables may indicate that factor analysis may be useful to create index variables. Table 2 shows the factor loadings for the ten generic leveling variables. There are two principal factors with eigenvalues greater than one. Not surprisingly, the first loads heavily on all the variables other than physical demands and work environment, and the second loads heavily on those two variables.

Similar to what we observed for the distribution of wages, both Figures 4a-4c show sorting by skill across firm types, with some overlap. Low-wage firms have a higher concentration of low-skill workers, with some right skew. High-wage firms have a somewhat smaller concentration of high-skill workers, with greater left skew. Median-wage firms have a very similar skill distribution to the overall distribution of all workers. Overall, the variance of skills are positively correlated to firm median wage—this is confirmed by Table 3, which shows that among workers in firms in the bottom wage quintile, the variances of the skill measures are less than half the variances for the top quintile. For the more cognitive and communicative skills of the first primary factor, median wage firms have a lower variance than high wage firms; however the factor that loads more heavily on physical demands and work environment has equal variance between the median wage firms and the high wage firms, indicating that low wage firms

[3] We report results using an additive index of all ten factors. We have also estimated all empirics using an additive index that excludes the physical demands and work environment variables—none of our results are significantly different.

have a high concentration of risky and physical jobs. Overall, the distribution of the skills shows greater variation for firms in the top quintile than for those in the bottom quintile. Low wage firms in particular have a more compressed skill distribution.

Just as with wages, we study differentials between high-skill, median-skill and low-skill workers within firms to highlight heterogeneity in the *within-firm* skill distributions across different types of firms. Figures 5a-5c plot the relative 90/10, 90/50 and 50/10 log skill differentials of workers, using first the additive index of skills and then each of the two primary factors with eigenvalues greater than one, respectively, by the firm's median wage percentile. These pictures highlight some of the same patterns observed in wage dispersion: average skewness changes from rightward to leftward as median wages increase. Again, at lower wage firms, the skill of the least skilled worker is very similar to that of the median worker; as median firm wages rise, the gap between the least skilled worker and the median worker increases. The opposite is true for the top half of the wage distribution within firms: in low-wage firms, the skill gap between the highest skilled worker and the median skilled worker is greater than the gap is at high-wage firms. We note once again that looking at a 90/10 skill differential would miss these distinctions.

Distribution of Wage Residuals Controlling for Skills

While Figures 1-5 clearly show some similarities between the distribution of wages and skills within the firm, it is impossible to determine from these figures the extent to which skill dispersion "explains" the wage patterns. In particular, given that both distributions change considerably with firm type, we ask if the relationship between skills and wages also varies with the type of firm. To illustrate the link between skills and wages, we estimate log wage regressions controlling for skills using a full set of indicator variables

for each Likert value the skill can take. Since this is still a descriptive analysis, these regressions include only skill variables, with no additional demographics or firm characteristics.

The regression results are reported in appendix table, A1. The R-squared value from the full-sample regression, .74 shows that the distribution of skills is closely linked to the distribution of wages, even without controlling for other factors. Beyond the R-squared, plotting the underlying residuals (the difference between actual and predicted wages) offers us the possibility to visualize how wage compression might vary by type of firm.

The plots of residuals, for both the full sample of workers as well as the three subsamples, are depicted in Figure 6. We are interested in both the mean and the variance of that distribution of residuals. The mean value of residuals does vary with the type of firm; residuals are on average higher for high-wage firms than for low wage firms. High-wage firms have a wage premium: actual wages exceed what would be predicted by skills alone.[4] The variance of residuals reveals how wage compression differs by type of firm. If there is little variance in the residual, then most workers at a particular type of firm earn close to their predicted wages after adjusting for any wage premium. Differences between the types of firms could be captured as a fixed effect. On the other hand, a wide variance of residuals suggests that much of the distribution of wages is not explained by the underlying distribution of skills.

[4] That premium may reflect a higher return to skill, but in a descriptive analysis such as this one we cannot identify this with certainty. The residual is correlated to unobserved characteristics. These unobserved characteristics include non-pecuniary aspects of the job that might affect compensation and unobserved characteristics of the workers who select into different types of workplaces.

Interestingly, the pattern in the variance of residuals is similar to the variance of observed wages; despite the across-firm type pattern of skills mirroring that of wages, controlling for skills does not completely remove the differences across firm types. Figures 2 and 4 showed that low-wage firms have relatively little dispersion in wages or skills and that high-wage firms have far more dispersion in wages and skills. The plot of residuals in Figure 6 is also more compact for the low wage firms than the high wage firms. Median wage firms are similar to the economy on the whole, but with a slightly narrower distribution. A significant degree of the variation in wages is not explained by skills alone and partitioning the data to focus on only similar firms fails to produce a tighter relationship between skills and wages.

Figure 7 further highlights that controlling for skills explains only some, but not all of the within-firm patterns observed in the wage distribution. Like in Figures 3 and 5, Figure 7 uses log differentials to compare across distributions. The fact that all three ratios increase from left to right indicates that, at higher-wage firms, skill differentials are less likely to predict wage differentials; there is more variance in the relationship. The three lines do not rise at the same rate, which indicates that skewness changes as firm type changes. Higher wage firms are more likely to have left-skewed residuals than low-wage firms. There are (likely institutional) factors that affect the residuals of a wage regression at low wage firms. Factors like explicit or implicit minimum wage requirements, hierarchical wage ladders, and union wage contracting can contribute to outcomes where firms employ both a narrow band of skills and pay many workers similar wages. Furthermore, these institutional factors make it unlikely that predicted wages are far below actual wages, which results in a positive skew to the distribution of residuals.

4. Using a two-stage regression to estimate the correlation between wage compression and median wage

In this section, we attempt to determine to what extent within-firm wage differentials among otherwise similar workers (after controlling for skill) vary across types of firms. We use a two-stage estimation that is similar to a technique first suggested by Winter-Ebmer and Zweimuller (1999) and used by numerous studies. The first stage is a wage regression that is estimated separately for each firm. To maximize the degrees of freedom, we do not regress on all skill variables, but rather use only an additive index in one set of specifications, and the two primary factors with eigenvalues above one in a second set of specifications. [5] Equation 1 represents these specifications:

$$\ln(w_{ij}) = \alpha_j + \beta_j S_{ij} + \varepsilon_i, \text{ or}$$

$$ln\ W_{ij} = \alpha_j + \beta_j factor1 + \delta_j factor\ 2 + \varepsilon_{ij} \qquad (1)$$

for worker i in firm j, where S denotes the index of skills. This wage regression is run once for each firm. We collect, as a measure of the unexplained wage variance in the firm, the root mean squared error (σ) from each regression.

In the second stage of our estimation, we regress median wages on σ, σ^2, and firm characteristics like size, and the percentage of unionized employees. The second stage of the estimation is represented by equation 2:

$$ln(\bar{W}_j) = \alpha + \gamma_1 \sigma_j \ + \gamma_2 \sigma_j^2 + \delta X + \varepsilon_i \qquad (2)$$

In equation 2, $\bar{W}_j$ denotes the firm's median wage, j indexes the firm, and X is a vector of firm characteristics that includes controls for the percent of jobs that are unionized and the

[5] Allternative specfications which use either the full set of individual skills (limiting our sample to firms with more than 10 observed employees), or subsets of skills, produce similar results to the ones discussed here.

log number of employees in the firm. *A* positive association between σ and median wage suggests that firms with less compressed wages are likely to pay higher median wages. If firms with higher median wages are also more productive, then compression is related to productivity.

Although variants of this approach have been widely used, it does have some limitations. Theory argues for a relationship between *productivity* and wage compression. Here, median wage is meant to proxy for median wage. In addition, as Mahy, Rycx and Volral (2011a and 2011b) highlight, the empirical approach suffers from a potential for endogeneity. If bonuses are paid in particularly productive years, then bonus payments increase both σ and median wage. For the purposes of this study, we are not focused on the limitations of the two-stage estimations or on alternative approaches for measuring wage compression. Our goal is to see whether the relationship between median wage and wage compression commonly found differs systematically depending on which points in the within-firm distribution are being compared. In other words, we replicate the basic result of prior work and then show that the result is particularly sensitive to whether we consider the left tail, the right tail, or the whole distribution at once.

This two stage process is thus estimated first for all workers. Then, taking into account the patterns we observed in figures 3 and 5, we restrict the sample of workers in the first stage to those that earn above the median wage in their firm, and then to those workers who earn below the median wage. Table 4 summarizes the results of the first stage, reporting the average explanatory power of the models for each set of estimations, as well as the average root mean squared error. [To be completed] Table 5 shows the results of the second stage estimation.

The first three columns report the results for all workers combined, the next three report results for only those workers in each firm earning above median wages, and the last three columns report results for those workers in each firm earning below median wages. The top panel controls for the additive skill index in the first stage, while the bottom panel controls for the two skill factors in the first stage. Consistent with Figure 7, the relationship between wage compression and median wages is stronger when considering the compression at the bottom of the wage distribution than when considering the compression at the top. For the full sample and for the low wage workers, wage compression, beyond that which is explained by skills, is strongly positively correlated with median wages. High paying firms have a greater extent of wage compression for all workers combined, and in particular for the firms' lower wage workers. Furthermore, the effect is increasing at a decreasing rate as the compression increases.

The extent of unionization and the size of the firm are also strongly positively related to high median wages. For high wage workers, however, the coefficients on the error and its square are much smaller in absolute value, and are even insignificant in the estimation controlling for the additive skill index in the first stage and controlling for unionization and firm size in the second. Among low wage workers, the correlation between median firm wage and wage compression is much weaker.

To the extent that we interpret median wages as a measure of firm-level productivity, these results indicate that the more productive a firm is, the more compressed is its wage distribution, in particular at the bottom. This is consistent with several institutional labor market features that might affect workers at the bottom of the

distribution more so than those at the top, such as monopsony power and implicit or explicit minimum wages.

Conclusion

In spite of the extensive work done on identifying the determinants of wages at either the individual or aggregate level, only a few authors have studied how the variation in skills relates to the variation in wages both within and between firms. Some authors argue that the relationship between these distributions can shed insight on "wage compression," which is defined by the observation that "the difference in productivity across workers or firms is only partly reflected by the difference in wages" (Mourre, 2002). Because productivity is difficult to measure directly, it is often proxied with either data about the individual worker's skills or with data about the firm's median wage. The consensus in the literature is that such compression is widespread (Santos-Pinto, 2012) and that compression is more often observed for high-wage firms (Lallemand, Plasman, and Rycx, 2007).

In spite of this consensus, most existing studies have limitations. For example, prior work must rely on education to proxy for skills. A better measure is the actual skills required for a job. Not all studies have individual data and must therefore look at mean wage by cell (gender, occupation, education, etc.) and then identify compression across occupation groups or across education. Above all, most prior work has not been able to identify how observed wage compression may vary across the distribution of firms.

The analysis in this paper consists of a largely descriptive approach that provides a fuller view of how the distribution of skills, the distribution of wages and wage

compression vary both within and across firms. Our data, which are nationally-representative for the United States and provide information about 137,000 individual jobs at over 15,000 different firms allow for a comprehensive view of the skill and wage distributions across the economy. In particular, the data allow us to carefully study the wage and skill distributions for very low-wage firms as well as very high-wage firms.

Prior work makes overall statements about wage compression. We argue that wage compression is strongly influenced by particular parts of the earnings distribution. We show that, at the bottom of the distribution, firms employ a narrow range of skills and pay a narrow range of wages. Both wage and skill distributions have a strong positive skew. One manifestation of this pattern is that, at these firms, the disparity between top-wage (skill) workers and median wage (skill) workers is larger than the disparity between median wage (skill) workers and low wage (skill) workers. At the middle and top of distribution, the pattern is reversed. Firms employ a wider range of skills and pay a wider range of wages. The skew is likely to be zero or negative.

Given that both skill and wage distributions show similar patterns, it is natural to ask if the pattern in observed wages is simply a reflection of the pattern in skills. We estimate wage regressions and study the residuals. This exercise shows that the distribution of skills does not entirely explain the distribution of wages within and across firms. The residuals themselves are still more compactly distributed for low wage firms and the skew in residuals is greater for estimations that are limited to a sub-sample of low-wage firms. Some of the pattern in the wage distribution is due to factors other than the distribution of skills.

Given the results on the distributions of wages, skills and residuals, it is natural to ask how the variation across firms is likely to affect the conclusions of the literature on wage compression. We replicate a common finding, that wage compression is greater for high wage firms. We then show, however, that this result is strongly influenced by compression among workers in the bottom tail of a firm's wage distribution. For these low-wage workers, the association between root mean squared error and median wage is particularly strong.

Our descriptive results do not allow us to identify exactly what, presumably institutional, factors make the skill-wage relationship so different for low-wage firms. Lower bounds on wages may explain the skew: it is unlikely to that workers will be observed earning wages far below their predicted wages. However, even low wage firms employ a wide range of skills, and pay a wide range of salaries. The variation in skills gives only a very incomplete explanation for the variation in wages. In fact, a wage structure that is less closely tied to observed skills is associated with improvements in median wage and presumably productivity. This may reflect firms relying on bonuses, or incentive pay to increase the pay of some workers. The result could also reflect differences across firms in recruiting and selecting those worker qualities that are unobservable in our data but are relevant for median wage and productivity.

Collectively, our results serve as useful reminder that the variations, not just mean values, of both the skill and wage distributions matter. Some workers earn a premium whereas other workers are paid at a discount, relative to the types of skills required for a job and type of employer. A study of this dispersion allows us to investigate the patterns in how skills and wages vary across different types of firms.

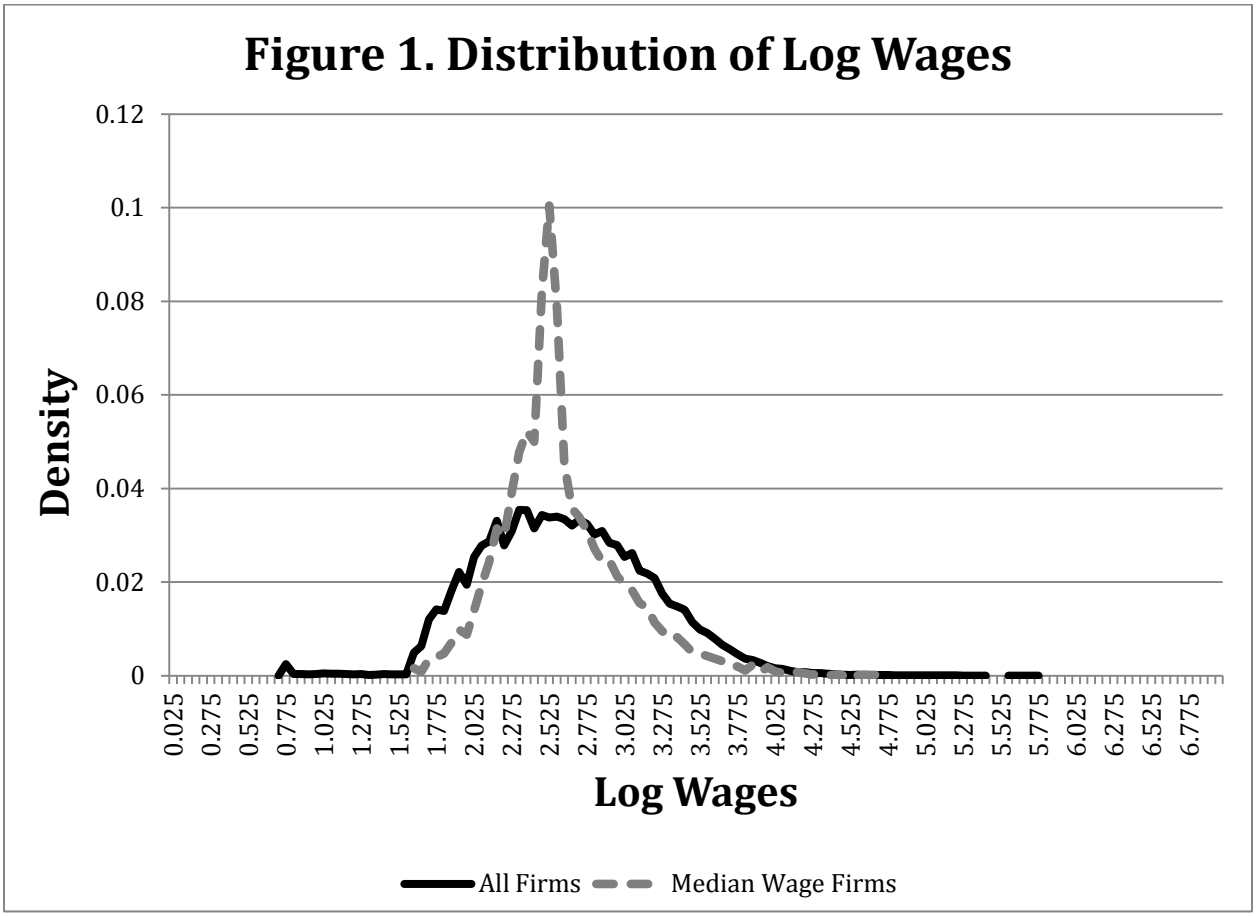
Figure 1. Distribution of Log Wages
Density
0.12
0.1
0.08
0.06
0.04
0.02
0
0.025
0.275
0.525
0.775
1.025
1.275
1.525
1.775
2.025
2.275
2.525
2.775
3.025
3.275
3.525
3.775
4.025
4.275
4.525
4.775
5.025
5.275
5.525
5.775
6.025
6.275
6.525
6.775
Log Wages
All Firms
Median Wage Firms

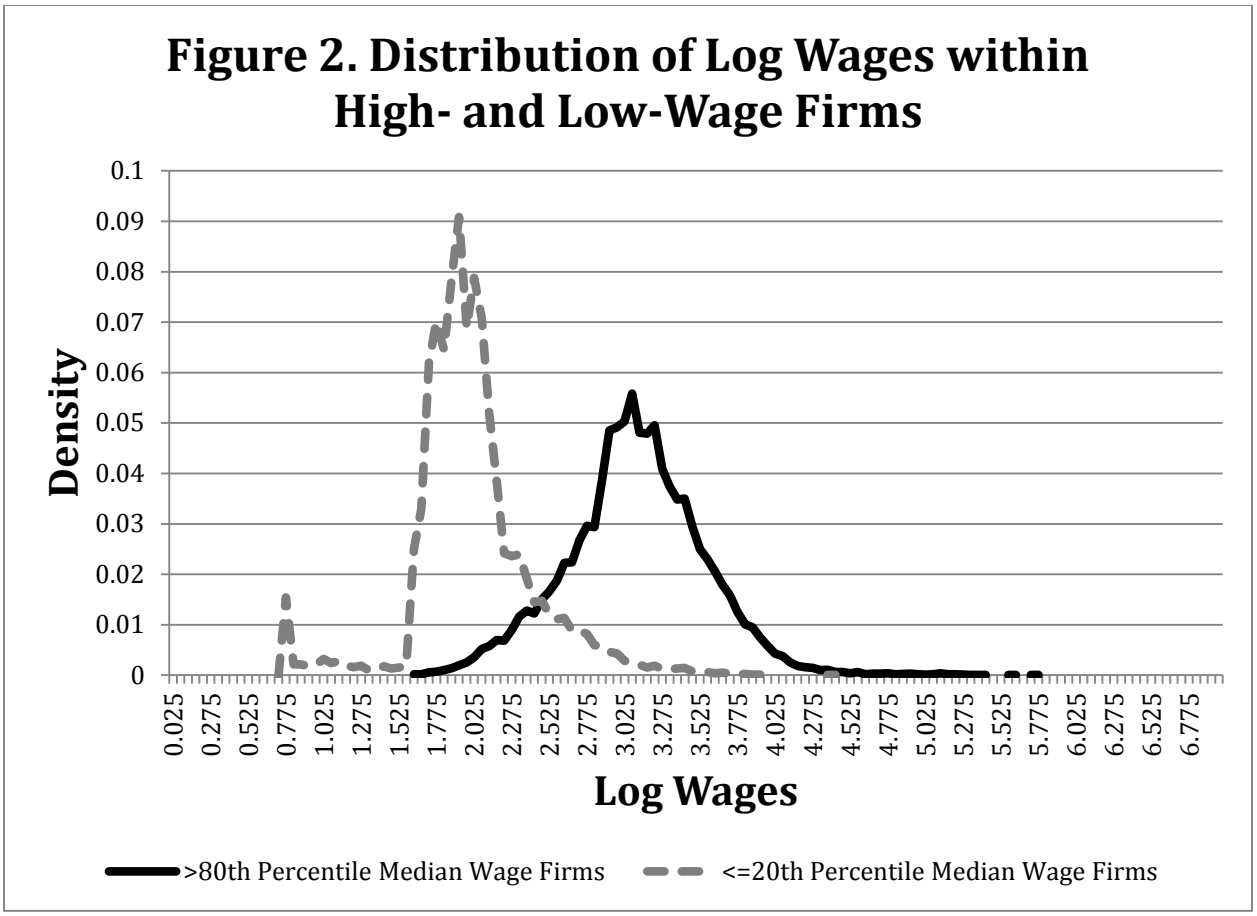
Figure 2. Distribution of Log Wages within High- and Low-Wage Firms
Density
0.1
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
0.025
0.275
0.525
0.775
1.025
1.275
1.525
1.775
2.025
2.275
2.525
2.775
3.025
3.275
3.525
3.775
4.025
4.275
4.525
4.775
5.025
5.275
5.525
5.775
6.025
6.275
6.525
6.775
Log Wages
>80th Percentile Median Wage Firms
<=20th Percentile Median Wage Firms

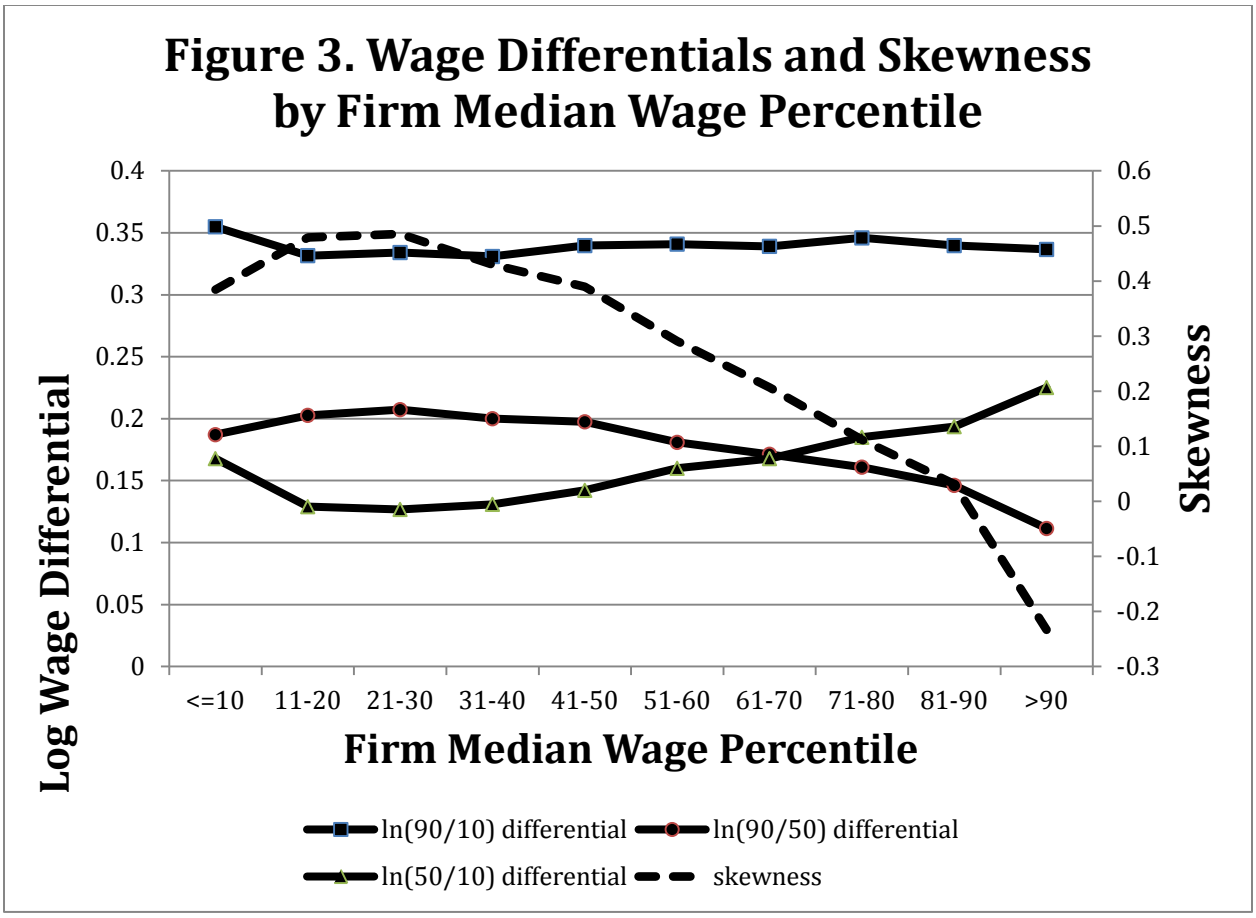
Figure 3. Wage Differentials and Skewness by Firm Median Wage Percentile
Log Wage Differential
Skewness
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
0.6
0.5
0.4
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
<=10
11-20
21-30
31-40
41-50
51-60
61-70
71-80
81-90
>90
Firm Median Wage Percentile
ln(90/10) differential
ln(90/50) differential
ln(50/10) differential
skewness

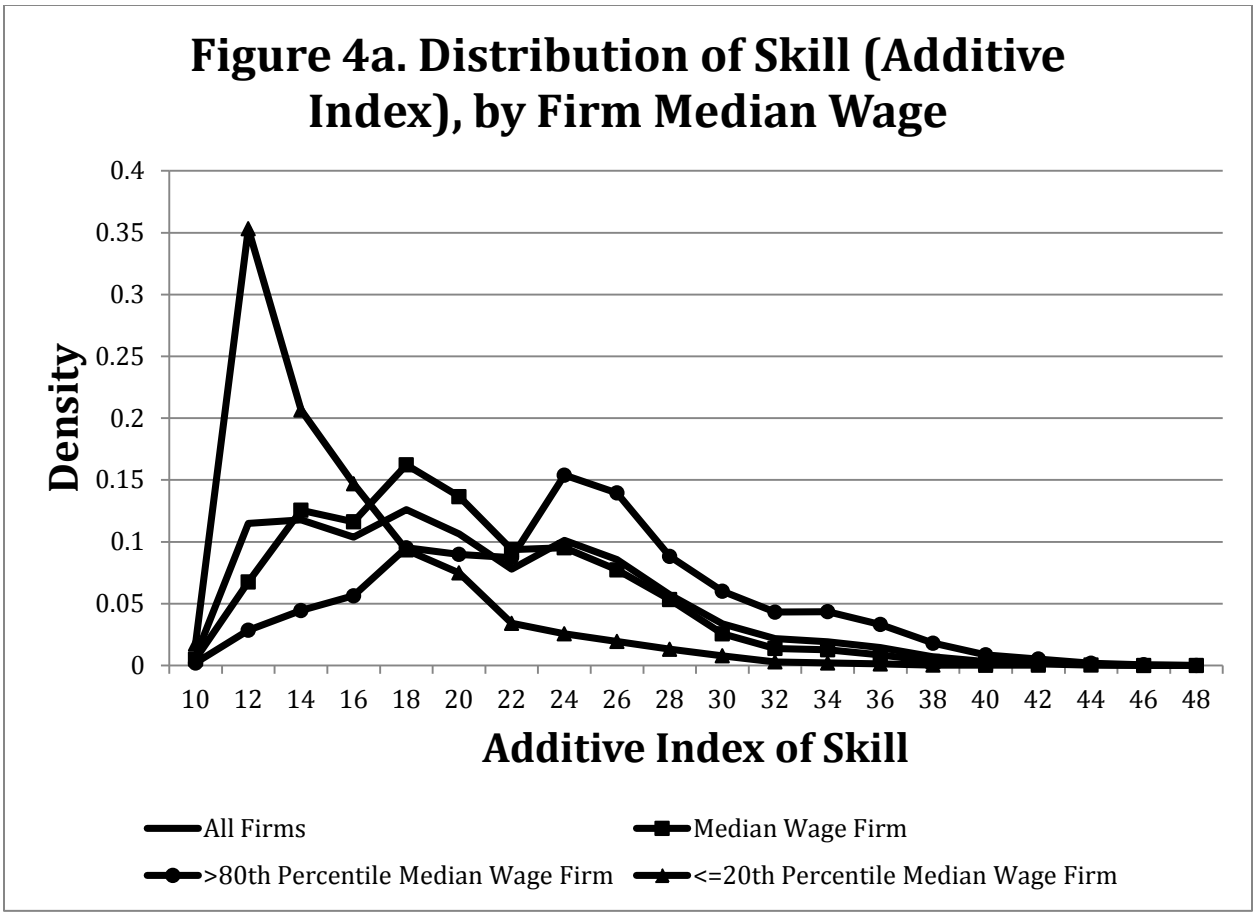
Figure 4a. Distribution of Skill (Additive Index), by Firm Median Wage
Density
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
10 12 14 16 18 20 22 24 26 28 30 32 34 36 38 40 42 44 46 48
Additive Index of Skill
All Firms
Median Wage Firm
>80th Percentile Median Wage Firm
<=20th Percentile Median Wage Firm

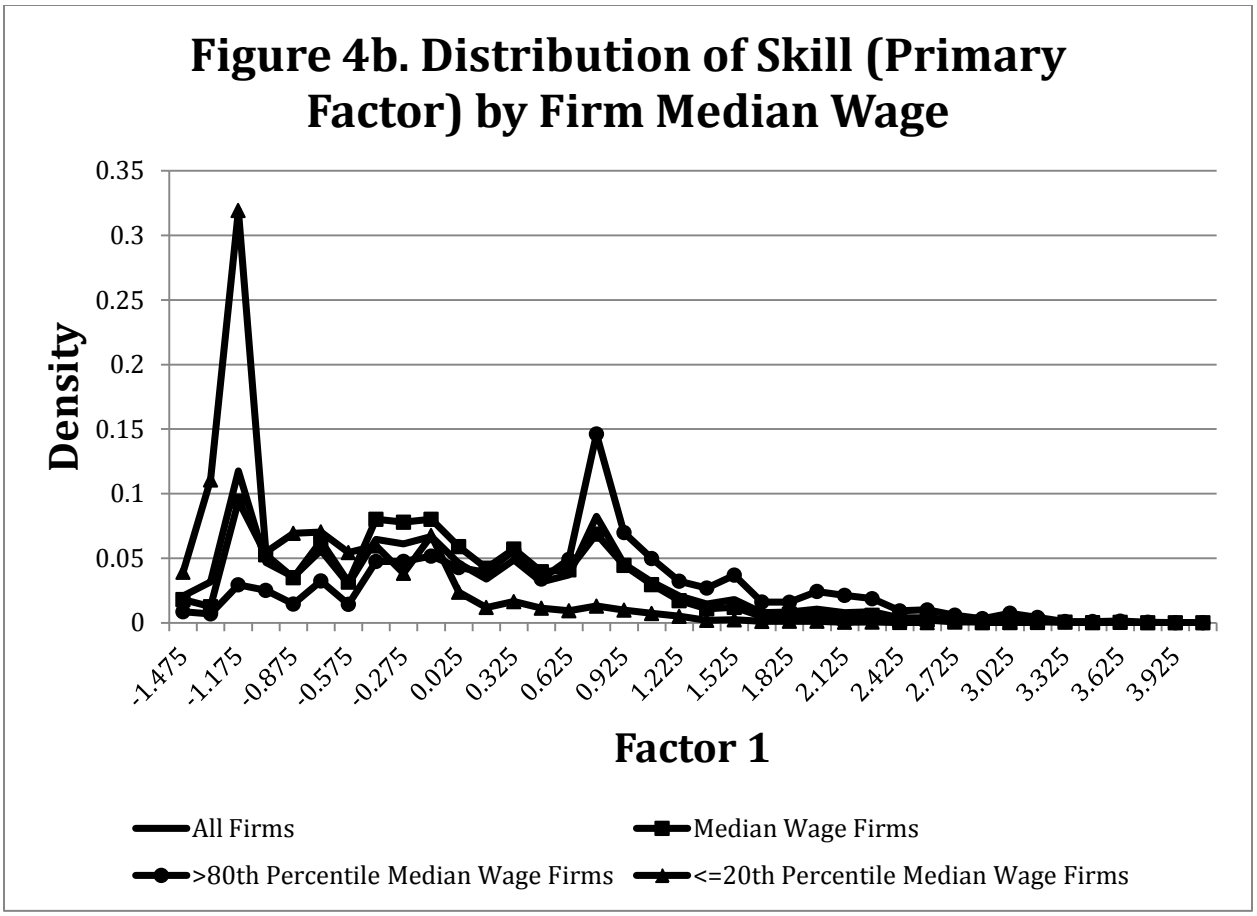
Figure 4b. Distribution of Skill (Primary Factor) by Firm Median Wage
Density
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
-1.475
-1.175
-0.875
-0.575
-0.275
0.025
0.325
0.625
0.925
1.225
1.525
1.825
2.125
2.425
2.725
3.025
3.325
3.625
3.925
Factor 1
All Firms
Median Wage Firms
>80th Percentile Median Wage Firms
<=20th Percentile Median Wage Firms

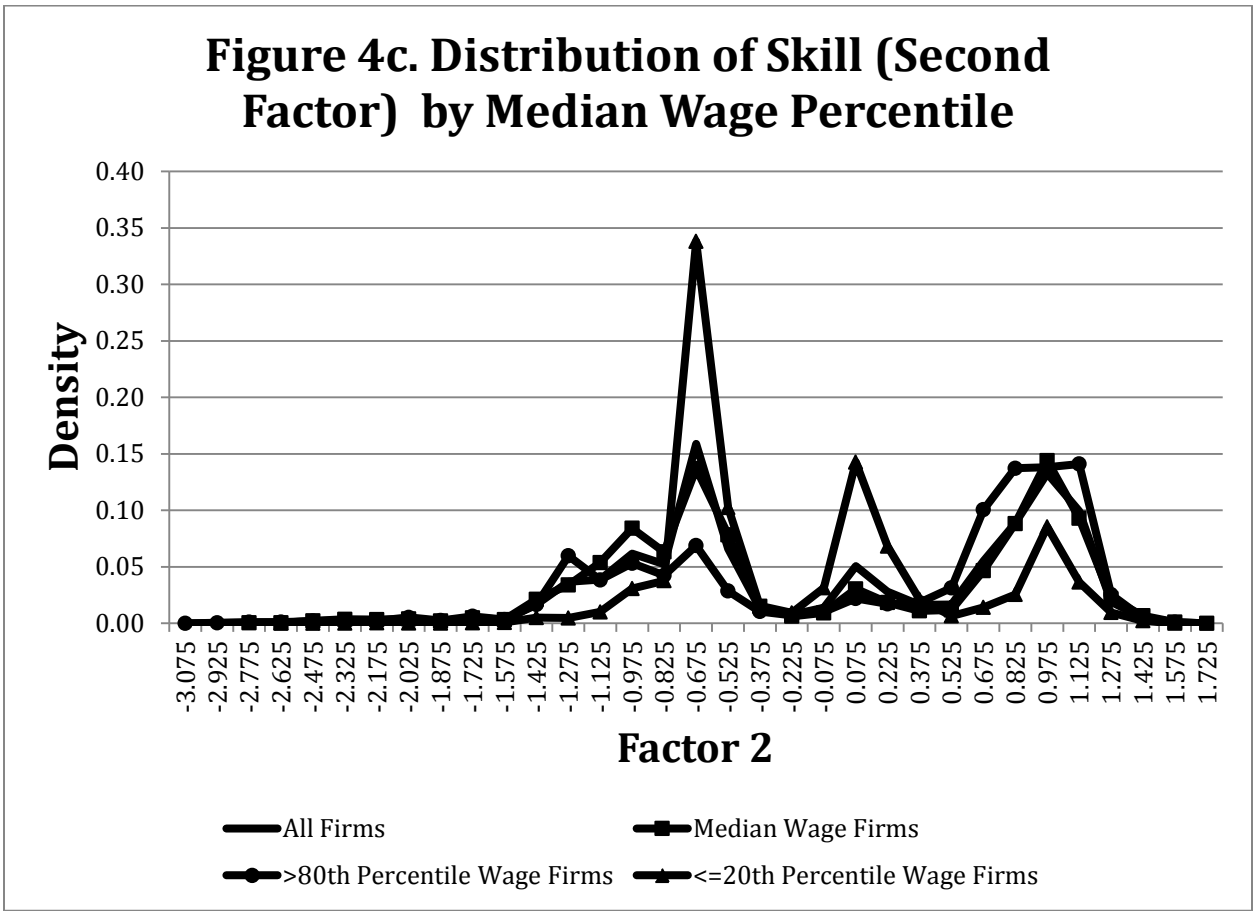
Figure 4c. Distribution of Skill (Second Factor) by Median Wage Percentile
Density
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
-3.075
-2.925
-2.775
-2.625
-2.475
-2.325
-2.175
-2.025
-1.875
-1.725
-1.575
-1.425
-1.275
-1.125
-0.975
-0.825
-0.675
-0.525
-0.375
-0.225
-0.075
0.075
0.225
0.375
0.525
0.675
0.825
0.975
1.125
1.275
1.425
1.575
1.725
Factor 2
All Firms
Median Wage Firms
>80th Percentile Wage Firms
<=20th Percentile Wage Firms

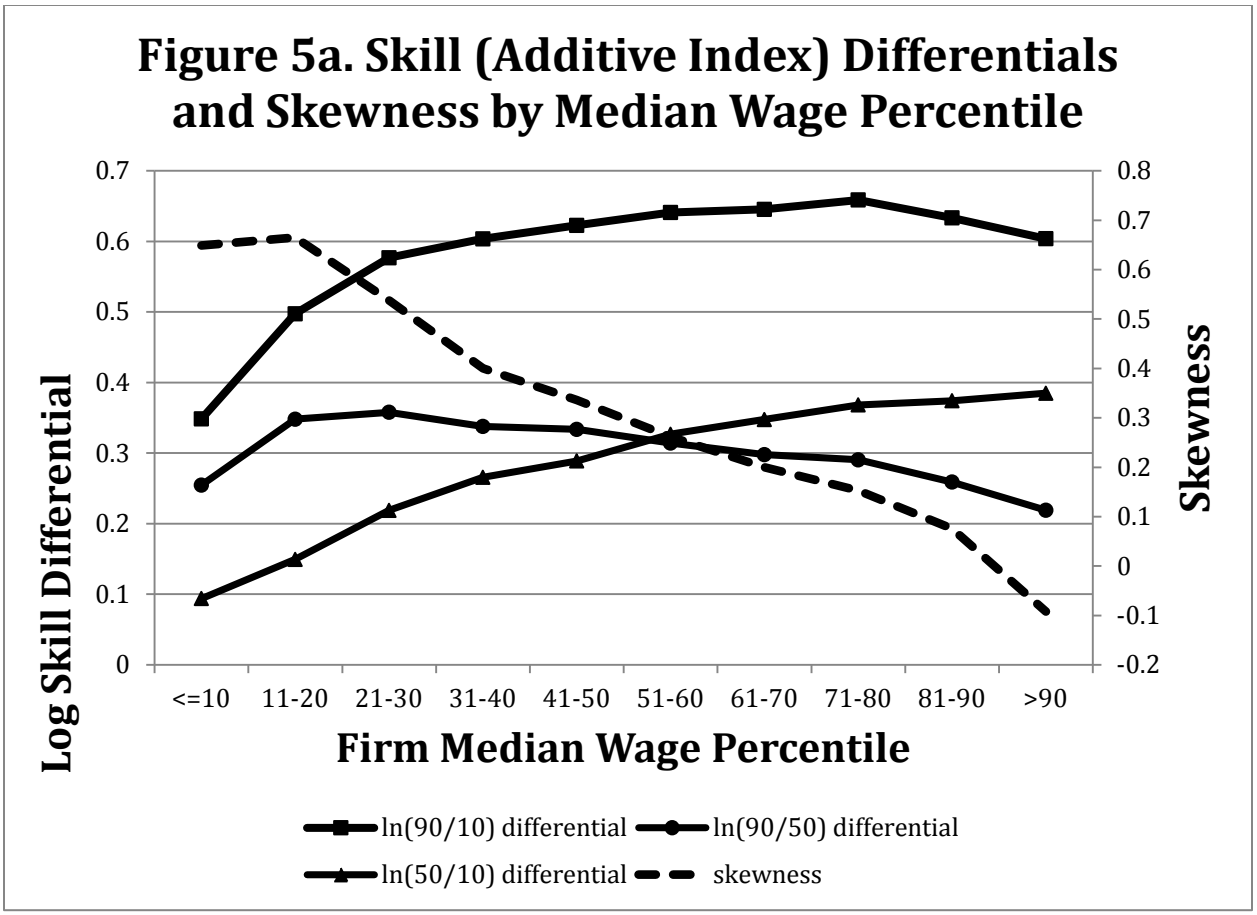
Figure 5a. Skill (Additive Index) Differentials and Skewness by Median Wage Percentile
Log Skill Differential
Skewness
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
-0.1
-0.2
<=10
11-20
21-30
31-40
41-50
51-60
61-70
71-80
81-90
>90
Firm Median Wage Percentile
ln(90/10) differential
ln(90/50) differential
ln(50/10) differential
skewness

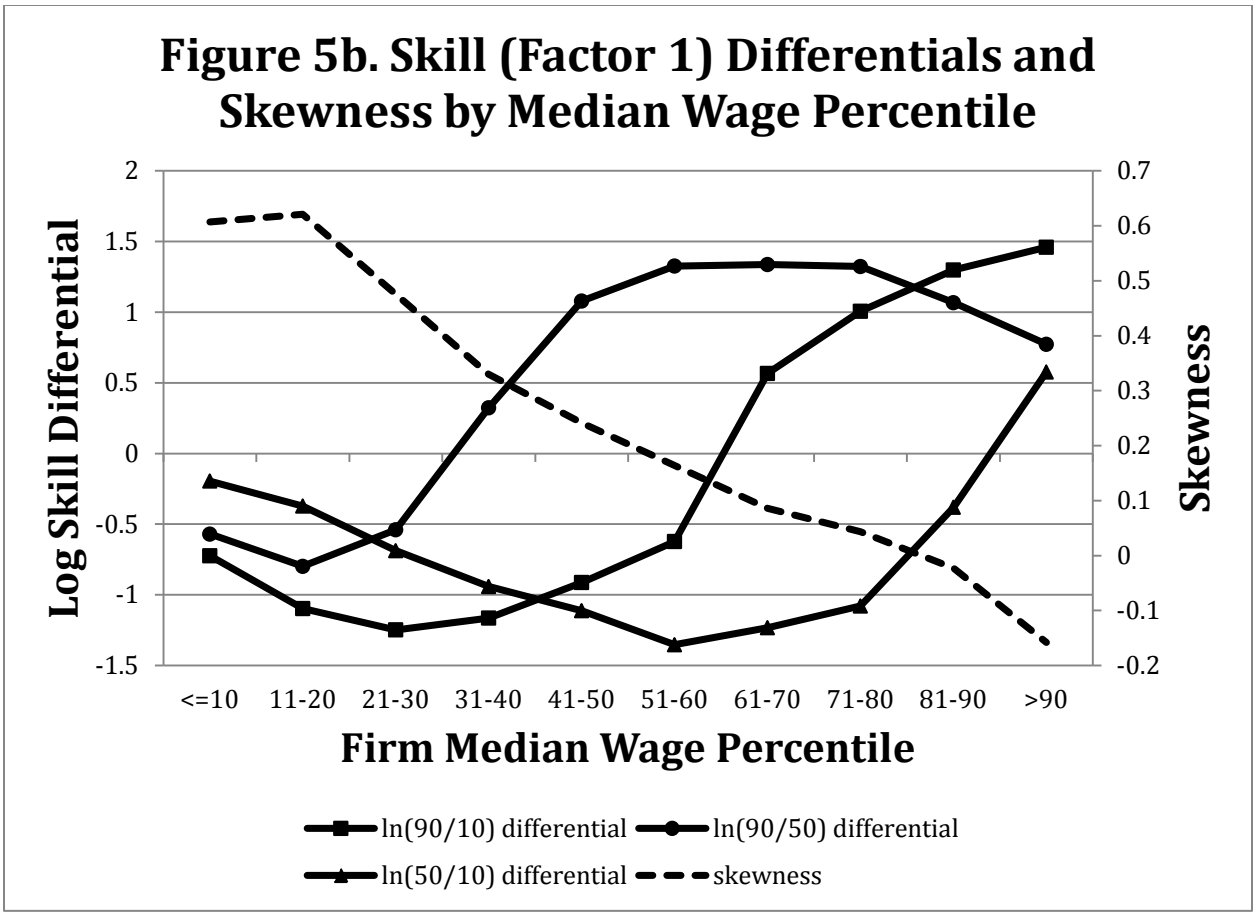
Figure 5b. Skill (Factor 1) Differentials and Skewness by Median Wage Percentile
Log Skill Differential
Skewness
2
1.5
1
0.5
0
-0.5
-1
-1.5
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
-0.1
-0.2
<=10
11-20
21-30
31-40
41-50
51-60
61-70
71-80
81-90
>90
Firm Median Wage Percentile
ln(90/10) differential
ln(90/50) differential
ln(50/10) differential
skewness

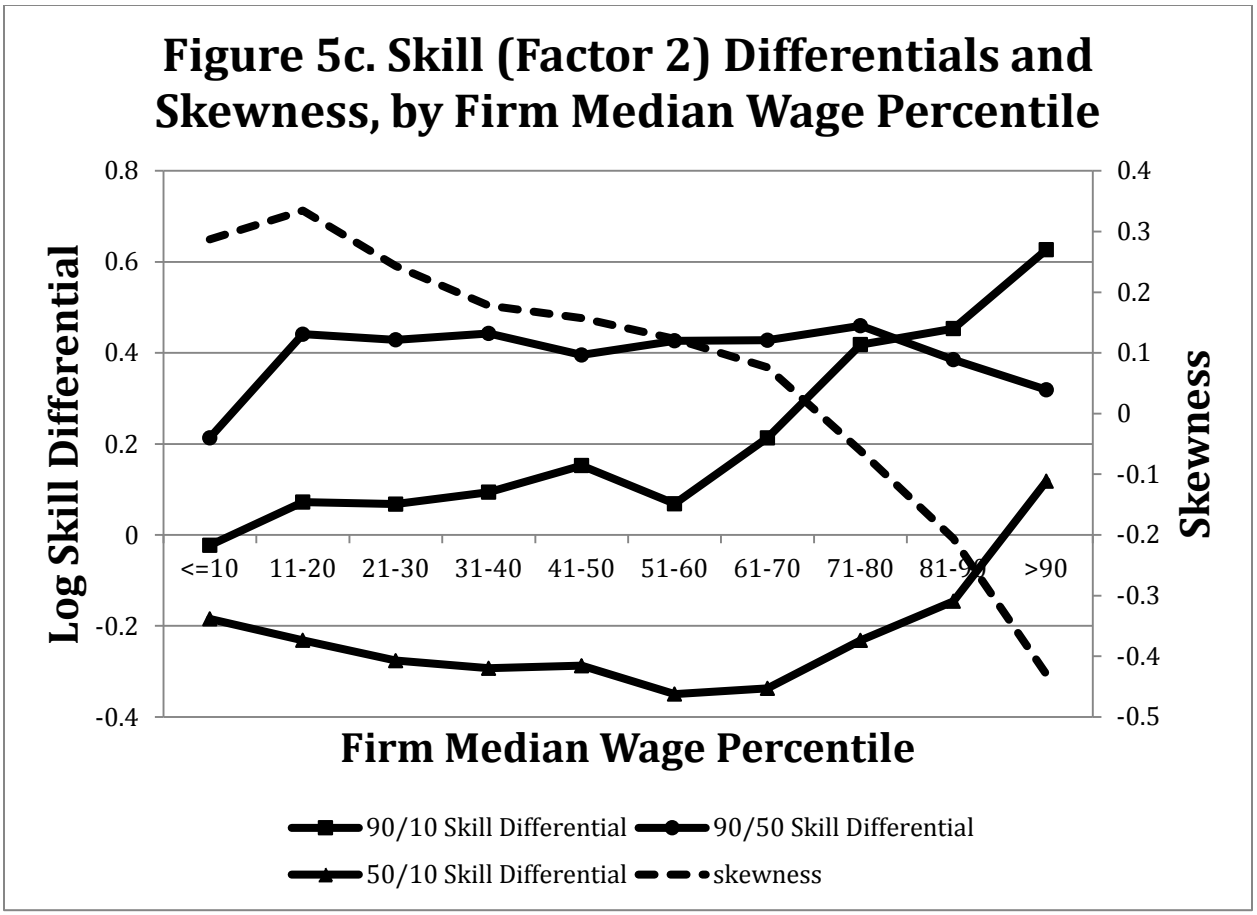
Figure 5c. Skill (Factor 2) Differentials and Skewness, by Firm Median Wage Percentile
Log Skill Differential
Skewness
0.8
0.6
0.4
0.2
0
-0.2
-0.4
0.4
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
-0.4
-0.5
<=10
11-20
21-30
31-40
41-50
51-60
61-70
71-80
81-90
>90
Firm Median Wage Percentile
90/10 Skill Differential
90/50 Skill Differential
50/10 Skill Differential
skewness

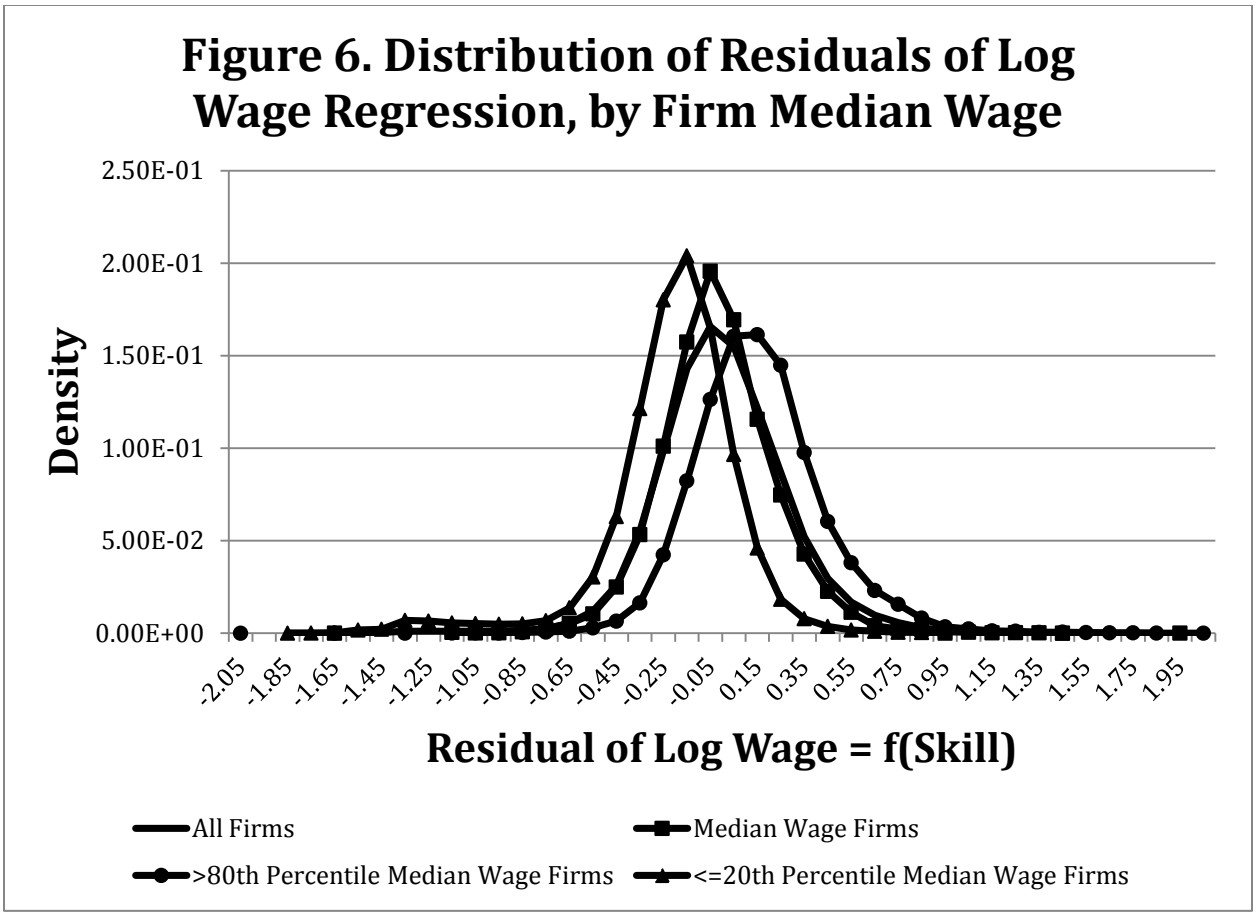
Figure 6. Distribution of Residuals of Log Wage Regression, by Firm Median Wage
Density
2.50E-01
2.00E-01
1.50E-01
1.00E-01
5.00E-02
0.00E+00
-2.05
-1.85
-1.65
-1.45
-1.25
-1.05
-0.85
-0.65
-0.45
-0.25
-0.05
0.15
0.35
0.55
0.75
0.95
1.15
1.35
1.55
1.75
1.95
Residual of Log Wage = f(Skill)
All Firms
Median Wage Firms
>80th Percentile Median Wage Firms
<=20th Percentile Median Wage Firms

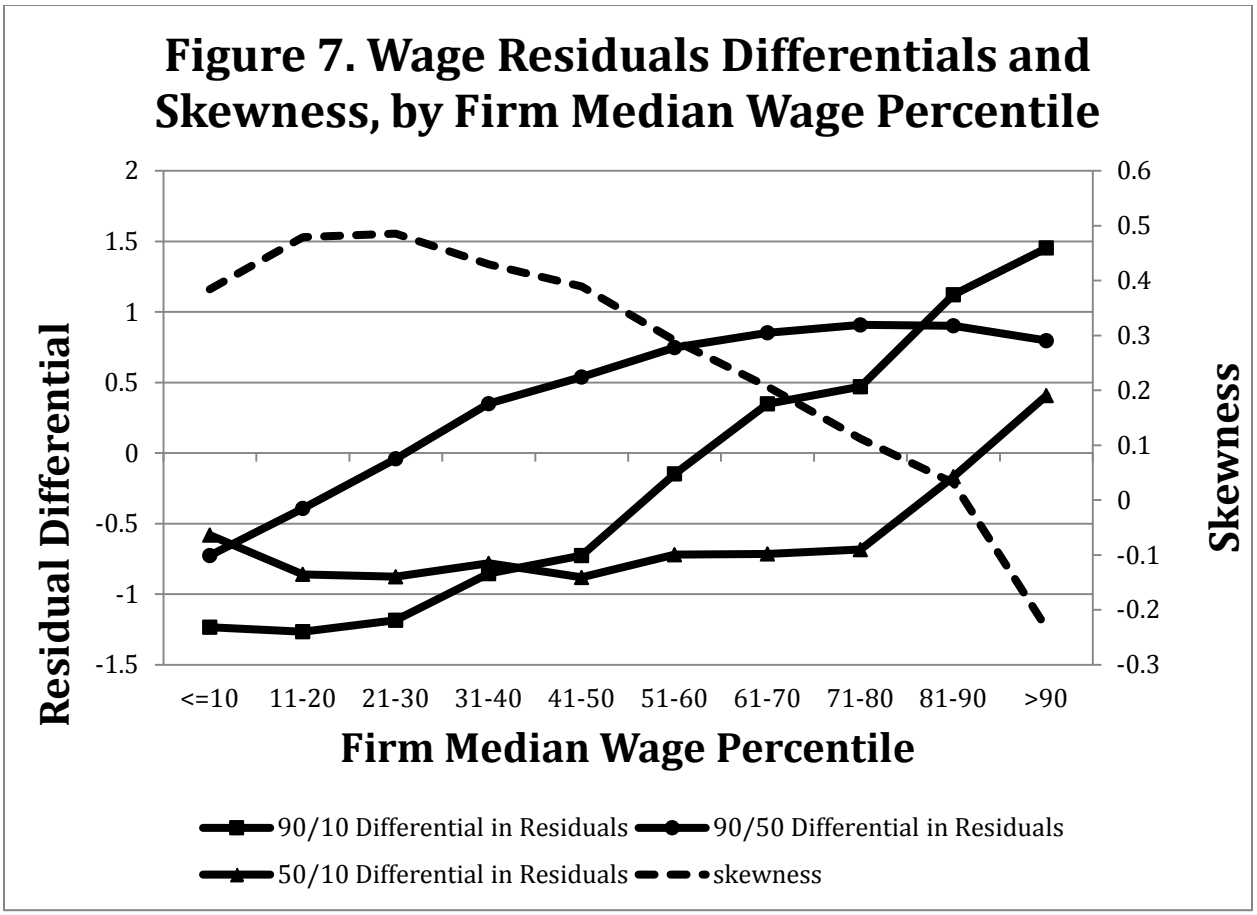
Figure 7. Wage Residuals Differentials and Skewness, by Firm Median Wage Percentile
Residual Differential
Skewness
2
1.5
1
0.5
0
-0.5
-1
-1.5
0.6
0.5
0.4
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
<=10
11-20
21-30
31-40
41-50
51-60
61-70
71-80
81-90
>90
Firm Median Wage Percentile
90/10 Differential in Residuals
90/50 Differential in Residuals
50/10 Differential in Residuals
skewness

Table 1. Summary Statistics of Generic Leveling Factors

	Distribution								
	1	2	3	4	5	6	7	8	9
Knowledge	10.5	25.7	19.9	13.5	7.0	14.4	7.2	1.6	0.1
Supervision Received	21.6	41.5	28.8	7.1	1.0				
Guidelines	33.3	36.1	24.7	5.2	0.7				
Complexity	19.3	35.1	35.7	6.8	3.0	0.2			
Scope and Effect	30.9	34.5	28.5	4.6	1.3	0.2			
Personal Contacts	44.9	42.7	12.2	0.3					
Purpose of Contacts	62.2	28.6	8.5	0.7					
Physical Demands	43.7	54.0	2.3						
Work Environment	51.5	46.8	1.7						
Supervisory Duties	78.7	8.9	10.4	1.8	0.2				

	Correlation								
	SR	Gu	C	SE	PC1	PC2	PD	WE	SD
Knowledge	.822	.802	.822	.803	.733	.750	-.450	-.334	.485
Supervision Received		.852	.863	.847	.663	.690	-.317	-.214	.489
Guidelines			.855	.875	.615	.664	-.284	-.165	.468
Complexity				.860	.627	.666	-.309	-.187	.462
Scope and Effect					.619	.667	-.240	-.137	.462
Personal Contacts						.760	-.487	-.443	.422
Purpose of Contacts							-.382	-.318	.474
Physical Demands								.769	-.180
Work Environment									-.132
Supervisory Duties									

Numbers in boxes above are median values.

Table 2. Orthogonally Rotated Factor Loadings

	Factor 1	Factor 2
Knowledge	.8518	.3313
Supervision Received	.9042	.1567
Guidelines	.9089	.0962
Complexity	.9051	.1267
Scope and Effect	.9190	.0587
Personal Contacts	.6645	.4787
Purpose of Contacts	.7321	.3426
Physical Demands	-.2002	-.8116
Work Environment	-.0861	-.8211
Supervisory Duties	.5181	.1187
Eigenvalue	5.914	1.269

Table 3. Variances of Wages and Skills, by Firm Median Wage Percentile

	Ln(hourly wages)	Additive Skill Index	Factor 1	Factor 2
All Firms	0.30	41.7	0.95	0.80
Median Wage (45-55%ile) Firms	0.16	31.5	0.71	0.93
High Wage (>80%ile) Firms	0.21	42.2	0.96	0.90
Low Wage (<=20%ile) Firms	0.25	18.6	0.41	0.42

Table 5. Second-Stage Regression of Firm Wage Model Error on Median Firm Skill Level

	All Workers			High Wage Workers			Low Wage Workers		
Additive Index In Stage I	I	II	III	I	II	III	I	II	III
Error	.079***	1.81***	1.25***	.116***	.416***	-.118*	.496***	2.07***	1.43***
	(.030)	(.069)	(.069)	(.034)	(.065)	(.064)	(.033)	(.067)	(.069)
Error2		-3.28***	-2.38***		-.754***	.129		-3.60***	-2.55***
		(.119)	(.118)		(.141)	(.136)		(.134)	(.134)
Unionization			.282***			.274***			.279***
			(.012)			(.012)			(.012)
Firm Size			.048***			.063***			.044***
			(.002)			(.002)			(.002)
R-squared	.0004	.0479	.1273	.0007	.0026	.1052	.0141	.0586	.1288
N		15340			14607			15334	
	All Workers			High Wage Workers			Low Wage Workers		
Factors In Stage I	I	II	III	I	II	III	I	II	III
Error	.142***	1.42***	.781***	.390***	.817***	.191***	.364***	1.61***	.856***
	(.030)	(.062)	(.064)	(.041)	(.068)	(.068)	(.036)	(.069)	(.072)
Error2		-2.63***	-1.64***		-1.32***	-.402***		-3.07***	-1.84***
		(.113)	(.113)		(.168)	(.162)		(.147)	(.147)
Unionization			.282***			.276***			.282***
			(.012)			(.012)			(.012)
Firm Size			.050***			.060***			.050***
			(.002)			(.002)			(.002)
R-Squared	.0014	.0357	.1164	.0062	.0105	.1054	.0066	.0340	.1133
N		15340			14607			15334	

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Table A1. Log wage OLS regressions, with controls for various skills					
	I	II	III	IV	V
Knowledge=1	-.372*** (.005)	-.843*** (.003)			
Knowledge=2	-.212*** (.004)	-.562*** (.003)			
Knowledge=3	-.144*** (.003)	-.289*** (.003)			
Knowledge=5	.167*** (.004)	.111*** (.004)			
Knowledge=6	.290*** (.003)	.313*** (.003)			
Knowledge=7	.418*** (.006)	.657*** (.004)			
Knowledge=8	.582*** (.013)	1.09*** (.007)			
Knowledge=9	.601*** (.038)	1.26*** (.031)			
Supervision Received=1	-.149*** (.005)		-.918*** (.003)		
Supervision Received=2	-.082*** (.003)		-.532*** (.002)		
Supervision Received=4	.071*** (.006)		.491*** (.004)		
Supervision Received=5	.132*** (.014)		.917*** (.009)		
Guidelines=1	-.200*** (.005)			-.933*** (.002)	
Guidelines=2	-.067*** (.003)			-.453*** (.002)	
Guidelines=4	.090*** (.006)			.459*** (.005)	
Guidelines=5	.135*** (.017)			.902*** (.011)	
Complexity=1	-.161*** (.007)				-1.30*** (.004)
Complexity=2	-.094*** (.006)				-.927*** (.004)
Complexity=3	-.032*** (.005)				-.432*** (.004)
Complexity=5	.051*** (.008)				.398*** (.006)
Complexity=6	.062* (.034)				.564*** (.024)
Scope & Effect=1	-.147*** (.007)				
Scope & Effect=2	-.093***				

	(.007)				
Scope & Effect=3	-.041*** (.006)				
Scope & Effect=5	.070*** (.013)				
Scope & Effect=6	.083*** (.036)				
Personal Contacts=1	.056*** (.004)				
Personal Contacts=2	-.009** (.004)				
Personal Contacts=4	.152*** (.016)				
Purpose of Contacts=1	-.028*** (.005)				
Purpose of Contacts=2	-.009** (.004)				
Purpose of Contacts=4	.020 (.013)				
Physical Demands=1	.091*** (.003)				
Physical Demands=3	.085*** (.006)				
Work Environment=1	-.078*** (.003)				
Work Environment=3	.003 (.007)				
Supervisory Duties=1	.041*** (.003)				
Supervisory Duties=2	.034*** (.004)				
Supervisory Duties=4	.057*** (.006)				
Supervisory Duties=5	.211*** (.017)				
No. Obs.	135379	135408	135393	135396	135428
R-squared	.7396	.6932	.6121	.6085	.6139
Standard errors in parentheses. *** Indicates p<.01; ** p<.05; * p<.10. For each set of skill indicators, the coefficients are estimated relative to one omitted value.					

Table A1. (cont'd)						
	VI	VII	VIII	IX	X	XI
Scope & Effect=1	-1.36*** (.005)					
Scope & Effect=2	-.932*** (.005)					
Scope & Effect=3	-.477*** (.005)					
Scope & Effect=5	.391*** (.009)					
Scope & Effect=6	.403*** (.025)					
Personal Contacts=1		-1.03*** (.004)				
Personal Contacts=2		-.642*** (.004)				
Personal Contacts=4		.444*** (.023)				
Purpose of Contacts=1			-1.01*** (.004)			
Purpose of Contacts=2			-.445*** (.004)			
Purpose of Contacts=4			.539*** (.014)			
Physical Demands=1				.414*** (.003)		
Physical Demands=3				.205*** (.009)		
Work Environment=1					.262*** (.003)	
Work Environment=3					.310*** (.011)	
Supervisory Duties=1						-.537*** (.004)
Supervisory Duties=2						-.155*** (.006)
Supervisory Duties=4						.511*** (.011)
Supervisory Duties=5						.953*** (.028)
	135436	135400	135400	135410	135407	135404
	.5924	.3692	.4191	.1370	.0573	.1850
Standard errors in parentheses. *** Indicates p<.01; ** p<.05; * p<.10. For each set of skill indicators, the coefficients are estimated relative to one omitted value.						