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Wage and job-skill distributions in the National Compensation Survey

Using nationally representative data on the specific skills required for individual jobs, we study how wage and skill distributions vary with firm type, as defined by a firm's median wage. We show that firms typically do not specialize by hiring similar workers. On the contrary, the distribution of wages and skills at middle- and high-wage firms is nearly as broad as the distribution in the entire population. Low-wage firms, however, have a more compact distribution of skills. The wage and skill distributions in high-wage firms skew leftward, whereas the distributions in low-wage firms skew rightward. We show that the skill requirements of low-wage jobs differ modestly by firm type, while the skill requirements of high-wage jobs are lower at high-wage firms than at low- and middle-wage firms.

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Wages and skills are central to the study of labor economics. However, there are still surprisingly large gaps in what we know about the distribution of both wages and skills within and across firms. The arrival of matched employer–employee data allows for some such comparisons. But because observable characteristics such as education tend to be poor proxies for job skills, it remains difficult to generate a deep understanding of how skills and wages are related across firms. This article examines the distribution of wages and skills for a nationally representative sample of U.S. firms. The data provide detailed information about the types of skills required for specific jobs. We show substantial variation in the distributions of wages and skills across firm types.

We sort firms by their median wages to examine how wages and skills are distributed across low-, middle-, and high-wage firms. Do high-wage firms pay all workers higher-than-average wages? Or do they merely have a right-

skewed distribution of wages, paying higher wages to workers at the top of the distribution? Also, is the distribution of wages matched by a similar, underlying distribution of skills?

In particular, we explore three specific questions about how wage and skill distributions differ by firm type.

Our first question asks: *Among the workers at a "typical" firm, as defined by median wage, is there a great deal of variation in either wages or skills?*

Previous research has shown a wide dispersion of wages among European workers in firms close to the median decile;[1] a median-wage firm has a substantial proportion of high- and low-wage jobs. The implication, therefore, is that firms of this type are not highly specialized or do not hire only specific types of workers. We seek to confirm this implication in an analysis focused on the wages and skills of U.S. workers, because skills offer a direct measure of the actual type of work being done.

Our second question asks: *Do the dispersion and the skewness of wage and skill distributions within individual firms vary by firm type?*

It may be that wage and skill dispersion varies with firm median wage. For example, low-wage firms might specialize exclusively in hiring workers at or near the minimum wage, producing more compact, right-skewed distributions of wages and skills. Similarly, it is plausible that high-wage firms that specialize by hiring high-wage workers might have left-skewed distributions of wages and skills. In addition to examining these possibilities, we probe how skewness changes across different firms sorted by median wage.

Our final question asks: *Do the skills associated with low- or high-wage jobs differ by firm type?*

There is some, albeit mixed, evidence that low-wage firms, which hire a disproportionate share of workers at or near the minimum wage, invest more in training and hiring practices, to align workers' skill levels with wages.[2] A minimum-wage worker at a low-wage firm might then have different skills than a similarly paid worker at a high-wage firm. Likewise, if high-wage firms specialize by employing high-skill workers, the skill requirements of jobs at such firms may also differ, implying a difference in skill requirements by firm type. In such cases, we would expect to see the types of skills associated with a particular wage level to vary with a firm's median wage.

Although our work relates to previous research on wage dispersion, it takes a different analytical approach. While other studies have focused on the distribution of wages across well-defined types of workers,[3] we consider within-firm wage dispersion by firm type. We categorize firms by median wage (low, middle, and high) and then ask to what degree the workers employed by those firms are similar to one another in terms of job skills and wages earned. From this perspective, our insights are most relevant to studying the nature of the firm and the degree to which modern firms either specialize (hire workers with similar skills) or diversify (hire workers with a wide range of skills).[4]

Data

We use restricted-access data on hourly wages and job-skill requirements for a nationally representative sample of establishments in the United States. The data, derived from the U.S. Bureau of Labor Statistics National Compensation Survey (NCS), cover the nonagricultural, nonfederal sectors of the U.S. economy. We limit the analysis to data from 1999 because that was a base year in which every establishment in the sample was surveyed about its jobs skill requirements.[5] NCS data were collected by field economists who visited sampled

establishments and randomly selected 5–20 workers (depending on establishment size) from the site's personnel records. Each selected worker represents a job, and the probability of selecting a particular job is proportional to the fraction of workers holding the same job in the establishment. Interviews with human resources representatives provide detailed information about the job requirements.

We aggregate establishment-level data to the firm level by Employer Identification Number. The data contain 137,181 jobs at 15,349 firms. Because a limited number of jobs are observed at each establishment within a firm, we define firm types by ranking firms in terms of their median wages and then using that ranking to group firms into wage ventiles.

Our sample data focus on job characteristics, rather than traits of individual workers. The data do not include information on employee benefits and demographic information about individual workers. The NCS measures skill requirements for each job as "leveling factors," which are intended to capture various job requirements consistently across occupations. These factors are based on those used in the Office of Personnel Management's Factor Evaluation System, which is used to set federal government workers' pay scales. There are 10 different leveling factors, or job design attributes: knowledge, supervision received, guidelines, complexity, scope and effect, personal contacts, purpose of contacts, physical demands, work environment, and supervisory duties. For each leveling factor, the field economist assigns a score, with the possible range of scores differing by job attribute, to describe the importance of the job attribute.

Knowledge, whose values range from 1 to 9, measures the nature and extent of the information and skills that workers are required to possess and apply to do acceptable work.

Supervision received, whose values range from 1 to 5, measures the nature and extent of supervision and instruction required for the job, the degree to which workers are allowed to modify and participate in job tasks, and the level of review of completed work.

Guidelines, whose values range from 1 to 5, measures the availability and specificity of instructions related to the work, and the extent of judgment needed to apply those instructions.

Complexity, whose values range from 1 to 6, measures the nature, number, variety, and intricacy of the tasks, processes, and methods required for completing the work; the difficulty in identifying what needs to be done; and the difficulty and originality involved in performing the work.

Scope and effect, whose values range from 1 to 6, measures the relationship between the nature of the work (the purpose, breadth, and depth of the assignment) and its effect on work products and services both within and outside the organization.

Personal contacts, whose values range from 1 to 4, measures the extent of nonsupervisory contacts and communications with the organization's internal and external constituents, the difficulty of communicating with those contacted, and the setting in which contacts take place.

Purpose of contacts, whose values range from 1 to 4, measures the complexity of the information sought or exchanged in personal contacts; contacts range from factual exchanges of information to complex communications involving significant or controversial issues.

Physical demands, whose values range from 1 to 3, measures the physical requirements of the work assigned, with a higher value indicating a more strenuous job.

Work environment, whose values range from 1 to 3, measures the risks and discomforts present in the worker's physical surroundings as well as the safety regulations associated with the performance of his or her work.

Supervisory duties, whose values range from 1 to 5, measures the amount of supervisory responsibility involved in the job.

Table 1 shows the distribution of the individual leveling factors for all workers in our sample. In general, a lower value of a variable correlates with a lower skill job—a job that requires more supervision and guidelines, is less complex, and requires less knowledge and personal communication. For the variables that reference physical demands and work environment, however, higher values associated with "skill" indicate a more strenuous, risky job. The median value of the factors (in **bold**) is often the lowest or next-lowest value.

Table 1. Distribution of values for generic leveling factors, before normalization

Generic leveling factor	1	2	3	4	5	6	7	8	9
Knowledge	10.1	27.1	**21.4**	13.1	7.3	12.9	6.2	2.0	0.1
Supervision received	21.2	**45.6**	25.2	7.0	1.0	—	—	—	—
Guidelines	33.6	**38.7**	22.0	5.1	.7	—	—	—	—
Complexity	19.2	**39.0**	32.7	5.9	3.0	.2	—	—	—
Scope and effect	31.5	**38.2**	24.5	4.0	1.7	.1	—	—	—
Personal contacts	42.0	**44.4**	13.1	.4	—	—	—	—	—
Purpose of contacts	**62.7**	28.3	8.4	.7	—	—	—	—	—
Physical demands	**49.4**	**49.8**	.8	—	—	—	—	—	—
Work environment	**59.6**	39.8	.7	—	—	—	—	—	—
Supervisory duties	**72.1**	7.7	17.2	2.5	.5	—	—	—	—

Note: Values in **bold** denote median values.

Source: U.S. Bureau of Labor Statistics.

Table 2 shows the correlations between the generic leveling factors. There is a high correlation between the variables for knowledge, supervision received, guidelines, complexity, personal contacts, and purpose of contacts. Similarly, the relationship between physical demands and work environment is fairly strong. This pattern indicates that variables that specifically reference skills (e.g., knowledge) are closely related to variables that generally reference autonomy (e.g., supervision received and guidelines). The variables for physical demands and work environment, while highly correlated with each other, are negatively correlated with the variables that reflect skills. Because it is not convenient to analyze all 10 leveling factors simultaneously, we create an additive index. To construct the index, we rescale variable values to range from .00 to 1.00 for each of the scaled responses. A generic leveling factor that is measured on a four-point scale has values of .00, .25, .75, or 1.00. The index is the sum of all 10 skill measures and, therefore, ranges from 0 to 10. It has a median value of 2.08.[6]

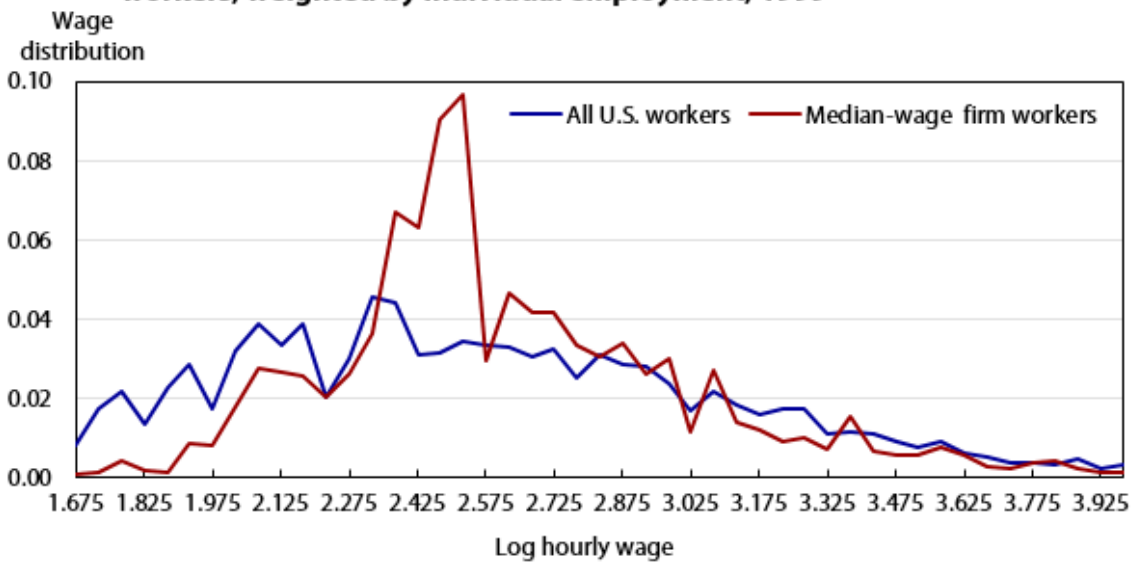
Table 2. Correlations among generic leveling factors

Generic leveling factor	Supervision received	Guidelines	Complexity	Scope and effect	Personal contacts	Purpose of contacts	Physical demands	Work environment	Supervisory duties
Knowledge	0.810	0.799	0.816	0.797	0.731	0.764	-0.443	-0.325	0.576
Supervision received	—	.851	.854	.848	.671	.701	-.295	-.202	.541
Guidelines	—	—	.853	.879	.611	.677	-.256	-.129	.518
Complexity	—	—	—	.862	.612	.669	-.289	-.157	.503
Scope and effect	—	—	—	—	.620	.673	-.226	-.124	.512
Personal contacts	—	—	—	—	—	.753	-.483	-.482	.472
Purpose of contacts	—	—	—	—	—	—	-.382	-.328	.532
Physical demands	—	—	—	—	—	—	—	.739	-.188
Work environment	—	—	—	—	—	—	—	—	-.152

Source: U.S. Bureau of Labor Statistics.

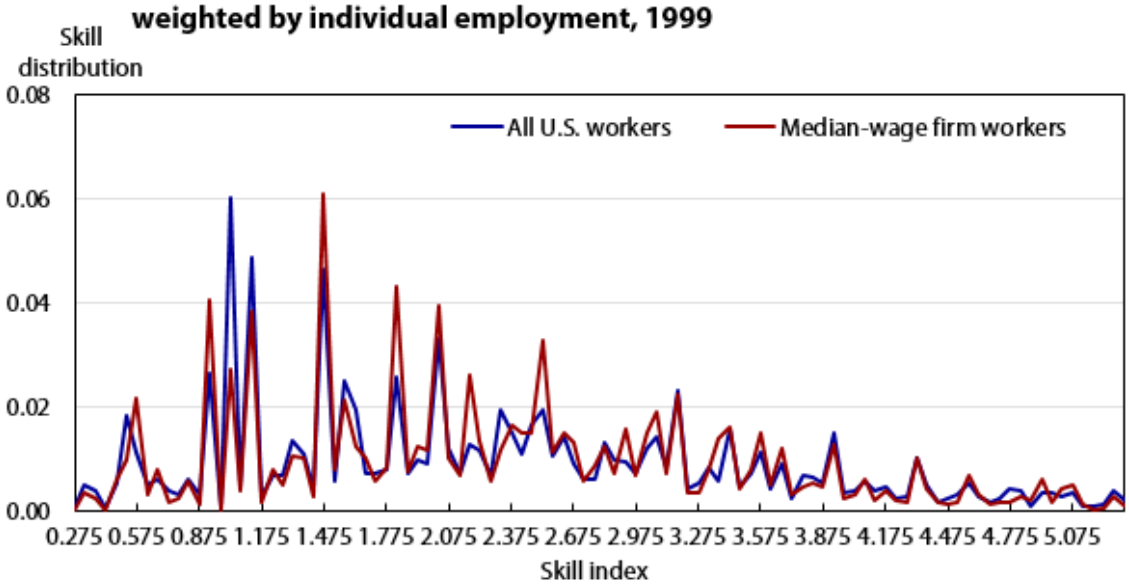
Results

Figure 1. Distribution of wages for all U.S. workers and for median-wage firm workers, weighted by individual employment, 1999



Note: Median-wage firms are those whose wages fall in the 45th through 55th percentile of all firms.
Source: U.S. Bureau of Labor Statistics.

Figure 2. Distribution of skill for all U.S. workers and median-wage firm workers, weighted by individual employment, 1999



Note: Median-wage firms are those whose wages fall in the 45th through 55th percentile of all firms.
Source: U.S. Bureau of Labor Statistics.

Our first research question asks how the wage and skill distributions of workers at a "typical" firm compare with the distributions of all workers in the sample. In figure 1, we compare the distribution of wages for all workers with the distribution of wages for workers at firms in the middle two ventiles (so firm median wages fall in the 45th–55th percentile of all firms), using individual employment weights, with the upper and lower tails suppressed for confidentiality.[7] The figure's more widely distributed curve depicts log hourly wages for all workers in the data. The other curve shows the distribution of log hourly wages only for workers who work at a firm whose median wage is in the 45th–55th percentile of all firms. In figure 2, we make the same comparison for the additive measure of skills, plotting the distribution of skills for all workers and the distribution of skills for workers at median-wage firms. Both figures show a similar pattern: the degree to which median-wage firms specialize in their hiring practices is surprisingly modest, and the distributions of wages and skills at median-wage firms look highly similar to the distributions for the full sample. The pattern also holds in the nondepicted tails of both figures and for an analogous figure (not shown) that uses the factorized skill index.

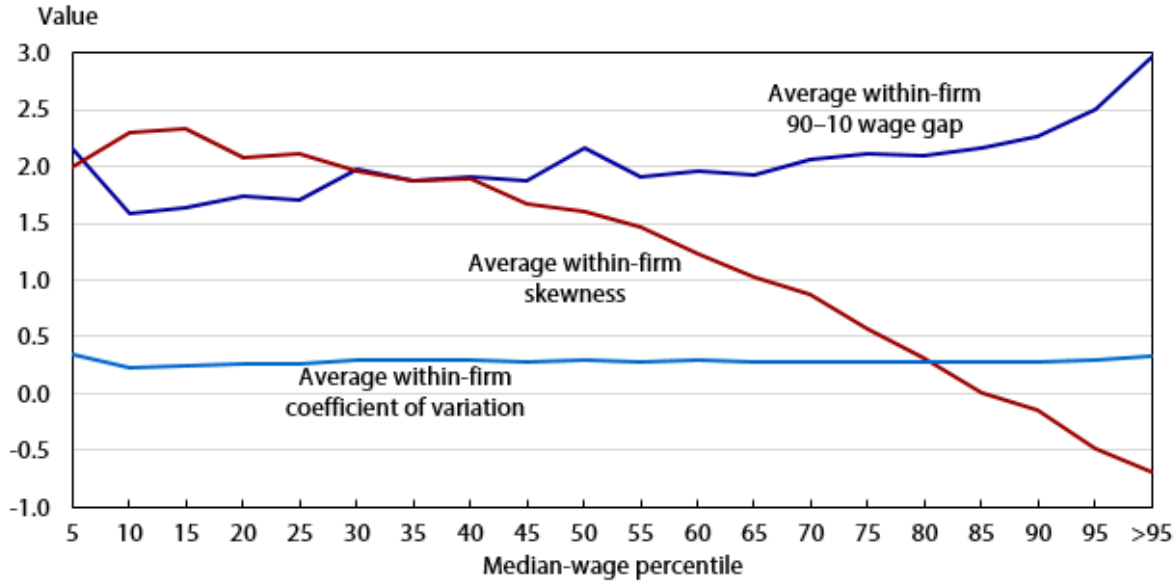
Aggregate numerical measures confirm that the amount of variation in wages and skills at median-wage firms is similar to the amount of variation at all firms. The ratio of the average within-firm standard deviation of wages to the full-sample standard deviation is .77, which means that the wage dispersion within firms is more than 75 percent of the total wage dispersion.[8] For skills, which are measured as an index of noncontinuous values, the standard deviation is not an appropriate measure of variation. Therefore, we calculate the interquartile ranges (IQRs) of both distributions. The ratio of the IQR of workers at the median-wage firm to the IQR of the full population of workers is .84.[9] The values for standard deviations and IQRs are reported in table 3. The firms that characterize the middle of the distribution pay a broad range of wages and hire workers with a broad range of skills.

Table 3. Wage and skill variation, skills normalized

Characteristic	Full sample			Median-wage firms		
	Median	Standard deviation	Interquartile range	Median	Standard deviation	Interquartile range
Log wages	12.450	11.500	9.870	12.600	8.830	6.310
Additive skill index	2.075	—	1.942	2.150	—	1.634
Factorized skill index	.373	—	.341	.370	—	.288

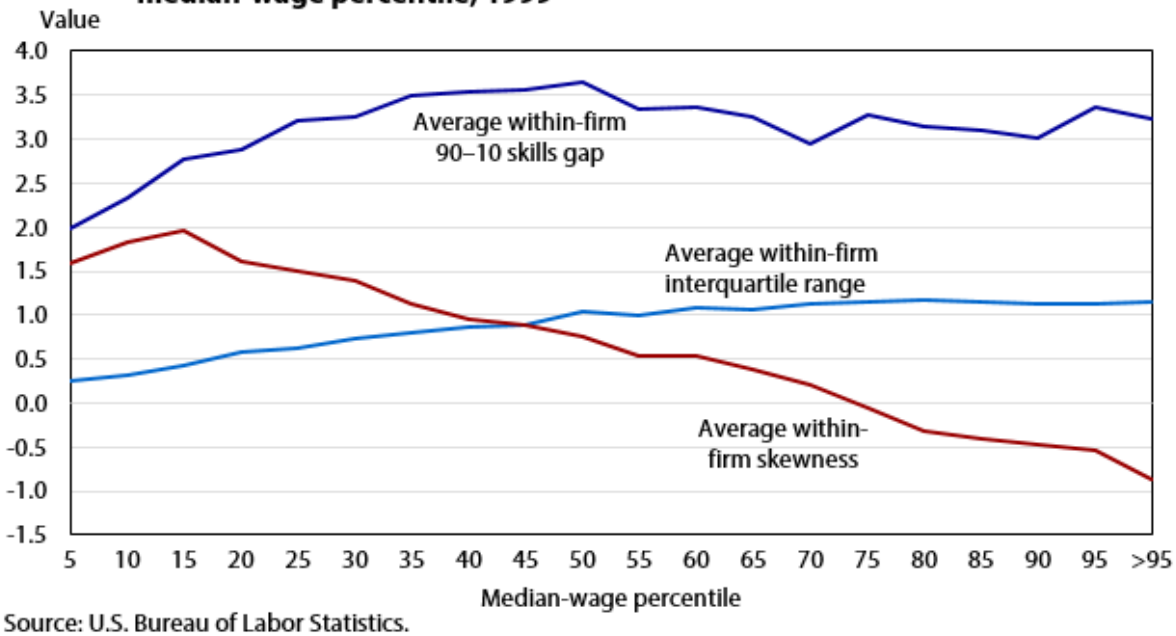
Source: U.S. Bureau of Labor Statistics.

Figure 3. Average within-firm 90–10 wage gap, skewness, and coefficient of variation, by median-wage percentile, 1999



Source: U.S. Bureau of Labor Statistics.

Figure 4. Within-firm 90–10 skills gap, skewness, and interquartile range, by median-wage percentile, 1999



Source: U.S. Bureau of Labor Statistics.

We now turn to our second research question, which asks how the dispersion and skewness of wages and skills vary across the 20 median-wage ventiles. Figures 3 and 4 plot measures of dispersion and skewness for the log wages and skills, respectively, of workers sorted by the firm's median-wage ventile. Each measure is calculated at the firm level and then averaged across all firms in that ventile. The two figures show that dispersion is largest for middle- and high-wage firms. In figure 3, the 90–10 log-wage differential is increasing across nearly all ventiles, but the coefficient of variation shows that this trend largely disappears after normalizing by the mean. In figure 4, both the 90–10 skill differential and the IQR increase substantially by firm type in the bottom half of the distribution. Low-wage firms have a more compressed distribution of skills.

In figures 3 and 4, the plots of skewness show a distinct pattern, with high positive values close to 2.0 on the left sides of both figures, and negative values on the right sides. Symmetric distributions have skewness of zero, with negative numbers indicating left skew (a longer left tail) and positive numbers indicating a right skew (a longer right tail). For both wages (figure 3) and skills (figure 4), the distributions are substantially right skewed for low- and median-wage firms, but become less skewed as a firm's median wage increases. This pattern of skewness occurs partly because both wages and scaled measures of skill have a lower bound. For high-wage firms, in which these lower bounds affect very few workers, the overall distributions have leftward skews, even in the presence of workers who earn very high wages.

To address our final research question, we compare jobs with similar wages at different types of firms and ask whether these jobs require different combinations of skills in a way that correlates with a firm's median wage. We first focus on low-wage jobs. Table 4 shows how the average skill levels of low-wage workers, defined here as those earning less than $5.75 per hour in 1999, vary by firm median-wage decile or quintile.[10] For most skill measures, low-wage jobs typically have the lowest possible value, so most values reported in the table are close to zero. Values in bold are significantly different from those in the center quintile, indicating average skill levels that are different from the skill levels found at firms in the center of the distribution. Low-wage jobs at low-wage firms are more likely to impose greater physical demands and workplace risks than low-wage jobs at median-wage

firms. For the remaining eight measures, skill levels associated with low-wage work rise slightly with the median wage of the firm, but these differences are generally not significant.

Table 4. Skill level of low-wage workers, by type of firm

Generic leveling factor	10th percentile	20th percentile	Median firm	80th–90th percentile
Knowledge	0.052	0.051	0.047	0.097
Supervision received	.048	.043	.042	.063
Guidelines	.009	.009	.008	**.042**
Complexity	.042	.041	.032	.053
Scope and effect	.017	.020	.018	.036
Personal contacts	.047	.034	.044	.050
Purpose of contacts	.006	***.002***	.011	.036
Physical demands	**.478**	**.448**	.365	.333
Work environment	**.350**	**.321**	.250	.233
Supervisory duties	***.001***	.003	.006	<.000
Skill index	**1.050**	**.973**	.822	.944
Number of firms	1157	354	122	60

Note: Values in **bold** are different from median firm values at the .05 significance level. Values in *italic* are smaller than the median-firm values.

Source: U.S. Bureau of Labor Statistics.

We also examine whether there is an analogous variation in the skill requirements for high-wage jobs. Table 5 presents evidence that this is indeed the case. The jobs of high-wage workers at high-wage firms typically require fewer skills than jobs that pay similar wages at other firms. This difference may be a reflection of a firm-level wage premium, or it may indicate the difficulty of measuring the full range of skills of high-skill workers. It is worth noting that the difference is evident only in table 4. The wage premium is not observed for low-wage workers—in fact, skill levels for these workers rise slightly, albeit insignificantly, with firm median wage.

Table 5. Skill level of high-wage workers, by type of firm

Generic leveling factor	10th–20th percentile	Median firm	80th percentile	90th percentile
Knowledge	0.693	0.703	***0.683***	***0.646***
Supervision received	.669	.670	***.636***	***.565***
Guidelines	**.580**	.608	***.578***	***.514***
Complexity	.554	.571	***.555***	***.489***
Scope and effect	**.475**	.502	***.483***	***.430***
Personal contacts	.559	.565	***.529***	***.468***
Purpose of contacts	.532	.525	***.488***	***.420***
Physical demands	.078	.073	**.123**	**.111**
Work environment	.050	.064	**.129**	**.090**
Supervisory duties	**.450**	.376	***.309***	***.139***
Skill index	4.640	4.660	***4.520***	***3.880***
Number of firms	199	1163	899	1437

Note: Values in **bold** are different from median firm values at the .05 significance level. Values in *italics* are smaller than the median-firm values.

Source: U.S. Bureau of Labor Statistics.

Conclusion

In this article, we examined the distribution of wages and skills across different types of firms, as defined by median wage. We found surprisingly wide distributions, even when we restricted our sample to the narrow range of workers in a particular ventile of firms. We showed that this pattern holds for any subsample of median- or high-wage firms. Only very low-wage firms were found to have compact distributions of skills. We then explored if this variance of wage and skill changes with the median wage of the firm.

Our results, especially those presented in figures 3 and 4, indicate that, among firms with relatively high median wages, the variance in wages and skills is relatively constant. A correlation between the median wage of the firm and the variance of skills and wages exists only among relatively low-wage firms. Skewness is the only measure of the distribution that correlates consistently with a firm's median wage. A strong rightward skew is typical for lower wage firms. For the firms paying the highest median wages, skewness disappears and even turns leftward.

Finally, we explored the skill composition of jobs with similar pay. A currently unresolved question is whether the minimum wage affects the skill requirements for low-wage jobs. We showed that skills associated with low-wage jobs differ only modestly in firms that hire disproportionate numbers of minimum-wage workers. Interestingly, for many skills, the average skill level for low-wage workers seems to rise slightly with firm median wage, while the average skill level for high-wage workers correlates negatively with firm median wage.

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NOTES

[1] See Edward P. Lazear and Kathryn L. Shaw, "Wage structure, raises, and mobility: international comparisons of the structure of wages within and across firms," in Edward P. Lazear and Kathryn L. Shaw, eds., *The structure of wages: an international comparison* (Chicago: University of Chicago Press, 2009).

[2] See Daron Acemoglu and Jörn-Steffen Pischke, "Minimum wages and on-the-job training," *Research in Labor Economics*, vol. 22, 2003; and Wiji Arulampalam, Alison L. Booth, and Mark L. Bryan, "Training and the new minimum wage," *The Economic Journal*, vol. 114, no. 494, 2004.

[3] See Richard Freeman and Ronald Schettkat, "Skill compression, wage differentials, and employment: Germany vs. the US," *Oxford Economic Papers*, vol. 53, no. 3, 2001; Erica L. Groshen, "Five reasons why wages vary among employers," *Industrial Relations*, vol. 30, no. 3, September 1991; Dale T. Mortensen, *Wage dispersion: why are similar workers paid differently?* (Cambridge: MIT Press, 2004); and Fernando Rios-Avila and Barry T. Hirsch, "Unions, wage gaps, and wage dispersion: new evidence from the Americas," *Industrial Relations*, vol. 53, no. 1, 2014.

[4] A similar question is addressed in Michel Gibbs, Alec Levenson, and Cindy Zoghi, "Why are jobs designed the way they are?" in Solomon W. Polachek and Konstantinos Tatsiramos, eds., *Research in labor economics, volume 30: jobs, training, and worker well-being* (West Yorkshire, UK: Emerald Group Publishing Limited, 2010).

[5] In subsequent years, skill measures were updated only for new establishments or for particular establishments whose job offerings had changed. Additionally, in 2000, the NCS dropped one skill measure—supervisory duties—and, in 2004, it further reduced the number of skill measures, to only four. For a detailed description of the NCS, see Brooks Pierce, "Using the National Compensation Survey to predict wage rates," *Compensation and Working Conditions* (U.S. Bureau of Labor Statistics, Winter 1999), https://www.bls.gov/opub/mlr/cwc/using-the-national-compensation-survey-to-predict-wage-rates.pdf; and Paul Carney, "Converting from nine factors to four in the occupational work leveling system of the National Compensation Survey," *Compensation and Working Conditions* (U.S. Bureau of Labor Statistics, September 2004), https://www.bls.gov/opub/mlr/cwc/converting-from-nine-factors-to-four-in-the-occupational-work-leveling-system-of-the-national-compensation-survey.pdf.

[6] Given the high correlation among the measures of skill, we also created a second index with the use of factor analysis, in which the sum of all measures was weighted (after accounting for correlations) by the unique contribution of each measure. We do not report results from this index because they are qualitatively identical to those derived from the additive index.

[7] This figure is inspired by a similar representation in Lazear and Shaw, "Wage structure, raises, and mobility." To maintain confidentiality, we do not show left and right tails in both this figure and figure 2.

[8] A similar calculation reported in Lazear and Shaw, "Wage structure, raises, and mobility," finds values between .6 and .8 for European countries.

[9] The analogous ratio for wages is .64.

[10] Because far fewer low-wage jobs are observed at high-wage firms, the table compares workers at the two lowest deciles with workers at the middle and upper quintiles.

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