The Impact of Human Capital in the American Labor Market Series

Skills, Skill Use at Work, and Earnings of American Workers

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Preface

This report is the sixth in a series of papers designed to study the role of foundational skills in the American labor market. Previous papers analyzed the connection between literacy and numeracy skills, which serve as important measures of human capital, and the earnings of prime-age full-time workers, part-time workers, and employed college graduates. Other papers examined critical linkages between skills and nonpecuniary outcomes such as employment status. Although each of these reports reveal a strong positive link between literacy and numeracy skills and labor market outcomes, there is an important factor that these reports have not addressed—the use of skills at work.

As with the previous reports in the series, this new report relies on the rich source of data from the Programme for the International Assessment of Adult Competencies (PIAAC), including direct assessment of literacy and numeracy skills and a host of information on education, income, and other demographic characteristics. But what is unique in this report is that it also utilizes detailed data on skill use including the frequency with which respondents reported using reading, numeracy, and writing skills in their job.

Skills and skill use are unsurprisingly similar and correlated concepts, but they measure different attributes. Skills reflect the acquired proficiencies of workers, whereas the use of reading, numeracy, and writing skills at work reflects an essential characteristic of occupations. This distinction is important to keep in mind because the skill hierarchy of the American occupational structure is organized on the extent to which these and other skills (both cognitive and noncognitive) are required and used at work.

The skills of workers and their employment in occupations that more extensively utilize those skills together exert a very strong and positive influence on worker earnings. These earning advantages reflect the increased productivity of workers when their strong skills are utilized at work. Simply put, for many workers, skills and the opportunity to more frequently use these skills on the job lead to greater worker productivity and correspondingly higher earnings. A worker with strong numeracy skills employed in a job where they are not in demand has little opportunity to deploy these skills at work, while that same individual employed in any of a variety of other occupations such as business operations, physical science, engineering, health professions, engineering and information systems, and the like, would have a much greater opportunity to use these numeracy skills at work.

Application of foundational skills on the job matters in another important way. In addition to a very large earnings advantage, skill use on the job contributes to further improvement in the foundational skills of workers who use them more extensively.[i] Engagement theory,

as it is known, suggests that individuals who continually exercise their reading, writing, and math skills at work also tend to increase their skills as the regular use of these skills enables individuals to maintain and expand them over time.

Analyses in this report show, for example, that the mean monthly earnings of workers with the lowest levels of skill use at work were less than half of their counterparts reporting the highest skill use at work. What's more, even after statistically controlling for the effect of literacy proficiencies, occupations, other human capital variables, job traits, and demographic traits, the use of reading skills at work remains positively associated with earnings. In other words, skill use has an important and independent effect on wages and productivity. This finding suggests the central role of effectively matching worker skills with occupational requirements in the American economy and the very high costs of failing to do so. Job search and matching worker skills with employer requirements is an essential, but often overlooked, element of a well-functioning labor market. Underutilization of the skills of workers is especially detrimental at a time when employers are struggling to fill job openings, particularly in occupations where foundational skill and occupational proficiency requirements are high. Indeed, severe worker shortages are reported across most professional, technical, and managerial occupations.

Skill mismatches can occur voluntarily, for example, when many skills proficient high school and college students choose to work in part-time positions while they are enrolled in school, and involuntarily when workers are unable to find employment in occupations that utilize their skills. In the case of involuntary skills mismatch, workers end up not utilizing their investment in educational attainment (with the intent of skills development) and incur a very large earnings penalty that is associated with the skills mismatch.

Labor market participants, particularly younger workers, are perhaps best thought of as investors who are attempting to maximize their returns to privately and publicly financed investments in skills. Better informed investors generally have much better returns than their poorly informed counterparts. All too often, educational institutions don't focus on or understand this phenomenon and consider their job done when an academic credential is awarded. Yet the payoff to skill development is critically dependent on gaining access to employment that extensively utilizes the workers' skills. Perhaps it's time to develop policies that will help to incentivize secondary and post-secondary educational institutions to more directly focus on the post-graduate outcomes of their students. Savvy investors seek information and advice about opportunities, yet the largest investment class in the nation, those in school, receive little information and advice about opportunities in the labor market.

—Paul Harrington and Irwin Kirsch

Notes

[1] Stephen Reder, "Adults' Engagement in Reading, Writing and Numeracy Practices," in *Applied Linguistics Faculty Publications and Presentation*, Vol. 22 (2017), http://archives.pdx.edu/ds/psu/21693; Nicholas Jonas, *Numeracy Practices and Numeracy Skills Among Adults*, OECD Education Working Papers No. 177 (Paris, France: OECD Publishing, 2018), https://doi.org/10.1787/8f19fc9f-en.

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Introduction

The literacy and numeracy proficiencies of individuals represent their personal stock of human capital that they have acquired over time. Human capital represents the potential of human resources (workers) to produce goods and services. It is the stock of knowledge, skills, abilities, and other characteristics of individuals that contributes to the potential of human resources. The human capital theory postulates that a greater stock of human capital and the corresponding cognitive skills enhances worker productive capacities in the labor market.[1] Research has consistently found a positive connection between human capital and labor market success.[2] Benefits from human capital also accrue in other social and noneconomic domains outside of the labor market.[3]

Foundational skills, educational attainment, and work experience typically represent the stock of human capital of individuals. However, because direct measures of skills based on large scale household surveys like the Programme for the International Assessment of Adult Competencies (PIAAC) are all too rare, educational attainment is frequently used as a proxy for skills and human capital.[4] Although educational attainment is associated with foundational skills, it is not a perfect substitute for them. Our research has shown that the skills of workers yield sizeable earnings premiums *independent* of earnings premiums associated with educational attainment.[5]

Other research studies have also consistently found a strong positive connection between skills and earnings that is postulated by the human capital theory.[6] There is, however, an important factor in the link between skills and earnings: the use of these skills at work. The personal stock of skills that workers possess is used to perform tasks at work that are necessary to produce goods and services. The earnings of workers are largely the result of workers' use of these skills on the job to perform different tasks at work that result in the production of goods and services. The stock of skills that workers possess determines their ability to perform different kinds of tasks at work. However, it is not just the *ability* to perform the tasks but the *actual performance* of these tasks at work that plays a key role in determining earnings of workers.

The skills of workers are closely related to earnings and labor market outcomes, but that is only part of the returns to skills story. The extent to which these skills are used at work to perform different tasks also plays an important role in determining the level of earnings of workers.[7] Mismatches between skills and jobs of individuals typically occur in the form of overqualification wherein the skills of workers exceed the skills required to perform duties on the job.[8] One of the consequences of such mismatches is lower earnings; for example, a college graduate employed as a barista is likely to earn barista wages rather than wages earned by a typical college graduate.[9]

Several studies have analyzed the tasks that workers need to perform at work to understand the skill requirements to effectively perform these tasks in different occupations and sectors of the economy.[10] In the absence of direct measures of skills and the use of skills at work that are available in the PIAAC database, studies that analyzed returns to tasks performed at work have relied on task measures developed through the U.S. Department of Labor's O*NET (Occupational Information Network) database.[11]

The PIAAC survey includes a skill use section that includes questions about the frequency with which respondents use reading, numeracy, and writing skills at work. Thus, the PIAAC survey measures both the proficiencies of adults as well as their use of these foundational proficiencies on the job. Additionally, the PIAAC background survey gathers comprehensive data on a variety of characteristics of respondents, their labor force status at the time of the PIAAC survey, work experience and work history, and detailed characteristics of the jobs of employed respondents.[12] Researchers have used the PIAAC database to study connections between skill use and a variety of outcomes in the labor market such as job satisfaction, overall well-being of workers, the likelihood of receiving training at work, as well as the connection between parental leave and female skill utilization and its effects on female career advancement and wages.[13] The benefits from skill use extend beyond improved outcomes; increased use of skills also enhances the proficiencies of individuals. According to practice engagement theory, the use of skills itself enhances proficiencies by allowing individuals to practice their skills.[14] Using data from three waves (2012, 2014, and 2015) of repeated assessments of literacy and numeracy proficiencies of a panel of respondents in Germany (PIAAC National Extension Study), Reder, Gauly, and Lechner[15] found positive associations between engagement in skills-related tasks and skill scores. They found that increased engagement in reading tasks is associated with higher literacy proficiency scores and that increased engagement in numeracy tasks is positively associated with numeracy proficiency scores.

An Organisation of Economic Co-operative Development (OECD) study of the link between numeracy practices and numeracy skills of workers found a positive association between numeracy skill use at work and at home and the numeracy proficiencies of workers, a phenomenon that the study referred to as a "use it or lose it" wherein workers who are required to intensively use their numeracy skills at work also use numeracy skills more intensively at home, bolstering their numeracy proficiencies overtime. Conversely, workers with limited engagement in numeracy tasks at work also use it less intensively at home, resulting in a decline in their numeracy skills over time.[16]

The rich contents of the PIAAC database provide a unique opportunity to study the links between worker skills, the use of foundational skills at work, and their impact on worker earnings. In this paper we focus on the connections between the use of reading skills at work, literacy proficiencies, and earnings.

Organization of this Paper

In this paper, we have used the 2012/2014/2017 integrated PIAAC data file to study the link between the earnings of workers and their use of reading skills at work.[17] This study builds on our previous research on the effect of skills on the earnings of American workers by examining the use of workers' skills on the job as an additional determinant of the earnings of American workers (in addition to human capital—literacy proficiencies, education, work experience—and other factors that are known to affect earnings).

Most analyses in this paper use *quartiles* of the index of reading skill use at work to measure the intensity of engagement in reading tasks at work. Each of the four quartiles include one fourth of 16- to 74-year-old workers (included in this study) based on the ranked value of their index of reading skill use at work. Workers in the highest quartile had the most intensive engagement in reading tasks at work while those in the lowest quartile were least engaged in reading tasks at work.

The paper begins with a descriptive analysis of the link between reading skill use at work and the literacy proficiencies of workers. We explore differences in the literacy proficiencies (mean literacy scores and levels of literacy proficiencies) of workers in each quartile of the index of reading skill use at work, and conversely, we present the use of reading skills at work by the level of literacy proficiencies of workers. The descriptive section also explores the connection between the occupation of workers and their use of reading skills at work. Engagement in reading tasks at work are likely to vary by occupation in which workers are employed. If the occupation requires little or no reading (low literacy requirements), then workers employed in those occupations will have a relatively diminished opportunity to utilize their reading skills on the job. Conversely, if job duties in an occupation require workers to engage in more reading at work, then the average worker in that occupation is likely to have a much greater chance to use literacy skills at work. We conclude the descriptive section with an exploration of differences in the monthly earnings of workers by their use of reading skills at work, their literacy proficiencies, and the occupation in which they are employed.

Standard errors are presented for all estimates in this paper. Any differences discussed in the paper are restricted to statistically significant differences that meet the .05 level of statistical significance.

Following the descriptive analysis, we present findings from multivariate regression analyses that explore the links between earnings and the use of reading skills at work, with regression controls for literacy proficiencies, educational attainment, work experience, occupation, and demographics. Our earnings regressions are specified as a human capital earnings function based on the Jacob Mincer framework, with the dependent variable

consisting of the natural log of earnings and the independent variables consisting of measures of human capital and other variables.[18] We have estimated the following three earnings regressions:

1. Earnings Regression Model 1: The first earnings regression model does not include any measure of reading skill use at work among the independent variables. This model estimates the independent effect of each of the three human capital measures on the earnings of workers after controlling for the remaining covariates of workers (excluding reading skill use at work).
2. Earnings Regression Model 2: The second regression model includes all the independent variables in the first model and an additional independent variable representing the use of reading skills at work by workers.
3. Earnings Regression Model 3: The third regression model uses all the independent variables in the second model except two: the index of reading skill use at work and occupations. These two independent variables (the index of reading skill use at work and occupations) are instead included in regression model 3 as interaction variables. A total of 16 interaction variables were defined with four quartiles of reading skill use at work and the four occupational groups.

About the Data

This paper is based on the PIAAC 2012/2014/2017 Restricted Use File (RUF) data provided to us by ETS. There were 12,153 respondents in 2012/2014/2017 U.S. PIAAC surveys, of which 7,502 were employed. We have restricted our findings to 16-to-74-year-old employed persons who had provided data on monthly earnings. Respondents to the PIAAC survey are asked about their gross (pretax) earnings at work. The earnings questions were designed to capture hourly, daily, weekly, biweekly, monthly, and annual earnings in order to minimize nonresponse. In cases where respondents were unwilling to provide exact gross pay, questions were also asked to capture earnings in categories. Data on gross monthly and hourly earnings in continuous form are made available to researchers only in the PIAAC Restricted Use File (RUF). The monthly earnings used in the analysis for this paper include bonuses for wage and salary workers and self-employed people.

The monthly earnings data were available for 6,712 workers between the ages of 16 and 74. After excluding earnings outliers (workers with earnings at the top and the bottom percentiles) and excluding workers with missing data in nativity status, work experience, weekly hours of work, disability status, sector of work, and occupation questions, we had a sample comprising 6,497 workers aged 16 to 74 years old for the analysis in this paper.

The PIAAC survey included a skills-use section that contains questions on the frequency with which respondents engage in job tasks that utilize reading, numeracy, and writing skills at work (similar skills-use questions outside of work are also included). In this paper, we focus on the connections among the use of reading skills at work, literacy proficiencies, and earnings.[19] To measure the frequency of reading skill use at work, respondents to the

PIAAC survey who were employed at the time of the survey or those who had worked in the 12 months prior to the survey were asked about their engagement in the following eight reading tasks at work:

1. Read directions or instructions
2. Read letters, memos or e-mails
3. Read articles in newspapers, magazines, or newsletters
4. Read articles in professional journals or scholarly publications
5. Read books
6. Read manuals or reference materials
7. Read bills, invoices, bank statements, or other financial statements
8. Read diagrams, maps, or schematics

Respondents were asked to report the frequency with which they engaged in each of these eight tasks from the following 5-point Likert scale:

1. Never
2. Less than once a month
3. Less than once a week but at least once a month
4. At least once a week but not every day
5. Every day

Using responses to these questions, the OECD PIAAC consortium created a single index using item response theory (IRT) representing an index of reading skill use at work. The IRT-based reading skill use index ranges in value from -0.956 to 7.021 with higher values representing more frequent use of reading skills at work.[20]

Descriptive Analysis of Reading Skills at Work

Literacy Proficiencies of Workers and Their Use of Reading Skills at Work

What is the link between the level of skills and the use of these skills at work? Are workers with higher skills more likely to use those skills on their job? The answer to this question is likely to be yes because workers with higher skills are more likely to have access to jobs where they can use their skills than workers with lower skills primarily because employers seek and appropriately compensate higher skilled workers for higher skilled occupations. Also, workers with lower skills may avoid jobs that need higher level skills to perform work at those jobs.

An examination of the mean literacy scores of workers in each of the four quartiles of reading skill use at work shows that workers with the lowest engagement in reading tasks at work (lowest quartile of the index of reading skill use at work) had a mean literacy score of 259, which placed them in the middle of level 2 out of 6 PIAAC literacy proficiency levels (below level 1, level 1, level 2, level 3, level 4, and level 5).[21] The mean literacy score of workers in the second quartile (second lowest) was 277, placing these workers in literacy level 3 (but just above the lower bound of the range defining level 3: 276 to 325). This means the literacy skill score (277) of workers in the second quartile is 17 points (0.34 SD[22]) higher than the mean literacy score of their counterparts in the lowest quartile. Workers in the third (second highest) quartile had a mean literacy score of 288 that was 11 points (0.22 SD) and 28 points (0.54 SD) higher than the mean literacy scores of their counterparts in the second and lowest quartiles, respectively. There was no difference between the mean literacy scores of workers in the third and the fourth (highest) quartiles of reading skill use at work.

These findings show a modest overall relationship between reading skill use and literacy proficiencies but a stronger relationship between the two concepts in the lower half of the skill use distribution. Correlation analysis between literacy and numeracy skills of workers and their use of reading and numeracy skills at work supports these findings. The analysis found correlation coefficients of 0.17 between literacy proficiency scores and the index of reading skill use at work and 0.16 between numeracy proficiency scores and the index of numeracy skill use at work. Both correlation coefficients are positive and statistically significant at the .01 level, indicating that proficiencies of workers and their engagement in proficiency-related practices (skill use) at work are positively related. However, the small size of the correlation coefficient reveals a relatively weak correlation between the skills of workers and their use of skills at work.

Table 1: Mean Literacy Proficiency Scores of 16- to 74-Year-Old Workers, by Quartiles of the Index of Reading Skill Use at Work, U.S., 2012/2014/2017 (Standard Errors in Parenthesis)

QUARTILE OF READING SKILL USE AT WORK	MEAN LITERACY PROFICIENCY SCORE
Lowest quartile	259 (1)
Second quartile	277 (1)
Third quartile	288 (1)
Highest quartile	287 (2)

The mean literacy score in each quartile of reading skill use, while informative in and of itself, masks a considerable degree of variability in literacy skills within each reading skill use quartile. Indeed, we found that 9 percent of workers in lowest reading skill use quartile had literacy proficiencies in levels 4/5 and 10 percent of workers in the highest reading skill use quartile had literacy skills at or below level 1. This result, however, is not surprising. Workers have many different objectives when choosing a job. For example, young highly

proficient college students may opt to work in a part-time job with low reading requirements, and in blue-collar occupations like the construction or machine trades, where reading is not as important as specific skills related to tool use and technology, employers may seek workers with highly specialized skills that may not be closely connected to literacy proficiencies and reading skills.

The distribution of workers by the level of their literacy proficiencies and skill use (presented in Table 2) provides a more complete view of their literacy proficiencies in the context of their use of reading skills on the job. Among workers with the lowest engagement in reading tasks at work (lowest quartile of reading skill use at work), 23 percent had literacy proficiencies at or below level 1 and about 39 percent had level 2 literacy proficiencies. Thus, nearly 62 percent of workers in the lowest quartile had literacy proficiencies below level 3. Literacy proficiency scores of the remaining 38 percent placed their literacy proficiencies at or above level 3, 30 percent in level 3, and nearly 8 percent in levels 4 and 5 combined. Literacy (and numeracy) proficiencies at or above level 3 are considered to be minimum level of skills required for positive economic, social, and educational outcomes.[23] Skills at and above level 3 are more sophisticated (than skills below level 3) and require the ability to integrate different sources of information and solve complex problems. More than six out of ten workers in the lowest quartile of reading skill use had literacy proficiency scores below level 3.

The share of workers with low levels of literacy proficiencies fell among workers in the second (lowest) quartile of reading skill use at work. A little over 14 percent of workers in the second quartile had literacy scores at or below level 1, 32 percent in level 2, 38.6 percent in level 3, and 14.5 percent in levels 4 and 5 combined. The share of workers in the second quartile with literacy skills below level 3 was much lower than that of their lowest quartile counterparts (47% versus 62%). A small majority of workers in the second quartile had literacy skill scores at level 3 or higher.

The distribution of workers by literacy proficiency levels in the third and the highest reading skill use quartiles was quite similar, as were their mean literacy scores presented in Table 1. In each of the top two quartiles of reading skill use at work, nearly 63 percent of workers had literacy scores at or above level 3, which was much larger than the share in the second quartile (53%) and the lowest quartile (38%). However, there were still nearly 10 percent of workers in each of these two top skill use quartiles with literacy proficiency scores at or below level 1 and 27 to 28 percent in literacy level 2. Even among workers with the highest engagement in reading tasks at work, there were workers with literacy scores below the minimum requirement for proficiency (level 3), including 9 to 10 percent with literacy scores at or below level 1.

Similarly, although the majority of workers in the lowest quartile and a sizeable share in the second lowest quartile had literacy proficiency scores below level 3, there were still modestly large shares of workers with level 3 or higher literacy scores: among workers in the lowest quartile, 30 percent had literacy scores that placed them in level 3 and 8 percent in levels 4 and 5 combined, and among workers in the second quartile, 39 percent had literacy scores in level 3 and 14 percent in levels 4 and 5 combined.[24]

Table 2: Percentage Distribution of 16- to 74-Year-Old Workers in Each Quartile of the Index of Reading Skill Use at Work, by Literacy Proficiency Levels, U.S., 2012/2014/2017 (Standard Errors in Parenthesis)

	PERCENTAGE DISTRIBUTION BY LITERACY PROFICIENCY LEVEL				
QUARTILE OF READING SKILL USE AT WORK	LEVEL 1 OR BELOW	LEVEL 2	LEVEL 3	LEVELS 4 AND 5 COMBINED	TOTAL
Lowest quartile	23.1 (1.5)	38.7 (1.8)	30.4 (1.8)	7.7 (1.1)	100.0
Second quartile	14.5 (1.1)	32.4 (1.8)	38.6 (2.2)	14.5 (1.5)	100.0
Third quartile	8.6 (1.0)	28.2 (1.5)	43.6 (2.2)	19.6 (1.4)	100.0
Highest quartile	9.9 (1.4)	26.7 (1.6)	44.4 (1.8)	19.0 (1.5)	100.0

These findings reveal that while the use of reading skills at work is related to the literacy proficiency of workers, the relationship is not close enough for the two concepts to be substitutes. Skill use at work cannot serve as just another measure of proficiency. The two concepts appear to measure different attributes: literacy skills measure a key proficiency of workers, whereas the use of reading skills at work reflects a key characteristic of their jobs. Taken together the skills of labor force participants can be considered the supply of literacy skills in the labor market whereas skill use at work is an indicator of the demand for reading skills in the labor market.[25] Each measure is therefore included as a separate explanatory variable in our earnings regression to capture the independent association of each with earnings of workers.

This finding is not unique to our study. An OECD study that compared skills and skill use of workers in 34 countries that participated in PIAAC found that although countries with higher proficiencies among the employed population also had high levels of skill use, a comparison of the ranking of these countries by proficiencies and skill use found differences in the ranking suggesting that while there is an association between skills and skill use among workers, the association is far from perfect.[26]

We now turn to an examination of the differences in the use of reading skills at work between workers with different levels of literacy proficiency. These differences are illustrated by examining the distribution of workers within each literacy proficiency level across quartiles of reading skill use at work. As noted above, we have used the IRT-based reading skill use index to classify all 16- to 74-year-old workers included in the analysis in this paper into four equally sized groups (quartiles) based on the value of their reading skill

use index. By definition, each quartile contains one-quarter of all 16- to 74-year-old workers included in this paper. This means that any difference (from one-quarter) in the quartile distribution of subgroups of workers represents above or below average (of all workers) use of reading skills at work. A comparison of the distribution of workers by skill use quartiles can therefore shed light on the differences in their use of reading skills at work.

Findings from an examination of the distribution across skill use quartiles of workers with different levels of literacy proficiency are presented in Table 3. These findings show that the share of workers in the lowest quartile of reading skill use was high among workers with the lowest levels of literacy proficiencies (at or below level 1) and declined sharply in successively higher literacy proficiencies levels (levels 2, 3, and 4/5). The lowest quartile of reading skill use at work accounted for 41 percent of workers with literacy proficiencies at or below level 1, 31 percent of those with level 2 literacy proficiencies, 19 percent in level 3, and just 13 percent in levels 4 and 5 combined. Workers with lower literacy skills were less likely to be frequent users of reading skills at work than workers with higher literacy skills. About the same share of workers (25%) in each of the four literacy level groups had reading skill use at work in the second skill use quartile.

The share of workers with the reading skill use index above the median was 33 percent among those with literacy skills at or below level 1, 43 percent in level 2, 56 percent in level 3, and 63 percent in levels 4 and 5 combined. Workers with the most intensive engagement in reading tasks at work (highest quartile) was just 18 percent among workers with the lowest level of literacy proficiencies (at or below level 1), 21 percent among workers with level 2 literacy skills, 28 percent in level 3, and 31 percent in levels 4 and 5 combined.

Table 3: Percentage Distribution of 16- to 74-Year-Old Workers within Each Literacy Proficiency Level by Quartiles of the Index of Reading Skill Use at Work, U.S., 2012/2014/2017 (Standard Errors in Parenthesis)

	PERCENTAGE DISTRIBUTION BY QUARTILE OF READING SKILL USE AT WORK				
LITERACY PROFICIENCY LEVEL	LOWEST QUARTILE	SECOND QUARTILE	THIRD QUARTILE	HIGHEST QUARTILE	TOTAL
Level 1 or below	17.5 (2.0)	21.1 (1.2)	28.3 (1.2)	31.3 (2.1)	100.0
Level 2	15.4 (1.7)	22.4 (1.4)	27.8 (1.3)	32.3 (1.8)	100.0
Level 3	25.8 (1.9)	25.7 (1.4)	24.6 (1.3)	23.8 (2.1)	100.0
Levels 4 and 5 combined	41.3 (2.1)	30.8 (1.3)	19.4 (1.2)	12.7 (1.7)	100.0

Workers with higher levels of literacy proficiencies were considerably more likely than their counterparts with low levels of literacy proficiencies to engage in reading tasks at work. However, there was some crossover: some workers with the lowest level of literacy proficiencies were intense users of reading skills at work, and at the other extreme, some workers with the highest level of literacy proficiencies had the lowest engagement in reading tasks at work (in the lowest quartile). About 17 percent of workers with the lowest

level of literacy proficiencies (level 1 or lower) and 21 percent of workers with level 2 literacy proficiencies reported intensive use of reading skills at work (in the highest quartile). And conversely, the use of reading skills at work placed 13 percent of workers with the highest literacy skills (levels 4 and 5 combined) and 19 percent of their counterparts with level 3 literacy skills in the lowest quartile of reading skill use at work.

Occupations of Workers and Their Use of Reading Skills at Work

An occupation represents a set of activities or tasks that workers perform on the job. Although not every worker in each occupation performs the same sets of tasks, there is a certain commonality in the tasks performed (and skills required) among workers employed in the same occupation. The number of tasks performed by workers in an occupation becomes even more varied when occupations are combined to form occupational groups. For example, workers employed in STEM occupations (i.e.: scientific, technical, engineering, and math) are likely to perform a variety of different tasks at work. However, one factor that is common among STEM occupations is numeracy tasks. Generally, STEM workers are expected to frequently engage in numeracy tasks and are expected to have strong quantitative skills.[27]

In this section, we have examined the connection between occupations of workers and the extent to which they use reading skills at work. Our analysis of occupations in this section and the entire paper is based on PIAAC's skills-based classification of occupations that aggregates all ISCO-08 occupations reported in PIAAC into the following four groups: skilled occupations, semiskilled white-collar occupations, semiskilled blue-collar occupations, and elementary occupations. A few examples of occupations in each group are presented below:[28]

- skilled occupations—professional, technical, managerial, and high-level sales occupations such as executives, managers, engineers, scientists, health practitioners, IT professionals, teaching professionals/educators, lawyers and judges, insurance/finance/real estate sales
- semiskilled white-collar occupations—administrative support and clerical occupations, low level sales occupations, personal services, protective services occupations
- semiskilled blue-collar occupations—construction workers, machine assemblers/operators /repairers, vehicle operators
- elementary occupations—laborers, helpers, handlers

An examination of the mean literacy skill scores of workers in the four occupational groups shows wide differences in literacy skills, which is not surprising because the classification of occupations into these four groups is broadly based on skills. The mean literacy skill score of workers employed in skilled occupations was 294, placing these workers in literacy

proficiency level 3 (defined as literacy scores between 276 and 325).[29] The mean literacy score of workers in the remaining three occupations placed them in literacy proficiency level 2 (defined as literacy scores between 226 and 275). Workers employed in semiskilled white-collar occupations had a mean literacy score of 268, which was 26 points or one-half of one standard deviation[30] below the mean literacy skill score for skilled occupation workers. Blue-collar and elementary occupation workers had mean scores of 256 and 248, respectively. These mean scores were 38 points (0.75 of 1 SD) and 46 points (0.91 of 1 SD) lower than those of their skilled occupation counterparts.

Table 4: Mean Literacy Proficiency Scores of 16- to 74-Year-Old Workers, by Occupation, U.S., 2012/2014/2017 (Standard Errors in Parenthesis)

OCCUPATIONS	MEAN LITERACY PROFICIENCY SCORE
Skilled occupations	294 (1)
Semiskilled white-collar occupations	268 (1)
Semiskilled blue-collar occupations	256 (2)
Elementary occupations	248 (3)

Not only were the mean literacy skills of workers in the skilled occupational group substantially higher than other occupations, but the use of reading skill at work was also more intensive among workers in skilled occupations than workers in semiskilled occupations or elementary occupations. An examination of the use of reading skills at work among workers in each of the four occupational groups reveals that workers employed in skilled occupations were much more likely to use reading skills at work than their peers in semiskilled (white-collar and blue-collar) and elementary occupations. The distribution of workers in each of the four occupations across quartiles of reading skill use at work are displayed in Table 4.[31]

The share of workers with the lowest frequency of reading at work (in the lowest quartile of reading skill use at work) was only 8.6 percent in the skilled occupational group, which is much lower than the 36 percent share in semiskilled white-collar occupations, 42 percent in semiskilled blue-collar occupations, and 62 percent among elementary occupation workers.

At the other extreme, 37 percent of skilled occupation workers had the highest engagement in reading tasks at work (highest quartile of reading skill use at work), compared to 14 percent among semiskilled white-collar workers and 12 percent among semiskilled blue-collar workers. Because of the insufficient sample size to report the highest quartile separately, the highest quartile and the third quartile for elementary occupation workers were combined in Table 5.

Table 5: Percentage Distribution of 16- to 74-Year-Old Workers in Each Major Occupation, by Quartiles of the Index of Reading Skill Use at Work, U.S., 2012/2014/2017 (Standard Errors in Parenthesis)

	PERCENTAGE DISTRIBUTION BY QUARTILE OF READING SKILL USE AT WORK				
OCCUPATIONS	LOWEST QUARTILE	SECOND QUARTILE	THIRD QUARTILE	HIGHEST QUARTILE	TOTAL
Skilled occupations	8.6 (0.5)	21.3 (0.8)	32.8 (0.7)	37.2 (0.8)	100.0
Semiskilled white-collar occupations	36.3 (1.2)	30.2 (1.1)	19.1 (1.1)	14.4 (1.0)	100.0
Semiskilled blue-collar occupations	41.8 (1.9)	29.4 (1.7)	16.8 (1.9)	11.9 (1.5)	100.0
Elementary occupations	61.9 (2.7)	22.4 (2.3)	15.6 (2.3)		100.0

NOTE: Due to insufficient sample size of elementary occupation workers in the third and the highest quartiles of reading skill use at work, we have combined these two quartiles to meet sample requirement of 62.

Workers with below median (lowest and second quartiles) use of reading skills at work comprised 30 percent of skilled workers, 66 percent of semiskilled white-collar workers, 71 percent of semiskilled blue-collar workers, and 85 percent of elementary occupation workers. Conversely, 70 percent of skilled occupation workers reported above median use of reading skills at work compared to just 34 percent, 29 percent, and 15 percent of semiskilled white-collar, semiskilled blue-collar, and elementary occupation workers, respectively.

As exceptionally high share of workers in elementary occupations was concentrated in the lowest quartile of reading skill use at work. Given the nature of work performed in elementary occupations, it is not surprising to find workers with infrequent use of reading skills on the job. In contrast, literacy tasks are reported to be much more frequently undertaken in skilled occupations compared to other occupational clusters. The nature of work performed in skilled occupations that include managers; chief executives; workers in health, education and engineering professions; and high level technical and associate professional workers requires workers to more frequently engage in reading tasks at work. More than 37 percent of these workers engaged intensively in reading tasks at work, placing them in the highest reading skill use quartile, and the frequency of use of reading skills at work placed another 33 percent of skilled occupation workers in the third (second highest) quartile.

Mean Monthly Earnings by Reading Skill Use at Work and Literacy Proficiencies

This section presents findings from our analysis of the mean monthly earnings of workers by their literacy skill levels, quartiles of reading skill use, and occupations. A comparison of the mean earnings of all 16- to 74-year-old workers by their literacy proficiency levels (Table 6) suggests a strong positive link between skills and earnings of workers that is quite consistent with our earlier studies that examined earnings gains from higher skills in U.S. labor markets.[32] Workers with higher levels of literacy (and numeracy) proficiencies are

more knowledgeable and can perform more sophisticated tasks on their jobs. The higher productive capacity of workers with higher literacy and numeracy proficiencies translates, on average, into higher earnings and better labor market outcomes.

As expected, the mean monthly earnings of workers increased with their literacy proficiencies.[33] Workers with the lowest level of literacy skills, at or below level 1, earned on average $2,740 per month, which is only half of the $5,450 mean monthly earnings of workers with the highest level of literacy skills (levels 4 or 5).

Table 6: Mean Monthly Earnings of 16- to 74-Year-Old Workers, by Literary Skill Levels, U.S., 2012/2014/2017 (Standard Errors in Parenthesis)

LITERACY PROFICIENCY LEVEL	MEAN MONTHLY EARNINGS
Level 1 or below	$2,738 (91)
Level 2	$3,318 (73)
Level 3	$4,241 (96)
Levels 4 and 5 combined	$5,452 (213)
Total	$3,923 (52)

Findings in Table 6 support the positive connection between literacy skills and earnings that is postulated by the human capital theory. However, as we observed earlier, a key intervening factor in the link between skills and earnings is the actual use of literacy skills in the workplace. The earnings of workers are a payment for their productivity in the production of goods and services. The stock of skills that workers possess determine their ability to perform different kinds of tasks at work, but it is in combination with the opportunity for workers to apply these skills in the performance of job tasks that realizes the production potential of workers and yields earnings increments associated with greater contributions from workers to a firm's production. Therefore, in addition to the skills of workers, their use of these skills at work is associated with their earnings.

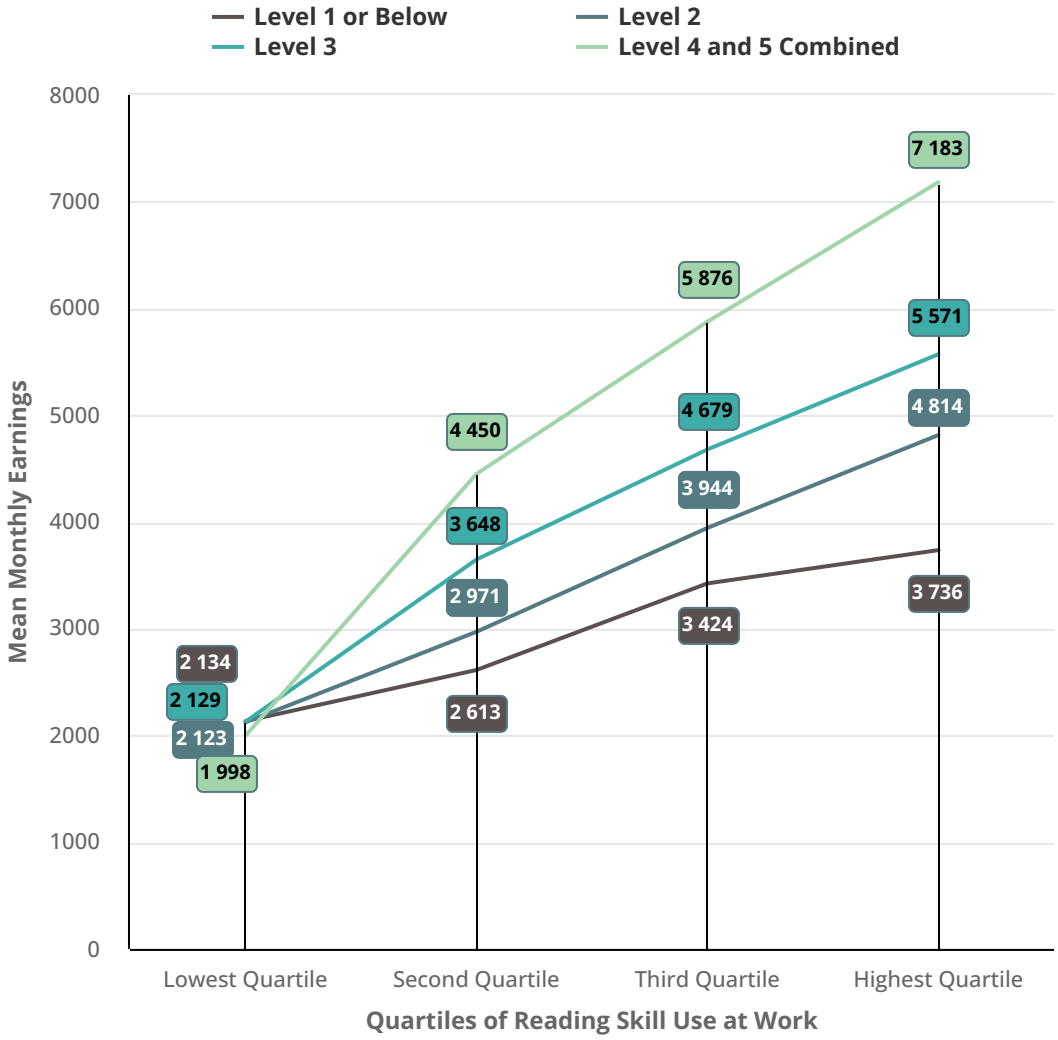
Table 7 provides an examination of the connection between earnings and reading skill use at work. These findings reveal that earnings of workers are strongly associated with their use of reading skill use on the job. Workers who used reading skills frequently at their job earned considerably more than their peers who used such skills less frequently. Earnings of workers rose steadily and sharply with higher use of reading skills at work, ranging from $2,117 in the lowest quartile to $5,584 in the highest quartile. The mean monthly earnings of workers in the highest quartile of reading skill use at work were 2.6 times higher than their peers in the lowest quartile.

Table 7: Mean Monthly Earnings of 16- to 74-Year-Old Workers, by Quartiles of the Index of Reading Skill Use at Work, U.S., 2012/2014/2017 (Standard Errors in Parenthesis)

QUARTILE OF READING SKILL USE AT WORK	MEAN MONTHLY EARNINGS
Lowest quartile	$2,117 (54)
Second quartile	$3,396 (75)
Third quartile	$4,599 (83)
Highest quartile	$5,584 (130)
Total	$3,923 (52)

The data in Table 7 indicate that earnings of workers vary widely by their use of reading skills at work but raise some key questions. Do these earnings gains associated with the use of reading skills at work vary by the literacy proficiencies of workers? How do earnings of workers with different levels of literacy proficiencies vary by their use of reading skills at work? These questions are explored by examining findings in Figure 1 that detail the relationship between mean monthly earnings and quartiles of reading skill use at work among workers with levels of literacy proficiencies.

Figure 1: Mean Monthly Earnings of 16- to 74-Year-Old Workers, by Quartiles of the Index of Reading Skill Use at Work and Literacy Proficiency Levels, U.S., 2012/2014/2017



The following key findings emerge from Figure 1:

- In each of the four literacy proficiency levels, the monthly mean earnings of workers increased in successively higher quartiles of reading skill use at work. Among workers with the lowest level of literacy proficiencies (level 1 or below), the mean monthly earnings increased from $2,139 in the first quartile of reading skill use at work to $3,736 in the highest quartile. Increases in mean monthly earnings by skill use quartile among workers with level 2 literacy proficiencies were somewhat sharper: $2,123 in the lowest quartile to $4,814 in the highest quartile. Workers with level 3 literacy proficiencies saw mean monthly earnings rise from $2,128 in the lowest quartile to $5771 in the highest quartile. The mean monthly earnings of their peers with the highest levels of literacy proficiencies (levels 4 and 5 combined) increased from $1,998 in the lowest quartile to $7,183 in the highest quartile of reading skill use at work.

- Although earnings of workers in each literacy proficiency level increased by reading skill use quartiles, the rate of earnings increase from the lowest to the highest quartile varied sharply across the four literacy levels. The mean monthly earnings in the highest quartile of reading skill use at work were 1.7 times higher than the lowest quartile among workers with literacy proficiencies at or below level 1, 2.2 times higher at literacy level 2, 2.7 times higher at literacy level 3, and 3.6 times higher at literacy levels 4 and 5 combined.
- Employment in jobs at the bottom quartile of the reading skill use distribution on average had no positive connection between skills and earnings. Workers in the bottom quartile with stronger literacy skills had mean monthly earnings that were not significantly different from the earnings of those with poor literacy skills at or below level 1. Literacy skills seem to have little pay-off for those employed in jobs with very low reading requirements.
- In contrast, employment in jobs with intensive use of reading skills (highest quartile) rose sharply with higher literacy skills. The mean earnings among these workers (with intensive use of reading skills at work) with level 4 or 5 literacy skills were nearly twice as high as those of their counterparts with literacy skills at or below level 1 ($7,183 versus $3,736).

The analysis presented above reveals that the frequent requirement for the use of reading skills at work translated into higher monthly earnings among all workers as well as among workers with different levels of literacy proficiencies. However, the rate of increase in earnings associated with higher skill use was larger among workers with higher levels of literacy skills than among workers with lower levels of literacy skills. The relationship between earnings and the use of reading skills at work was stronger among workers with higher levels of literacy proficiencies. Both literacy skills and the frequency of engagement reading tasks at work are associated with higher earnings among workers. Regression analysis presented in the subsequent section of the paper provides insights into the effect of the use of reading skills on the earnings of workers, independent from the effect of their literacy skills on earnings.

Mean Monthly Earnings by Reading Skill Use at Work and Occupations

In this section, we examine the links between earnings and use of reading skills at work in the context of the occupation in which workers were employed. Analysis presented previously (Table 4) shows that out of four occupational groups, workers employed in skilled occupations reported the highest use of reading skills at work, followed by semiskilled white-collar workers among whom the use of reading skills at work was moderately higher than semiskilled workers employed in blue-collar occupations. Elementary occupation workers were least likely to use reading skills on their jobs.

We begin with an examination of the mean earnings of workers in each of the four skill-based occupational groups. Workers in skilled occupations had the highest level of earnings, $5,279 followed by semiskilled blue-collar workers with mean monthly earnings of $3,329 and semiskilled white-collar workers with mean monthly earnings of $2,308. Elementary occupation workers had the lowest mean earnings: $1,860 per month (Table 8).

Although the mean literacy skill score of semiskilled blue-collar workers was lower than semiskilled white collar-workers, the mean monthly earnings of semiskilled blue-collar workers were somewhat higher than semiskilled white-collar workers. Underlying this is the difference in the kinds of jobs that comprise the two occupational groups. Semiskilled white-collar workers are employed in clerical and lower-level sales and service occupations. These jobs are often staffed by entry-level workers (often school-enrolled teens and young adults) and characterized by very high proportions of part-time work and high rates of worker turnover.[34] In contrast, semiskilled blue-collar workers are employed in blue-collar occupations as trades workers, operators, and assemblers for jobs that are much more likely to be full-time and often require occupationally specific tasks, technologies, and tool requirements that can require specific licensing for employment.

Table 8: Mean Monthly Earnings of 16- to 74-Year-Old Workers, by Occupations, U.S., 2012/2014/2017 (Standard Errors in Parenthesis)

OCCUPATIONS	MEAN MONTHLY EARNINGS
Skilled occupations	$5,279 (91)
Semiskilled white-collar occupations	$2,308 (60)
Semiskilled blue-collar occupations	$3,329 (90)
Elementary occupations	$1,860 (101)
Total	$3,923 (52)

Increased use of reading skills at work was associated with higher earnings in each of the four occupational groups, albeit at very different rates (Table 9). In skilled occupations, the mean monthly earnings in the highest quartile were 2.4 times that of their counterparts in the lowest quartile. In semiskilled white-collar occupations, the mean monthly earnings of workers in the highest quartile were nearly 2.0 times higher than the earnings of workers in the lowest quartile.

Among semiskilled blue-collar workers, there was considerably less variability in monthly earnings across skill use quartiles. The mean monthly earnings of workers in the highest quartile of reading skill use were only 1.37 times the earnings in the lowest quartile among semiskilled blue-collar workers. Among elementary occupation workers, the mean monthly earnings in the top two quartiles combined ($2,514) were 1.5 times higher than that of their counterparts in the lowest quartile ($1,635).

Table 9: Mean Monthly Earnings of 16- to 74-Year-Old Workers, by Quartiles of the Index of Reading Skill Use at Work and Occupations, U.S., 2012/2014/2017 (Standard Errors in Parenthesis)

	EARNINGS BY QUARTILE OF READING SKILL USE AT WORK			
OCCUPATIONS	LOWEST QUARTILE	SECOND QUARTILE	THIRD QUARTILE	HIGHEST QUARTILE
Skilled occupations	$2,601 (124)	$4,440 (137)	$5,388 (129)	$6,283 (162)
Semiskilled white-collar occupations	$1,694 (72)	$2,258 (68)	$2,751 (98)	$3,367 (166)
Semiskilled blue-collar occupations	$2,845 (119)	$3,517 (143)	$3,798 (180)	$3,899 (272)
Elementary occupations	$1,635 (114)	$2,026 (202)	$2,514 (414)	

NOTE: Due to insufficient sample size of elementary occupation workers in the third and the highest quartiles of reading skill use at work, we have combined these two quartiles to meet sample requirement of 62.

The descriptive section of this paper reveals a significant link between the use of reading skills at work and earnings of workers. Separate analyses of the links between the use of reading skills at work among workers with different levels of skills and workers in different occupations also indicate that earnings increased with increased use of reading skills at work in each literacy proficiency level and occupational subgroup of workers, albeit at different rates. Workers with higher levels of literacy proficiencies saw higher earnings premiums from increased use of skills than their counterparts with lower levels of literacy proficiencies; workers employed in skilled occupations accrued higher earnings premiums from skill use at work than those who were employment in semiskilled or unskilled occupations. This descriptive analysis also found little connection between literacy skills levels and earnings for workers in jobs with low reading skill use. Skills only matter in jobs where workers have the opportunity to use those skills. Descriptive analysis, however, cannot disentangle the independent effects of the use of reading skills at work from the effects of human capital, occupations and other job characteristics, and demographic traits of workers on the earnings of workers. The independent effect of the use of reading skills at work on earnings can be estimated with regression analysis.

Multivariate Regression Analysis of Earnings

In this section of the paper, we explore the relationship between the use of reading skills at work and earnings using multivariate regression analysis with statistical controls for skills, education, experience, occupation, and other job traits known to affect earnings, including the demographic traits of workers. Multivariate regressions in this section are based on the human capital theory that postulates that the earnings of workers are determined by the quantity of their human capital and the rate of return to that human capital in the labor market.[35] Findings from earnings regression analysis designed to estimate the independent effect of reading skill use at work on the earnings of workers are detailed below.[36] We have used human capital earnings function approach of Jacob Mincer[37] that is typically used to estimate returns to human capital after statistical controls for background traits and other variables known to affect earnings. The earnings regressions in this paper are an expanded

version of the basic Jacob Mincer earnings function. The dependent variable in these earnings functions consists of the natural log of monthly earnings, and the independent variables include the use of reading skills at work, the three measures of human capital (skills, educational attainment, and work experience), and other explanatory variables including background traits of workers (gender, race/ethnicity, foreign-born status, disability status), characteristics of the job (weekly hours of work, sector of employment, occupation), and the region of residence of the worker.

We have estimated the three earnings regressions models. The dependent variable in all three earnings regressions models is the natural log of monthly earnings. A detailed list and description of the dependent variable and all independent variables included in these regression models is presented in Appendix E. The three earnings regression models differ in the inclusion/specification of reading skill use at work.

1. Earnings Regression Model 1: The first earnings regression model does not include any measure of reading skill use at work among the explanatory variables. This model estimates the independent effect of each of the three human capital measures on the earnings of workers after controlling for the remaining covariates of workers.
2. Earnings Regression Model 2: The second regression model includes all the explanatory variables in the first model and an additional explanatory variable representing the use of reading skills at work by workers. This model is specified to estimate the effect of the use of reading skills at work on the earnings of workers after statistically controlling the effect on earnings of the human capital traits of workers and all other explanatory variables included in the regression. The measure used to represent the use of reading skills at work is the index measuring the use of reading skills at work that was created (using IRT methodology) by PIAAC from responses to eight questions on the frequency with which workers engaged in reading activities at work. The IRT-based reading skill use index is continuous and ranges in value from -0.956 to 7.021. Respondents with higher value of the index have a higher probability of frequently using reading skills at work.[38] We have standardized the IRT-based scale of reading skill use at work to have mean of 0 and standard deviation of 1.
3. Earnings Regression Model 3: The third regression model uses all the explanatory variables in the second model with a different specification of the following two variables: reading skill use at work and occupations. These two variables (reading skill use at work and occupations) are instead included in model 3 as interaction variables. Instead of the using the index of reading skill use at work, we have used quartiles of the index of reading skill use at work and created 16 interaction variables from the four quartiles of reading skill use at work and the four skill-based occupational groups. These interaction variables were included in model 3 to measure regression-based effects (on earnings) of the use of reading skills at work across the four occupational clusters after statistically controlling for the human capital traits of workers and all other explanatory variables included in the regression.

Regression Analysis of Earnings and Reading Skill Use at Work

Findings from the earnings regression models 1 and 2 are presented in Table 10. Both regression models have the same dependent variable (natural log of monthly earnings) and only one difference in independent variables: the index of reading skill use at work is not included in model 1 but is *included* in model 2.

Even after controlling for the remaining two human capital variables (education and work experience), weekly hours of work, occupation of workers, and demographic traits, both regression models (1 and 2) find a strong positive effect of literacy proficiencies on the monthly earnings of workers. Findings from regression model 1 show that an increase of one standard deviation in the literacy score is expected to increase monthly earnings of 16- to 74-year-old workers by 6.7 percent after statistical controls for other covariates included in the regression. The addition of the use of reading skills at work to the independent variables in regression model 2 resulted in almost no difference in the estimated effect of literacy skills on earnings; model 2 found that an increase in the literacy skill score by one standard deviation is expected to increase monthly earnings by 6.6 percent (compared to 6.7 percent in model 1).

Model 2 found a sizeable independent effect on earnings of workers attributable to their use of reading skills at work. An increase of one standard deviation in the index of reading skill use at work is expected to increase the earnings of workers by 4.7 percent. This effect is independent of the effect of literacy skills, educational attainment, work experience, occupation, weekly hours of work, and demographic traits of workers on their earnings.

These regressions also find that educational attainment of workers has a strong positive effect on the earnings of workers after regression controls. Findings in regression model 1 show that compared to high school graduates, the monthly earnings of workers are expected to be 12 percent lower among those who failed to complete high school, 6 percent higher among workers with some college education below the bachelor's degree (some college without a credential, certificate, or an associate's degree), and nearly 34 percent higher among workers with a bachelor's or a higher degree.

The addition of reading skill use at work in regression model 2, results in a small decline in the regression-based estimates of the effect of educational attainment of workers on their earnings, indicating that some of the effect of education on earnings is attributable to the extent of their use of reading skills at work. According to findings in model 2, compared to high school graduates, the earnings of workers are expected to be 9.8 percent lower among those who had not completed high school (12 percent in model 1), 5.1 percent higher among workers with college education below the bachelor's degree (6.1 percent in model 1), and 31.3 percent higher among workers with a bachelor's or higher degree (33.5 percent in model 1).

Education is included in these models as a measure of formal investment in human capital whereas work experience is considered a measure of additional human capital acquired after completing formal schooling through postschool training/experience acquired from

employment. Wages are expected to grow with work experience because workers acquire additional skills and move on to higher paying positions as they continue to work in the labor market.

Work experience is entered in these earnings regressions as a quadratic variable to capture the relationship between work experience and earnings postulated by Jacob Mincer. According to Mincer, earnings increase with additional work experience but at a decreasing rate.[39]

Findings from models 1 and 2 reveal that an additional year of work experience is expected to raise monthly earnings by 4 percent in model 1 and 3.9 percent in model 2 after controlling for all other regression covariates. The negative and statistically significant coefficient on the experience-squared variable indicates that the earnings of workers rise with additional work experience, but the rate of earnings growth slows down as the years of work experience increases (diminishing returns to additional work experience). Estimates of the expected effect of work experience on earnings of workers changed very little with the addition of reading skill use at work in model 2 (+4.0 percent in model 1 and +3.9 percent in model 2).

The total earnings of workers are determined by the wage that they earn per hour and the number of hours on the job. PIAAC data provide information on the number of hours that workers worked per week at the time of the PIAAC survey. We have included the weekly hours of work as an explanatory variable in both regression models. Findings from both models show a strong positive connection between weekly hours of work and monthly earnings. According to regression model 1, each additional hour of work is expected to increase monthly earnings of workers by 3.8 percent, holding all other explanatory variables constant (Table 10). The addition of reading skill use at work as an explanatory variable in model 2 resulted in almost no change in the regression-based link between weekly hours of work and earnings (3.7 percent higher earnings for each additional weekly hour of work in model 2 compared to 3.8 percent in model 1).

Earnings of workers are also affected by characteristics of the job in which they are employed, particularly occupation. Occupations represent the tasks that workers perform on the job and therefore are related to the knowledge and ability requirements of workers as well as their social skills and behavioral traits needed to be a productive contributor to the firm. Generally, occupations that require higher levels of skills will pay higher wages to attract and adequately compensate workers with higher levels of human capital in the form of skills and educational attainment. Regression findings show a strong link between the occupation of workers and their earnings. Regression model 1 found that earnings of workers in different occupations are expected to exceed the earnings of workers in elementary occupations by 52 percent in skilled occupations, 18 percent in semiskilled blue-

collar occupations, and 12 percent in semiskilled white-collar occupations. These occupational earnings premiums are sizeable, especially after regression controls for skills, education, experience, and other job-related traits and demographic traits of workers.

Findings from regression model 2, which has an additional regression control for the use of reading skills at work, show slightly smaller coefficients for occupational variables, implying that some of the link between occupation and earnings is attributable to the use of reading skills on the job. However, regression-based links between occupations and earnings estimated in earnings regression model 2 are still quite large. Compared to the earnings of workers in elementary occupations, workers are expected to earn 45.3 percent more in skilled occupations (52.5 percent in model 1), 9.4 percent more in semiskilled white-collar occupations (12.4 percent in model 1), and 16.2 percent in semiskilled blue-collar occupations (18.0 percent in model 1).

The economic sector in which a worker is employed is another job characteristic that is often related to their earnings. In the PIAAC surveys, workers were asked to report their economic sector of employment, which we have classified into two groups: (a) the private sector (b) and the public sector and private nonprofit sector combined. The base group includes workers employed in the private sector. Earnings regression analysis (models 1 and 2) found that the monthly earnings of workers are not expected to vary by sector of employment after controlling skills, education, job traits, and background traits of workers.

Gender, race/ethnicity, nativity status, and disability status are the four demographic variables included in both earnings regressions (models 1 and 2) presented in Table 10. Model 1 found that the monthly earnings of male workers are expected to be 18.6 percent higher than female workers, even after controlling for human capital characteristics of workers, the characteristics of their jobs, and other demographic characteristics. The regression-based male earnings premium was slightly lower in model 2: 17.8 percent. These sizeable male earnings premiums are not unique to this study. In our previous studies of the earnings of college graduates and prime-age full-time workers, we found large male earnings premiums in earnings regressions: 17 to 19 percent among college graduates and 25 to 27 percent among prime-age full-time workers.[40] However, we found no gender differences in the earnings regressions of part-time workers.[41] The gender gap in earnings has been widely studied among researchers, and although these studies have not found a simple explanation for the phenomenon, they have found a pattern of widening gender gap in earnings over the working lifetime, and many have attributed that pattern to women's career interruptions from bearing and raising children.[42]

After controlling for literacy proficiency, educational attainment, and all other covariates included in both regression models (model 1 and 2), there were no regression-based differences between the earnings of workers by their race/ethnicity. Regression coefficients

in both models indicate no statistical difference between the earnings of White workers and those of Black, Hispanic, and Asian workers. The two regression models also found no statistical difference between the monthly earnings of native-born and foreign-born workers.[43]

Labor market outcomes of individuals with sensory and cognitive disabilities are generally poorer in comparison to individuals without disabilities. Individuals with disabilities have lower labor force participation rates, lower employment rates, and higher unemployment rates.[44] Even when employed, workers with disabilities work fewer hours per week and fewer weeks per year than workers without disabilities. Both earnings regressions models (1 and 2) found that the monthly earnings of workers with disabilities are expected to be 6.4 percent lower than workers without disabilities.[45]

The final set of explanatory variables in the earnings regressions represents the region of residence of workers. These variables are designed to capture the geographic variation in the monthly earnings of workers that could arise from variations in labor demand and supply, cost of living, policies, regulations, and other variables that affect earnings. The earnings regressions (models 1 and 2) found that the earnings of workers in the Northeast and West are expected to be 11 percent and 10 percent higher, respectively, than workers residing in the South, holding constant education, skills, job traits, and demographic traits of workers. The earnings of workers in the Midwest are not expected to be different than workers residing in the South. Estimates of regression-based differences in earnings of workers by the region of their residence from model 2 were very similar to model 1.

Table 10: Regression-Based Estimates of Expected Percent Change in Monthly Earnings of 16- to 74-Year Old Employed Individuals, U.S., 2012/2014/2017 (Regression Models 1 and 2)[46]

	PERCENT EFFECT	
VARIABLE	REGRESSION MODEL 1	REGRESSION MODEL 2
Skills		
Standardized literacy score	6.7***	6.6***
Use of reading skills at work		
Standardized index of use of reading skills at work	—	4.7***
Missing index of use of reading skills at work	—	-16.4***
Educational attainment level (Base group: High school graduate)		
Less than high school	-12.0***	-9.8***
Some college, certificate, or associate's degree	6.1***	5.1**
Bachelor's or higher degree	33.5***	31.3***
Years of work experience		
Experience	4.0***	3.9***
Experience-squared	-0.1***	-0.1***
Intensity of employment		
Weekly hours of work	3.8***	3.7***
Skill-based occupational group (Base group: Elementary occupations)		
Skilled occupations	52.5***	45.3***
Semiskilled white-collar occupations	12.4***	9.4***
Semiskilled blue-collar occupations	18.0***	16.2***
Sector of employment (Base group: Private sector)		
Public or private non-profit sector	-0.9	-1.9
Gender (Base group: female)		
Male	18.6***	17.8***
Race/ethnicity (Base group: White)		
Hispanic	-2.3	-2.4
Black	-0.9	-1.6
Asian, Pacific Islander, Other Races	2.5	2.0
Nativity status (Base group: Native-born)		
Foreign-born	4.0	4.5
Disability Status (Base group: Without disabilities)		
With disability	-6.4***	-6.4***
Region of residence (Base group: South)		
Northeast	10.9***	11.5***
Midwest	0.7	0.7
West	10.2***	9.9***
R-squared of Model 1 = 0.629; R-squared of Model 2 = 0.632		
N of Model 1 = 6,497; N of Model 2 = 6,497		

— Not applicable.
Statistical significance: *** sig. at .01 level, ** sig at .05 level.

The R-squared of the two regressions is quite high: 0.629 for model 1 and 0.632 for model 2, meaning that these models explain 62.9 percent and 63.2 percent, respectively, of the variation in the monthly earnings of 16- to 74-year-old workers in the U.S. in 2012/2014/2017. These regressions indicate a strong positive effect of the use of reading skills at work

on the monthly earnings of workers, even with regression controls for three measures of human capital—skills, education, and experience—and job traits of weekly hours of work, occupation, and economic sector of employment, as well as demographic traits of workers.

Regression Analysis of Earnings and Reading Skill Use at Work in Different Occupations

The descriptive section revealed sizeable differences in the use of reading skills as well as earnings among workers by the occupation in which they were employed. The use of reading skills at work was the highest among workers in skilled occupations, followed by workers in semiskilled white-collar occupations among whom the use of reading skills at work was lower than skilled occupation workers but higher than workers in semiskilled blue-collar occupations, who in turn used reading skills at work more frequently than workers in elementary occupations.

Earnings regressions presented in Table 10 (models 1 and 2) found sizeable differences in earnings of workers by their occupation after regression controls for human capital, skill use, job traits, and demographic traits of workers. In this section, we present findings from earnings regression model 3, in which we replaced occupations and reading skill use at work with 16 interaction variables (15 independent variables and 1 in the base group) based on four skill-based occupational groups and four quartiles of reading skill use at work. These variables are designed to estimate the independent effect (after regression controls) of reading skill use at work in different occupations.

Findings presented in Table 11 reveal that the change in the specification of occupation and reading skill use in earnings regression model 3 resulted in small declines in the estimated coefficients of the three measures of human capital (in model 3) compared to estimates of these coefficients in model 2 (Table 10). However, the coefficients of each of the human capital measures on earnings were still sizeable. An increase in the literacy skill score by one standard deviation is expected to increase earnings by nearly 6 percent (Table 11). Compared to the earnings of workers with just a high school diploma, workers with some college education below the bachelor's degree and workers with a bachelor's degree or higher level of education are expected to earn 4.4 percent and nearly 29 percent more, respectively; workers without a high school diploma are expected to earn nearly 10 percent less than high school graduate workers (Table 11). Meanwhile, each additional year of work experience is expected to raise earnings of workers by 3.8 percent, and the negative coefficient estimated for the earnings-squared variable means that earnings are expected to increase with additional years of work experience at a decreasing rate.

Earnings regression model 3 (Table 11) estimated a sizeable effect (very similar to models 1 and 2) of weekly hours of work on earnings (3.6 percent expected increase in earnings for an additional weekly hour of work).

The 18 percent regression-based earnings advantage of male workers relative to female workers estimated in regression model 3 was also very similar to models 1 and 2. The coefficients of variables representing demographic traits of workers and their region of residence were also relatively unchanged (in model 3 compared to models 1 and 2). The earnings regression (model 3) found the following: no statistical differences between the monthly earnings of Black, Hispanic, and Asian/other race workers compared to the base group (White workers); nearly 6 percent earnings disadvantage of workers with disabilities compared to workers without disabilities; and the earnings of workers in the Northeast and West regions are expected to be 11 and 10 percent higher, respectively, compared to the base group of workers residing in the South. Findings for the regression-based link between monthly earnings of workers and their nativity status in model 3 were somewhat different from models 1 and 2. Findings from earnings regression model 3 indicate that the earnings of foreign-born workers are expected to be 4.7 percent higher than native-born workers after statistical controls for all the independent variables included in the regression. The coefficient is significant at .05 level.

The last set of independent variables, representing the interaction of reading skill use at work (quartiles) and occupation, measure regression-based effects of the frequency of reading skill use at work on monthly earnings of workers within each of the four occupational groups (Table 11 and Figure 2). The base group consists of elementary occupation workers with the lowest use of reading skills at work (lowest quartile of the index of reading skill use at work).

Table 11: Regression-Based Estimates of Expected Percent Change in Monthly Earnings of 16- to 74-Year Old Employed Individuals, U.S., 2012/2014/2017 (Regression Model 3)[47]

VARIABLE	PERCENT EFFECT REGRESSION MODEL 3
Skills	
Standardized literacy score	5.9***
Educational attainment level (Base group: High school graduate)	
Less than high school	-9.9***
Some college, certificate, or associate's degree	4.4**
Bachelor's or higher degree	28.7***
Years of work experience	
Experience	3.8***
Experience-squared	-0.1***
Intensity of employment	
Weekly hours of work	3.6***
Sector of employment (Base group: Private sector)	
Public or private non-profit sector	-2.2
Gender (Base group: Female)	
Male	18.1***
Race/ethnicity (Base group: White)	
Hispanic	-2.1
Black	-1.7
Asian, Pacific Islander, Other Races	1.5
Nativity status (Base group: Native-born)	
Foreign-born	4.7**
Disability status (Base group: Without disabilities)	
With disability	-5.9***
Region of residence (Base group: South)	
Northeast	11.3***
Midwest	0.9
West	9.6***
Interaction of occupation and quartile of reading skill use at work	
Skilled occupations, lowest quartile	22.0***
Skilled occupations, second quartile	56.1***
Skilled occupations, third quartile	69.4***
Skilled occupations, highest quartile	67.3***
Semiskilled white-collar occupations, lowest quartile	6.0
Semiskilled white-collar occupations, second quartile	16.1***
Semiskilled white-collar occupations, third quartile	22.9***
Semiskilled white-collar occupations, highest quartile	24.9***
Semiskilled blue-collar occupations, lowest quartile	10.8
Semiskilled blue-collar occupations, second quartile	29.8***
Semiskilled blue-collar occupations, third quartile	24.9***
Semiskilled blue-collar occupations, highest quartile	28.7***
Elementary occupations, second quartile	4.7
Elementary occupations, third and highest quartiles combined	8.5
Missing index of use of reading skills at work	-3.3
R-squared = 0.637 N = 6497	

Statistical significance: *** sig. at .01 level, ** sig at .05 level.

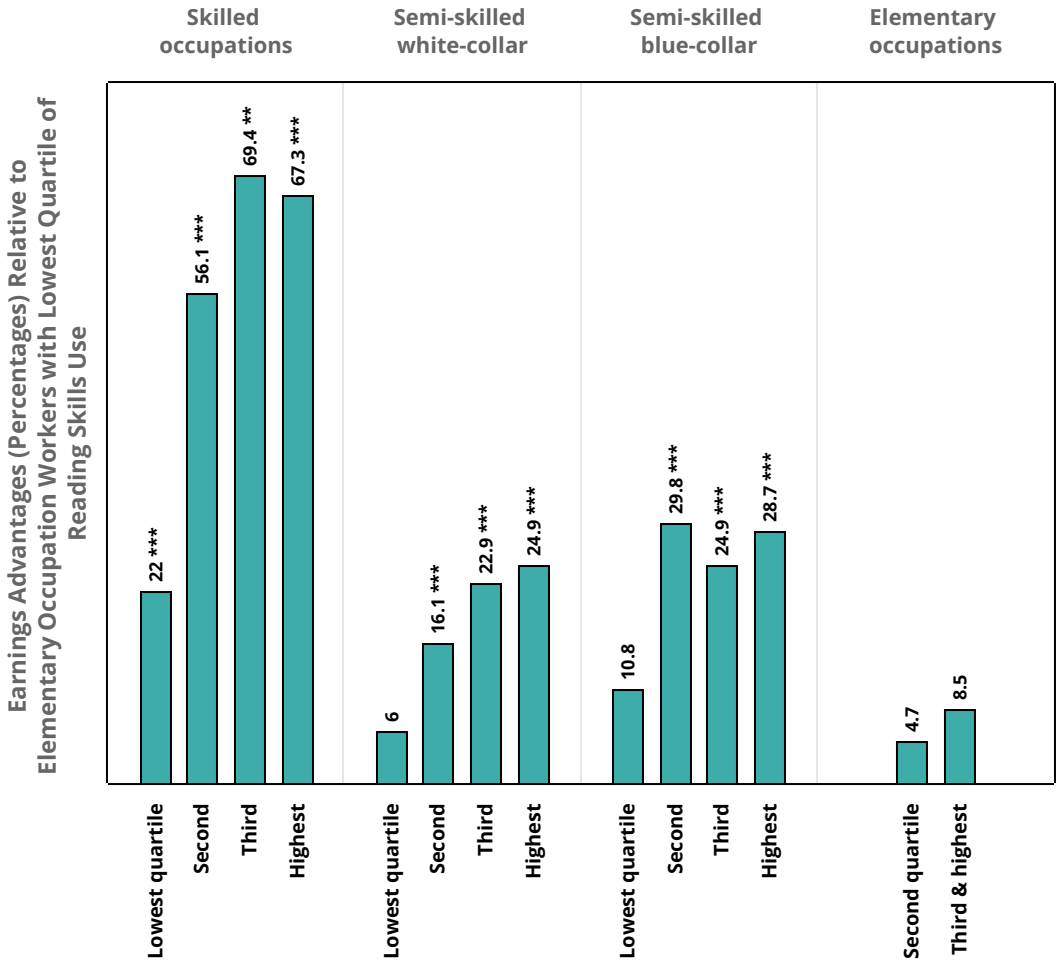
NOTE: Due to insufficient sample size of elementary occupation workers in the third and the highest quartiles of reading skill use at work, we have combined these two quartiles to meet sample requirement of 62.

Among workers employed in skilled occupations, the earnings of those in each of the four reading skill use quartiles are expected to considerably exceed the earnings of the base group: 22 percent among skilled occupation workers with the lowest use of reading skills at

work (lowest quartile); 56 percent in the second quartile; and 69 and 67 percent, respectively, in the third and the highest quartiles of reading skill use at work. Not only are workers in these (skilled) occupations expected to earn more than elementary occupation workers in the lowest quartile of reading skill use at work, but increased use of reading skills at work, particularly in the lowest, second, and third quartiles, is expected to yield sizeable earnings advantages among skilled occupation workers. There was little difference between regression-based estimates of the earnings premiums of skilled occupation workers in the third and the highest quartiles of reading skill use compared to the base group.

Among semiskilled white-collar workers, the monthly earnings of those in the lowest quartile are not statistically different from the earnings of the base group, but the earnings of these (semiskilled white-collar) workers in the remaining three quartiles are expected to exceed the earnings of the base group (elementary occupation workers with reading skill use in the lowest quartile) by 16 percent in the second quartile and 23 to 25 percent in the third and highest quartiles. Although earnings of semiskilled white-collar workers are expected to grow with increased use of reading skills at work, these increases are relatively modest compared to the expected increases in earnings with increased use of reading skills among skilled occupation workers.

Figure 2: Regression-Based Estimates of Expected Percent Difference in the Monthly Earnings of 16- to 74-Year Old Workers in Each Occupation by Quartile of Reading Skill Use at Work, Compared to Workers in the Base Group (Elementary Occupation Workers in the Lowest Quartile of Reading Skill Use at Work), U.S., 2012/2014/2017



Statistical significance: *** sig. at .01 level, ** sig at .05 level.

Note. Due to insufficient sample size of elementary occupation workers in the third and the highest quartiles of reading skill use at work, we have combined these two quartiles to meet sample requirement of 62.

Similar patterns are observed for semiskilled blue-collar workers: no statistical difference in the monthly earnings of these workers in the lowest reading skill use quartile compared to the base group, and 25 to 30 percent higher expected earnings (compared to the base group) among semiskilled blue-collar workers in the second, third, and highest quartiles of reading skill use at work. Estimates of expected earnings premiums from increased use of reading skills at work, relative to the base group, ranged from no earnings premium (coefficient positive but not statistically significant) in the lowest quartile to 30 percent in the second quartile, 25 percent in the third quartile, and 29 percent in the highest quartile of reading skill use at work.

Among workers employed in elementary occupations, increased use of reading skills at work is not expected to yield any statistically significant increase in earnings. After regression controls for all other variables included in regression model 3, we found no statistically significant link between earnings and the use of reading skills at work among elementary occupation workers.

Summary and Implications of Findings

The use of reading skills at work is associated with a sizeable earnings premium. Workers who gain access to jobs that make use of reading skills to perform tasks at work can reap large rewards in the form of higher earnings, largely depending on the combined effects of their literacy skills and the intensity of their skill use at work. Unsurprisingly, workers with higher levels of literacy proficiencies and those who are employed in skilled occupations are more likely to be frequent users of reading skills at work than their counterparts with lower levels of literacy proficiencies and employed in semiskilled and unskilled occupations. But, even after statistically controlling for the effect of literacy proficiencies, occupations, other human capital variables, job traits, and demographic traits, the use of reading skills at work remains positively associated with a sizeable increase in earnings. And the earnings premiums to skill use are largest among workers employed in skilled occupations, substantia, but more modest in semiskilled occupations, and nonexistent in unskilled occupations.

An important exception to these results is found among workers employed in positions that have relatively low levels of reading skill use. Individuals working in low reading skill use jobs have commensurately lower earnings. However, unlike most other employed persons, those working in jobs with reading skill use at work in the bottom quartile of the distribution have no earnings gains as the level of literacy skills increase. This stands in very sharp contrast with the three top reading skill use quartiles, where stronger skills pay off in the form of higher earnings. These findings suggest that about three-fourths of employed Americans work in positions where literacy skills have large wage pay-offs but one in four American workers are employed in jobs where literacy skills have no wage pay-offs because of the limited opportunity to use literacy skills in these jobs.

Key Findings:

Literacy Proficiencies and the Use of Reading Skills at Work

The literacy proficiencies of workers varied widely by the frequency of their engagement in reading tasks at work (reading skill use at work), particularly among workers with below median level (lowest quartile and second quartile) of reading skill use at work. A comparison of the mean literacy proficiency score of workers in each quartile of the index

of reading skill use at work found a difference of 18 points (0.36 *SD*), between workers in the bottom two skill use quartiles, and 11 points (0.22 *SD*) between the second and third quartiles. There was almost no difference (1 point) between the mean literacy scores of workers in the third and highest quartiles. Similar patterns prevailed in the distribution of literacy skills of workers in each reading skill use quartile. A large majority (63 percent) of those employed in jobs with reading use intensity in the top one-half of that distribution had level 3 or better literacy skills. Similarly, more than half (53 percent) of those employed in jobs ranked in the second lowest quartile had literacy skill scores that placed them at level 3 or higher. Surprisingly, 38 percent of workers in the lowest quartile of reading skill use at work had literacy skill scores at or above level 3. Despite their strong literacy skills, workers in this latter set are employed in jobs with little opportunity to exercise their literacy skills at work.

Conversely, the use of literacy skills at work by workers varied widely by their level of literacy proficiencies. Workers with higher levels of literacy proficiencies were considerably more likely than their counterparts with low levels of literacy proficiencies to engage in reading tasks at work. Above median use of reading skills at work comprised only 33 percent of those with the lowest level of literacy skills (level 1 or below) compared to 63 percent among workers with the highest level of literacy skills (levels 4 and 5 combined). These findings are consistent with labor market theory that predicts market forces would tend to match worker skills with employer skills requirements.

Occupations and the Use of Reading Skills at Work

Workers employed in skilled occupations were considerably more likely to use reading skills at work than their counterparts employed in semiskilled white-collar occupations, semiskilled blue-collar occupations, and elementary occupations. Reading is itself an important method of acquiring various kinds of workplace knowledge and ability. Thus, it is not surprising to see reading is frequently used in occupations that require workers to learn how to engage in a greater variety and more complex set of workplace tasks than other workers. The share of workers employed in jobs with reading skill use above median level (third and highest quartiles combined) was 70 percent in skilled occupations, 33 percent in semiskilled white-collar occupations, 28 percent in semiskilled blue-collar occupations and 15 percent in elementary occupations. The share of workers in the lowest quartile of reading skill use at work ranged from 9 percent among skilled occupation workers to 36 percent among semiskilled white-collar workers, 42 percent among semiskilled blue-collar workers, and 62 percent among elementary occupation workers.

Earnings and the Use of Reading Skills at Work

Workers who used reading skills frequently at their job earned considerably more than their peers who used such skills less frequently. The mean monthly earnings of workers in the lowest quartile of reading skill use at work were $2,117, rising to $3,396 for those in the second quartile, $4,599 in the third quartile, and $5,584 in the highest quartile. The mean monthly earnings of workers in the highest quartile of reading skill use at work were 2.6 times higher than their peers in the lowest quartile.

Earnings and the Use of Reading Skills at Work by Literacy Proficiencies

The relationship between earnings and the use of reading skills at work was stronger among workers with higher levels of literacy proficiencies. Even at literacy skills level 1 or below, workers who used reading skills at work most frequently had earnings that were much higher (1.7 times greater) than those who used reading skills at work infrequently. The difference between mean earnings in the highest quartile and the lowest skill use quartile varied across each of the four literacy levels; the size of the difference increased with the literacy level. The mean monthly earnings in the highest quartile of reading skill use at work were 1.7 times higher than the lowest quartile among workers with literacy proficiencies at or below level 1, 2.2 times in literacy level 2, 2.7 times in literacy level 3, and 3.6 times higher in literacy levels 4 and 5 combined. These findings mean that there are considerable earnings premiums associated with higher levels of literacy proficiencies. Moreover, the size of earning gains associated with literacy proficiencies increased in each successively higher skill use quartile. The payoff to worker skills is deeply related to employment characterized by opportunities to use (and further develop) those skills.

We find that skills do not have a payoff in jobs that entail very low levels of reading skill use. Our examination of earnings gains by literacy proficiency levels in each skill use quartile revealed that at the bottom of the skill use distribution, there was no gain in earnings associated with higher levels of literacy proficiencies. However, among the remaining three quartiles of skill use, higher levels of literacy proficiencies are associate with increasing earnings premiums to literacy proficiencies at successively higher skill use quartiles. These findings imply that overall gains to literacy in the American labor market are largely concentrated in employment characterized by reading skill use frequency in the top three quarters of the reading skill use distribution in the United States. Employment in the bottom quarter of the distribution of reading skill use provides little opportunity to reward strong literacy skills. The nature of work at this level requires insufficient reading use to reward the literacy skills of workers employed in these truly low-skill occupations.

Earnings and the Use of Reading Skills at Work by Occupations

Although earnings increased among workers in successively higher quartiles of reading skill use at work, the rate of increase in earnings was different across occupations. Workers employed in skilled occupations (largely professional managerial and paraprofessional fields) saw the biggest rise in earnings by quartile of reading skill use at work: mean earnings in the highest quartile were 2.4 times higher than the mean earnings in the lowest quartile. Earnings of semiskilled white-collar workers in the highest quartile were nearly 2.0 times higher than the earnings of their counterparts in the lowest quartile. Workers in semiskilled blue-collar occupations saw relatively modest increase in earnings; with earnings in the highest quartile 1.3 times more than the earnings in the lowest quartile. Workers in elementary occupations saw no statistically significant increase in earnings from the lowest quartile to the second quartile and from the second to the (combined) third/highest quartiles.

Earnings Regressions: Earnings and the Use of Reading Skills at Work

Both earnings regressions (one excluding reading skill use among the explanatory variables and the second including reading skill use) found strong positive effects of literacy proficiencies on the monthly earnings of workers. An increase of one standard deviation in the literacy score is expected to increase monthly earnings of 16- to 74-year-old workers by 6.7 percent in the regression excluding reading skill use at work and by about the same, 6.6 percent, in the regression including reading skill use at work.

Although the addition of reading skill use at work to the explanatory variables did not change estimates of the effect of literacy proficiencies on earnings, it found a sizeable independent effect of the use of reading skills at work on earnings. An increase of one standard deviation in the index of reading skill use at work is expected to increase the earnings of workers by 4.7 percent. This effect is independent of the effect of literacy skills, educational attainment, work experience, occupation, weekly hours of work, and demographic traits of workers on their earnings. These findings indicate that access to jobs with intensive use of reading skills is expected to result in a sizeable earnings premium for workers independently from earnings premiums from their literacy proficiencies, educational attainment, and other covariates included in the regressions.

Earnings Regression: Earnings and the Use of Reading Skills at Work across Different Occupations

The link between earnings and the use of reading skills at work was strongest among workers employed in skilled occupations, more modest but still substantial in semiskilled white-collar occupations and semiskilled blue-collar occupations, and nonexistent in

elementary occupations. Compared to the base group (elementary occupation workers in the lowest quartile of reading skill use at work), earnings in the lowest quartile are expected to be 22 percent higher in skilled occupations, and *not* statistically different in semiskilled white collar and semiskilled blue-collar occupations; earnings in the highest quartile are expected to be 67 percent higher in skilled occupations, 25 percent higher in semiskilled white-collar occupations, and 28 percent higher in semiskilled blue-collar occupations. Regression analysis found no statistically significant differences between earnings of elementary occupation in the second quartile and the two highest quartiles combined, relative to the lowest quartile.

These regression findings support our descriptive discussion about the central role of the frequency of reading skill use in influencing the labor market value of literacy skills. Employment in skilled occupations characterized by comparatively high levels of reading skill use intensity result in progressively larger earnings premiums in our regression model. Using reading skills at work more intensively also results in earning advantages for most semiskilled white-collar and blue-collar workers. However, we find no earnings advantage for semiskilled white-collar or blue-collar workers employed in jobs with relatively infrequent use of reading skills in workplace over their counterparts employed in lower skill and lower skill use elementary occupations.

Implications:

Literacy and numeracy skills of workers are measures of their human capital and are strongly connected to their earnings in the labor market. Skills represent the ability of workers to perform specific tasks at work necessary to produce goods and services. But workers are not paid wages for their *potential* to perform tasks; rather they are paid for the *actual* performance of tasks that result in the production of goods and services.

Our findings highlight the importance of matching worker skills with skills required on the job. Workers who are employed in jobs where they can more fully use their literacy skills at work are more likely to have higher earnings than if they were employed in jobs that do not utilize their skills. Our earlier study of skills and earnings of college graduate workers had related findings: the earnings premiums of college graduates were closely related to their access to employment in college level occupations. Enhancing skills is an important but only a partial answer to increase earnings and well-being of workers and increase productivity of the workforce. The other part of the answer lies in the use of worker skills on the job. Returns to skills in the labor market requires not just higher level of worker skills but also a higher level of use of these skills at work.

Job seekers' ability to grow and prosper on the job is heavily dependent on the opportunities to apply their knowledge and skills at work. Employer recruitment and hiring managers need to have a solid understanding of the foundational skills and abilities that a new hire brings to the firm as well as determine how to best match the skills of potential hires with the tasks and duties associated with this work. Public and private job development and placement professionals need to go beyond educational degree and computer algorithms to match workers with jobs.[48] The best of these will seek to understand the nature of work (tasks, duties, and skill requirements) within specific industry and occupational labor market segments and local firms in these segments and make referrals based on their knowledge of both the job seeker skills and the requirements of employers. But this requires a personal knowledge and personal relationships: ultimately, as Nobel Laureate Robert Solow observed, the labor market is a social institution and professionals who develop a deep understanding of employers and job seekers within a specific labor market segment will create the best outcomes.[49] Workers also need to navigate the job market (or their current place of work) with a focus on finding a job (or a position within the firm) that best utilizes their skills.

The benefits from the use of skills at work are not just restricted to higher earnings. According to practice engagement theory, the use of skills itself enhances proficiencies by allowing individuals to practice their skills.[50] Workers who are required to use their skills intensively bolster their proficiencies while workers with limited engagement in tasks that use their skills see a decline in their skills over time.[51] This phenomenon is frequently described as "use it or lose it." Work (of any kind) is already known to enhance the stock of human capital. Employment provides opportunities to engage in skill use which in turn enhances skills. Although every job is not perfectly matched with the skills of workers, employment provides the opportunity to practice skill use and therefore is likely to add to the proficiencies of workers over time. Extended joblessness reduces the opportunity to "use it" and so may increase the probability of "losing it." All earnings functions in this study found a strong positive association between past work experience and earnings of workers: about 3.8 percent higher earnings for each additional year of work experience. Workers who engage in the use of their skills at work also accrue additional benefits from bolstering their literacy and numeracy proficiencies over time.

The current and projected future slowdown of the growth in the nation's labor supply associated with the aging of the population and with the ongoing increase in pandemic-related withdrawals from the labor force means that the benefits of optimal use of the skills of the workforce extend beyond individual workers to the entire economy. Optimizing the match between worker skills and skill requirements on the job would maximize utilization of skills available in the workforce.

Appendix A: Numeracy Proficiencies and Use of Numeracy Skills/Earnings Regressions

Table A1: Mean Numeracy Proficiency Scores of 16- to 74-Year-Old Workers, by Quartiles of the Index of Numeracy Skill Use at Work, U.S., 2012/2014/2017 (Standard Errors in Parenthesis)

QUARTILE OF NUMERACY SKILL USE AT WORK	MEAN NUMERACY PROFICIENCY SCORE
Lowest quartile	254 (2)
Second quartile	274 (2)
Third quartile	271 (2)
Highest quartile	283 (2)

Table A2: Percentage Distribution of 16- to 74-Year-Old Workers by Numeracy Proficiency Levels and Quartiles of the Index of Numeracy Skill Use at Work, U.S., 2012/2014/2017 (Standard Errors in Parenthesis)

	NUMERACY PROFICIENCY LEVEL			
QUARTILE OF NUMERACY SKILL USE AT WORK	LEVEL 1 OR BELOW	LEVEL 2	LEVEL 3	LEVELS 4 AND 5 COMBINED
Lowest quartile	28 (1.8)	37 (1.7)	28 (2.1)	7 (1.1)
Second quartile	16 (1.4)	34 (1.7)	37 (1.7)	13 (1.2)
Third quartile	18 (1.7)	35 (1.7)	34 (1.8)	13 (13.0)
Highest quartile	15 (1.4)	27 (1.9)	38 (1.8)	20 (1.5)

Table A3: Mean Numeracy Proficiency Scores of 16- to 74-Year-Old Workers, by Occupation, U.S., 2012/2014/2017 (Standard Errors in Parenthesis)

OCCUPATIONS	MEAN NUMERACY PROFICIENCY SCORE
Skilled occupations	284 (1)
Semiskilled white-collar occupations	256 (2)
Semiskilled blue-collar occupations	254 (3)
Elementary occupations	241 (4)

Table A4: Percentage Distribution of 16- to 74-Year-Old Workers by Quartiles of the Index of Numeracy Skill Use at Work and Occupations, U.S., 2012/2014/2017 (Standard Errors in Parenthesis)

	QUARTILE OF NUMERACY SKILL USE AT WORK			
OCCUPATIONS	LOWEST QUARTILE	SECOND QUARTILE	THIRD QUARTILE	HIGHEST QUARTILE
Skilled occupations	19 (0.9)	24 (0.9)	25 (0.7)	32 (0.9)
Semiskilled white-collar occupations	32 (1.4)	24 (1.0)	29 (1.1)	15 (0.9)
Semiskilled blue-collar occupations	28 (2.0)	28 (1.8)	24 (1.6)	20 (1.8)
Elementary occupations	45 (3.4)	25 (3.1)	30 (3.3)	

NOTE: Due to insufficient sample size of elementary occupation workers in the third and the highest quartiles of numeracy skill use at work, we have combined these two quartiles to meet sample requirement of 62.

Table A5: Mean Monthly Earnings of 16- to 74-Year-Old Workers, by Numeracy Skill Levels, U.S., 2012/2014/2017 (Standard Errors in Parenthesis)

NUMERACY PROFICIENCY LEVEL	MEAN MONTHLY EARNINGS
Level 1 or below	$2,902 (90)
Level 2	$3,579 (98)
Level 3	$4,691 (125)
Levels 4 and 5 combined	$5,995 (205)
Total	$4,153 (60)

Table A6: Mean Monthly Earnings of 16- to 74-Year-Old Workers, by Quartiles of the Index of Numeracy Skill Use at Work, U.S., 2012/2014/2017 (Standard Errors in Parenthesis)

QUARTILE OF NUMERACY SKILL USE AT WORK	MEAN MONTHLY EARNINGS
Lowest quartile	$3,058 (96)
Second quartile	$3,862 (90)
Third quartile	$4,238 (98)
Highest quartile	$5,481 (133)
Total	$4,153 (60)

Table A7: Mean Monthly Earnings of 16- to 74-Year-Old Workers, by Quartiles of the Index of Numeracy Skill Use at Work and Numeracy Proficiency Levels, U.S., 2012/2014/2017 (Standard Errors in Parenthesis)

NUMERACY PROFICIENCY LEVEL	QUARTILE OF NUMERACY SKILL USE AT WORK			
	LOWEST QUARTILE	SECOND QUARTILE	THIRD QUARTILE	HIGHEST QUARTILE
Level 1 or below	$2,571 (143)	$2,887 (168)	$3,064 (253)	$3,362 (212)
Level 2	$2,853 (163)	$3,439 (180)	$3,805 (217)	$4,467 (207)
Level 3	$3,445 (219)	$4,171 (192)	$4,687 (220)	$6,122 (236)
Levels 4 and 5 combined	$4,471 (681)	$5,226 (358)	$5,872 (368)	$7,165 (3,007)

Table A8: Mean Monthly Earnings of 16- to 74-Year-Old Workers, by Occupations, U.S., 2012/2014/2017 (Standard Errors in Parenthesis)

OCCUPATIONS	MEAN MONTHLY EARNINGS
Skilled occupations	$5,279 (91)
Semiskilled white-collar occupations	$2,308 (60)
Semiskilled blue-collar occupations	$3,329 (90)
Elementary occupations	$1,860 (101)
Total	$3,923 (52)

Table A9: Mean Monthly Earnings of 16- to 74-Year-Old Workers, by Quartiles of the Index of Numeracy Skill Use at Work and Occupations, U.S., 2012/2014/2017 (Standard Errors in Parenthesis)

	QUARTILE OF NUMERACY SKILL USE AT WORK			
OCCUPATIONS	LOWEST QUARTILE	SECOND QUARTILE	THIRD QUARTILE	HIGHEST QUARTILE
Skilled occupations	$4,139 (166)	$4,962 (134)	$5,499 (142)	$6,369 (171)
Semiskilled white-collar occupations	$2,175 (124)	$2,302 (111)	$2,396 (97)	$2,958 (120)
Semiskilled blue-collar occupations	$2,960 (169)	$3,464 (133)	$3,637 (249)	$4,274 (218)
Elementary occupations	$1,618 (152)	$1,591 (139)	$2,332 (264)	

NOTE: Due to insufficient sample size of elementary occupation workers in the third and the highest quartiles of numeracy skill use at work, we have combined these two quartiles to meet sample requirement of 62.

Table A10: Regression-Based Estimates of Expected Percent Change in Monthly Earnings of 16- to 74-Year Old Employed Individuals, U.S., 2012/2014/2017 (Regression 1 with Literacy Proficiency)

VARIABLES	COEF.	STD. ERR.	Z	P>Z	(ANTI-LOG OF COEFF.-1)*100
pv_litz	0.065	0.012	5.6	0.000	6.7
male	0.171	0.015	11.5	0.000	18.6
hispanic	-0.023	0.025	-0.9	0.350	-2.3
black	-0.009	0.024	-0.4	0.711	-0.9
asian_pi_other	0.025	0.041	0.6	0.539	2.5
foreign_born	0.039	0.023	1.7	0.085	4.0
no_hsdiploma	-0.128	0.030	-4.3	0.000	-12.0
some_college	0.059	0.022	2.7	0.007	6.1
bachelors_pl	0.289	0.028	10.4	0.000	33.5
public_nonprf_sector	-0.009	0.018	-0.5	0.630	-0.9
disabled	-0.066	0.021	-3.2	0.002	-6.4
weekly_hours	0.037	0.001	40.9	0.000	3.8
experience	0.039	0.002	17.7	0.000	4.0
experiencesq	-0.001	0.000	-13.4	0.000	-0.1
skilled_occ	0.422	0.037	11.3	0.000	52.5
sem_skilledwc_occ	0.117	0.035	3.4	0.001	12.4
sem_skilledbc_occ	0.166	0.038	4.4	0.000	18.0
northeast	0.104	0.036	2.9	0.004	10.9
midwest	0.007	0.029	0.2	0.822	0.7
west	0.097	0.028	3.5	0.001	10.2
_cons	5.543	0.040	139.9	0.000	—
e_r2	0.629	0.010	61.4	0.000	—
e_N = 6,497					

— Not applicable.

Table A11: Regression-Based Estimates of Expected Percent Change in Monthly Earnings of 16- to 74-Year-Old Employed Individuals, U.S., 2012/2014/2017 (Regression 2 with Literacy Proficiency and Reading Skill Use at Work)

VARIABLES	COEF.	STD. ERR.	Z	P>Z	(ANTI-LOG OF COEFF.-1)*100
pv_litz	0.064	0.011	5.6	0.000	6.6
readworkz	0.046	0.011	4.3	0.000	4.7
readwork_missing	-0.179	0.038	-4.7	0.000	-16.4
male	0.164	0.015	11.3	0.000	17.8
hispanic	-0.024	0.025	-1.0	0.331	-2.4
black	-0.017	0.025	-0.7	0.513	-1.6
asian_pi_other	0.020	0.041	0.5	0.629	2.0
foreign_born	0.044	0.023	1.9	0.056	4.5
no_hsdiploma	-0.103	0.030	-3.4	0.001	-9.8
some_college	0.050	0.022	2.3	0.022	5.1
bachelors_pl	0.272	0.027	10.0	0.000	31.3
public_nonprf_sector	-0.019	0.018	-1.1	0.283	-1.9
disabled	-0.066	0.021	-3.2	0.001	-6.4
weekly_hours	0.036	0.001	39.8	0.000	3.7
experience	0.038	0.002	17.8	0.000	3.9
experiencesq	-0.001	0.000	-13.7	0.000	-0.1
skilled_occ	0.374	0.037	10.1	0.000	45.3
sem_skilledwc_occ	0.089	0.034	2.6	0.009	9.4
sem_skilledbc_occ	0.150	0.038	4.0	0.000	16.2
northeast	0.109	0.036	3.1	0.002	11.5
midwest	0.007	0.029	0.2	0.824	0.7
west	0.095	0.028	3.4	0.001	9.9
_cons	5.636	0.046	123.5	0.000	—
e_r2	0.632	0.010	60.9	0.000	—
e_N = 6,497					

— Not applicable.

Table A12: Regression-Based Estimates of Expected Percent Change in Monthly Earnings of 16- to 74-Year-Old Employed Individuals, U.S., 2012/2014/2017 (Regression 3 with Literacy Proficiency and Reading Skill Use at Work/Occupation)

VARIABLES	COEF.	STD. ERR.	Z	P>Z	(ANTI-LOG OF COEFF.-1)*100
pv_litz	0.057	0.011	5.0	0.000	5.9
male	0.167	0.015	11.4	0.000	18.1
hispanic	-0.022	0.024	-0.9	0.370	-2.1
black	-0.017	0.025	-0.7	0.477	-1.7
asian_pi_other	0.015	0.041	0.4	0.714	1.5
foreign_born	0.046	0.023	2.0	0.047	4.7
no_hsdiploma	-0.104	0.029	-3.6	0.000	-9.9
some_college	0.043	0.021	2.0	0.043	4.4
bachelors_pl	0.252	0.026	9.7	0.000	28.7
public_nonprf_sector	-0.022	0.018	-1.2	0.219	-2.2
disabled	-0.061	0.021	-3.0	0.003	-5.9
weekly_hours	0.036	0.001	40.0	0.000	3.6
experience	0.037	0.002	17.2	0.000	3.8
experiencesq	-0.001	0.000	-13.1	0.000	-0.1
skilled_occ_rdqrt1	0.199	0.052	3.8	0.000	22.0
skilled_occ_rdqrt2	0.446	0.049	9.1	0.000	56.1
skilled_occ_rdqrt3	0.527	0.056	9.4	0.000	69.4
skilled_occ_rdqrt4	0.514	0.054	9.4	0.000	67.3
semskl_wc_occ_rdqrt1	0.058	0.049	1.2	0.237	6.0
semskl_wc_occ_rdqrt2	0.150	0.051	3.0	0.003	16.1
semskl_wc_occ_rdqrt3	0.206	0.053	3.9	0.000	22.9
semskl_wc_occ_rdqrt4	0.222	0.055	4.0	0.000	24.9
semskl_bc_occ_rdqrt1	0.102	0.054	1.9	0.058	10.8
semskl_bc_occ_rdqrt2	0.261	0.064	4.1	0.000	29.8
semskl_bc_occ_rdqrt3	0.222	0.056	4.0	0.000	24.9
semskl_bc_occ_rdqrt4	0.252	0.078	3.2	0.001	28.7
elementary_occ_rdqrt2	0.046	0.082	0.6	0.575	4.7
elementary_occ_rdqrt34	0.081	0.109	0.8	0.454	8.5
readwork_missing	-0.033	0.052	-0.7	0.518	-3.3
northeast	0.107	0.036	3.0	0.003	11.3
midwest	0.009	0.029	0.3	0.752	0.9
west	0.092	0.027	3.4	0.001	9.6
_cons	5.607	0.053	105.7	0.000	—
e_r2	0.637	0.010	—	—	—
e_N = 6,497					

— Not applicable.

Table A13: Regression-Based Estimates of Expected Percent Change in Monthly Earnings of 16- to 74-Year-Old Employed Individuals, U.S., 2012/2014/2017 (Regression 1 with Numeracy Proficiency)

VARIABLES	COEF.	STD. ERR.	Z	P>Z	(ANTI-LOG OF COEFF.-1)*100
pv_numz	0.067	0.012	5.7	0.000	6.9
male	0.156	0.016	9.9	0.000	16.9
hispanic	-0.018	0.026	-0.7	0.474	-1.8
black	0.003	0.024	0.1	0.898	0.3
asian_pi_other	0.025	0.041	0.6	0.533	2.6
foreign_born	0.026	0.022	1.2	0.244	2.6
no_hsdiploma	-0.126	0.030	-4.2	0.000	-11.9
some_college	0.059	0.021	2.8	0.005	6.1
bachelors_pl	0.284	0.028	10.2	0.000	32.9
public_nonprf_sector	-0.006	0.018	-0.3	0.745	-0.6
disabled	-0.067	0.021	-3.2	0.001	-6.4
weekly_hours	0.037	0.001	40.7	0.000	3.8
experience	0.039	0.002	18.0	0.000	4.0
experiencesq	-0.001	0.000	-13.7	0.000	-0.1
skilled_occ	0.423	0.037	11.4	0.000	52.7
sem_skilledwc_occ	0.119	0.034	3.5	0.000	12.7
sem_skilledbc_occ	0.165	0.038	4.4	0.000	17.9
northeast	0.105	0.036	3.0	0.003	11.1
midwest	0.007	0.029	0.3	0.798	0.7
west	0.096	0.028	3.5	0.001	10.1
_cons	5.549	0.039	141.9	0.000	—
e_r2	0.629	0.010	61.8	0.000	—
e_N = 6,497					

— Not applicable.

Table A14: Regression-Based Estimates of Expected Percent Change in Monthly Earnings of 16- to 74-Year Old Employed Individuals, U.S., 2012/2014/2017 (Regression 2 with Numeracy Proficiency and Numeracy Skill Use at Work)

VARIABLES	COEF.	STD. ERR.	Z	P>Z	(ANTI-LOG OF COEFF.-1)*100
pv_numz	0.056	0.012	4.7	0.000	5.7
numworkz	0.056	0.009	6.2	0.000	5.8
numwork_missing	-0.126	0.020	-6.2	0.000	-11.8
male	0.146	0.016	9.3	0.000	15.7
hispanic	-0.026	0.026	-1.0	0.320	-2.6
black	0.009	0.024	0.4	0.717	0.9
asian_pi_other	0.016	0.041	0.4	0.685	1.7
foreign_born	0.037	0.022	1.7	0.098	3.8
no_hsdiploma	-0.114	0.030	-3.8	0.000	-10.8
some_college	0.053	0.021	2.5	0.011	5.4
bachelors_pl	0.277	0.028	10.1	0.000	31.9
public_nonprf_sector	0.012	0.019	0.6	0.536	1.2
disabled	-0.069	0.020	-3.4	0.001	-6.7
weekly_hours	0.036	0.001	39.7	0.000	3.7
experience	0.039	0.002	17.7	0.000	4.0
experiencesq	-0.001	0.000	-13.5	0.000	-0.1
skilled_occ	0.372	0.037	10.1	0.000	45.0
sem_skilledwc_occ	0.090	0.034	2.7	0.008	9.4
sem_skilledbc_occ	0.151	0.037	4.1	0.000	16.3
northeast	0.111	0.035	3.2	0.002	11.8
midwest	0.008	0.030	0.3	0.793	0.8
west	0.095	0.028	3.4	0.001	10.0
_cons	5.649	0.043	132.0	0.000	—
e_r2	0.634	0.010	61.7	0.000	—
e_N = 6,497					

— Not applicable.

Table A15: Regression-Based Estimates of Expected Percent Change in Monthly Earnings of 16- to 74-Year-Old Employed Individuals, U.S., 2012/2014/2017 (Regression 3 with Numeracy Proficiency and Numeracy Skill Use at Work/Occupation)

VARIABLES	COEF.	STD. ERR.	Z	P>Z	(ANTI-LOG OF COEFF.-1)*100
pv_numz	0.055	0.012	4.5	0.000	5.6
male	0.143	0.016	8.9	0.000	15.4
hispanic	-0.027	0.027	-1.0	0.318	-2.7
black	0.009	0.023	0.4	0.702	0.9
asian_pi_other	0.018	0.040	0.5	0.647	1.8
foreign_born	0.034	0.023	1.5	0.131	3.5
no_hsdiploma	-0.123	0.029	-4.2	0.000	-11.6
some_college	0.058	0.021	2.8	0.005	5.9
bachelors_pl	0.281	0.028	10.1	0.000	32.4
public_nonprf_sector	0.017	0.018	0.9	0.347	1.8
disabled	-0.071	0.020	-3.5	0.000	-6.9
weekly_hours	0.036	0.001	39.7	0.000	3.6
experience	0.039	0.002	17.7	0.000	3.9
experiencesq	-0.001	0.000	-13.4	0.000	-0.1
skilled_occ_numqrt1	0.378	0.054	7.0	0.000	46.0
skilled_occ_numqrt2	0.450	0.050	8.9	0.000	56.9
skilled_occ_numqrt3	0.492	0.051	9.6	0.000	63.6
skilled_occ_numqrt4	0.573	0.054	10.6	0.000	77.3
semskl_wc_occ_numqrt1	0.150	0.049	3.1	0.002	16.2
semskl_wc_occ_numqrt2	0.137	0.057	2.4	0.017	14.6
semskl_wc_occ_numqrt3	0.169	0.052	3.2	0.001	18.5
semskl_wc_occ_numqrt4	0.263	0.053	4.9	0.000	30.0
semskl_bc_occ_numqrt1	0.179	0.066	2.7	0.007	19.6
semskl_bc_occ_numqrt2	0.245	0.065	3.8	0.000	27.8
semskl_bc_occ_numqrt3	0.238	0.056	4.2	0.000	26.9
semskl_bc_occ_numqrt4	0.352	0.074	4.7	0.000	42.2
elementary_occ_numqrt2	0.016	0.095	0.2	0.868	1.6
elementary_occ_numqrt34	0.105	0.088	1.2	0.230	11.1
numwork_missing	0.101	0.046	2.2	0.027	10.6
northeast	0.108	0.035	3.1	0.002	11.4
midwest	0.009	0.030	0.3	0.768	0.9
west	0.093	0.028	3.3	0.001	9.8
_cons	5.557	0.056	100.0	0.000	—
e_r2	0.635	0.010	—	—	—
e_N = 6,497					

— Not applicable.

Appendix B: IRT-Based Reading and Numeracy Skill Use Scale

In PIAAC surveys, respondents are asked numbers of questions on different skill use at work and in everyday life (home). Questions about skill use at home were asked of all respondents 16 and older while questions about skill use at work were asked to those with work experience in the 12 months prior to the PIAAC survey date. To gauge the use of reading and numeracy skill use, respondents who were employed at the time of the PIAAC survey or in the 12 months prior to the PIAAC survey were asked about their engagement in the following reading and numeric tasks at work:

Questions about reading tasks:

1. Read directions or instructions?
2. Read letters, memos or e-mails?
3. Read articles in newspapers, magazines or newsletters?
4. Read articles in professional journals or scholarly publications?
5. Read books?
6. Read manuals or reference materials?
7. Read bills, invoices, bank statements or other financial statements?
8. Read diagrams, maps or schematics?

Questions about numeracy tasks:

1. Calculate prices, costs or budgets
2. Use of calculate fractions decimals or percentages
3. Use a calculator handheld or computer
4. Prepare charts graphs tables
5. Use simple algebra or formulas
6. Use more advance math or stat such as calculus, complex algebra, trig or regression

Respondents were asked to report the frequency with which they engaged in each one of these tasks from the following five-point Likert scale:

1 Never
2 Less than once a month
3 Less than once a week but at least once a month
4 At least once a week but not every day
5 Every day

Using responses to these questions, the PIAAC consortium and the OECD created skill use indices using IRT. One index represents an index of reading skill use at work and another index represents numeracy skill use at work, the generalized partial credit model and Warm's mean weighted likelihood estimation.[52] According to PIAAC technical documentation, the IRT-based scale on skill use was "constructed using item response theory. Item parameters were estimated using the generalized partial credit model (GPCM), and person-specific levels of skill use were estimated using weighted likelihood estimation (WLE). . . . Scale values were derived for all respondents who reported at least some activities in each of these domains. . . . 'Do not know' and 'refusal' responses were treated as missing."

The PIAAC consortium and the OECD created indices for 13 different skill use domains. We have used two skill-use domains (reading and numeracy) in this paper. These indices are not anchored to the 1 to 5 Likert scale used to elicit responses on the survey. For example, to construct the reading at work IRT scale index, the PIAAC consortium used eight questions on the frequency of various reading activities at work. A single index (READWORK) was created from responses of these eight questions using IRT methodology. The READWORK variable thus constructed was continuous variable with score ranging from -0.9553 to 7.02084 with higher values representing more frequent use of reading skills at work. The other IRT-based skill use indices were created similarly.

In our analysis, we used the two skill use IRT-bases scales: use of reading skills at work (READWORK) and use of numeracy skills at work (NUMWORK). Table B1 displays unweighted frequency, mean, standard deviation, and minimum and maximums values of the two IRT-based scales used in our analysis. Table B2 presents the mean, standard deviation, minimum values and maximum values for the three IRT-based scales on reading and numeracy skill use at work. As displayed in table B2, the scales also have negative values.

Table B1: Frequency, Zero Values, Valid Skip, Missing Values of The Three IRT-Based Scales on Reading and Numeracy Skill Use at Work

	READWORK		NUMWORK	
ITEM	FREQ.	% DIST.	FREQ	% DIST.
Valid indices values	8,457	68.6	7,286	59.1
All zero response	677	5.5	1,848	15.0
Valid skip	3,019	24.5	3,019	24.5
Missing response	177	1.4	177	1.4
Total	12,330	100.0	12,330	100.0

Table B2: Mean, Standard Deviation, Minimum Value of Scale, and Maximum Value of Scale for Three IRT-Based Scales on Reading and Numeracy Skill Use at Work

STATISTIC	READWORK	NUMWORK
Mean value of scale	1.446	1.283
Std. deviation of scale	1.290	1.324
Min. value of scale	-0.95553	-0.09020
Max. value of scale	7.02084	6.04990

As shown in Table B1, there were missing and zero values of IRT-based scales. For our analysis, we assigned 0 value to the following categories in the scales:

- "do not know" and "refusal"
- "examinees who responded in the lowest category for each item on a given scale did not receive scores on that particular scale"
- "examinees with fewer than three responses to items on a given scale did not receive scores"

The analysis of quartiles of IRT-based scale indices presented in descriptive section of the report excluded 0 values but included negative scale values. In regression analysis, we created a dummy variable representing missing index to represent these groups of respondents. In regression analysis of this report, we also created interaction variables of proficiency scores and IRT-based skill use scales. For ease of interpretation, we standardized the literacy and numeracy scales of the entire U.S. PIAAC sample to have a mean of 0 and a standard deviation of 1. According to PIAAC technical documentation, the PIAAC consortium created IRT-based skill use scales with a mean of 1 and a standard deviation of 2. We further standardized IRT-based reading and numeracy skill use scales at work to have a mean of 0 and a standard deviation of 1. Findings of literacy and numeracy skills and interaction variables in the report are based on 10 plausible scores and standard errors include both sampling and measurement errors.

Quartiles of Skill Use

In our analysis, we have created quartiles of reading and numeric skill use at work indices. As mentioned previously, these quartiles excluded 0 scale value but included negative scale values. The skill use quartiles are weighted quartiles generated using final PIAAC data sample weight (SFPWT0). Table B3 displays weighted, unweighted, mean, standard deviation, and minimum and maximum values of quartiles of reading and numeric skill use at work indices.

Table B3: Quartiles of Reading Skill Use Scale at Work and Numeracy Skill Use Scale at Work and Their Mean, Standard Deviation, Minimum and Maximum Values, U.S., PIAAC 2012-2014-2017 (Restricted to Regression Universe)

QUARTILE	UNWEIGHTED *N*	WEIGHTED *N*	MEAN VALUE OF INDEX	STANDARD DEVIATION	MIN. VALUE	MAX. VALUE
READWORK Quartile						
Lowest Quartile	1,627	32,294,424	1.035	0.533	-0.956	1.617
Second Quartile	1,572	32,265,654	1.896	0.148	1.618	2.153
Third Quartile	1,541	32,280,582	2.422	0.164	2.153	2.729
Highest Quartile	1,498	32,253,019	3.406	0.784	2.729	7.021
NUMWORK Quartile						
Lowest Quartile	1,417	28,446,285	0.990	0.436	-0.090	1.547
Second Quartile	1,366	28,103,583	1.878	0.172	1.551	2.142
Third Quartile	1,326	28,672,670	2.453	0.188	2.142	2.845
Highest Quartile	1,355	27,766,486	3.561	0.634	2.848	6.050

NOTE: The quartiles exclude 0 values of indices but include negative values.

Appendix C: Details on PIAAC Proficiency Levels for Literacy and Numeracy Scales

Table C1: Score Boundaries and Task Descriptions for PIAAC Proficiency Levels on the Literacy Scale[53]

LITERACY PROFICIENCY LEVEL AND SCORE BOUNDARIES	LITERACY TASK DESCRIPTION
below level 1 (0 to 175)	The tasks at this level require the respondent to read brief texts on familiar topics to locate a single piece of specific information. Only basic vocabulary knowledge is required, and the reader is not required to understand the structure of sentences or paragraphs or make use of other text features. There is seldom any competing information in the text and the requested information is identical in form to information in the question or directive. While the texts can be continuous, the information can be located as if the text were noncontinuous. Tasks below Level 1 do not make use of any features specific to digital texts.
level 1 (176 to 225)	Most of the tasks at this level require the respondent to read relatively short digital or print continuous, noncontinuous or mixed texts to locate a single piece of information which is identical to or synonymous with the information given in the question or directive. Some tasks may require the respondent to enter personal information into a document, in the case of some noncontinuous texts. Little, if any, competing information is present. Some tasks may require simple cycling through more than one piece of information. Knowledge and skill in recognizing basic vocabulary, evaluating the meaning of sentences, and reading of paragraph text is expected.
level 2 (226 to 275)	At this level, the complexity of text increases. The medium of texts may be digital or printed, and texts may comprise continuous, noncontinuous or mixed types. Tasks in this level require respondents to make matches between the text and information, and may require paraphrase or low-level inferences. Some competing pieces of information may be present. Some tasks require the respondent to • cycle through or integrate two or more pieces of information based on criteria, • compare and contrast or reason about information requested in the question, or • navigate within digital texts to access and identify information from various parts of a document.
level 3 (276 to 325)	Texts at this level are often dense or lengthy, including continuous, noncontinuous, mixed or multiple pages. Understanding text and rhetorical structures become more central to successfully completing tasks, especially in navigation of complex digital texts. Tasks require the respondent to identify, interpret or evaluate one or more pieces of information and often require varying levels of inferencing. Many tasks require the respondent construct meaning across larger chunks of text or perform multistep operations in order to identify and formulate responses. Often tasks also demand that the respondent disregard irrelevant or inappropriate text content to answer accurately. Competing information is often present, but it is not more prominent than the correct information.
level 4 (326 to 375)	Tasks at this level often require respondents to perform multiple-step operations to integrate, interpret, or synthesize information from complex or lengthy continuous, noncontinuous, mixed, or multiple type texts. Complex inferences and application of background knowledge may be needed to perform successfully. Many tasks require identifying and understanding one or more specific, noncentral ideas in the text in order to interpret or evaluate subtle evidence claim or persuasive discourse relationships. Conditional information is frequently present in tasks at this level and must be taken into consideration by the respondent. Competing information is present and sometimes seemingly as prominent as correct information.
level 5 (376 to 500)	At this level, tasks may require the respondent to search for and integrate information across multiple, dense texts; construct syntheses of similar and contrasting ideas or points of view; or evaluate evidence-based arguments. Application and evaluation of logical and conceptual models of ideas may be required to accomplish tasks. Evaluating reliability of evidentiary sources and selecting key information is frequently a key requirement. Tasks often require respondents to be aware of subtle, rhetorical cues and to make high-level inferences or use specialized background knowledge.

Table C2: Score Boundaries and Task Descriptions for PIAAC Proficiency Levels on the Numeracy Scale[54]

NUMERACY PROFICIENCY LEVEL AND SCORE BOUNDARIES	NUMERACY TASK DESCRIPTION
below level 1 (0 to 175)	Tasks at this level are set in concrete, familiar contexts where the mathematical content is explicit with little or no text or distractors and that require only simple processes such as counting, sorting, performing basic arithmetic operations with whole numbers or money, or recognizing common spatial representations.
level 1 (176 to 225)	Tasks in this level require the respondent to carry out basic mathematical processes in common, concrete contexts where the mathematical content is explicit with little text and minimal distractors. Tasks usually require simple one-step or two-step processes involving, for example, performing basic arithmetic operations; understanding simple percents such as 50%; or locating, identifying and using elements of simple or common graphical or spatial representations.
level 2 (226 to 275)	Tasks in this level require the respondent to identify and act upon mathematical information and ideas embedded in a range of common contexts where the mathematical content is fairly explicit or visual with relatively few distractors. Tasks tend to require the application of two or more steps or processes involving, for example, calculation with whole numbers and common decimals, percents and fractions; simple measurement and spatial representation; estimation; and interpretation of relatively simple data and statistics in texts, tables and graphs.
level 3 (276 to 325)	Tasks in this level require the respondent to understand mathematical information which may be less explicit, embedded in contexts that are not always familiar, and represented in more complex ways. Tasks require several steps and may involve the choice of problem-solving strategies and relevant processes. Tasks tend to require the application of, for example, number sense and spatial sense; recognizing and working with mathematical relationships, patterns, and proportions expressed in verbal or numerical form; and interpretation and basic analysis of data and statistics in texts, tables and graphs.
level 4 (326 to 375)	Tasks in this level require the respondent to understand a broad range of mathematical information that may be complex, abstract or embedded in unfamiliar contexts. These tasks involve undertaking multiple steps and choosing relevant problem-solving strategies and processes. Tasks tend to require analysis and more complex reasoning about, for example, quantities and data; statistics and chance; spatial relationships; change; proportions; and formulas. Tasks in this level may also require comprehending arguments or communicating well-reasoned explanations for answers or choices.
level 5 (376 to 500)	Tasks in this level require the respondent to understand complex representations and abstract and formal mathematical and statistical ideas, possibly embedded in complex texts. Respondents may have to integrate multiple types of mathematical information where considerable translation or interpretation is required; draw inferences; develop or work with mathematical arguments or models; and justify, evaluate and critically reflect upon solutions or choices.

Appendix D: Skill-Based Classification of PIAAC Occupations

Skilled occupations:

"1"	"Managers"
"11"	"Chief executives, senior officials and legislators"
"12"	"Administrative and commercial managers"
"13"	"Production and specialised services managers"
"14"	"Hospitality, retail and other services managers"
"2"	"Professionals"
"21"	"Science and engineering professionals"
"22"	"Health professionals"
"23"	"Teaching professionals"
"24"	"Business and administration professionals"
"25"	"Information and communications technology professionals"
"26"	"Legal, social and cultural professionals"
"3"	"Technicians and associate professionals"
"31"	"Science and engineering associate professionals"
"32"	"Health associate professionals"
"33"	"Business and administration associate professionals"
"34"	"Legal, social, cultural and related associate professionals"
"35"	"Information and communications technicians"

Semiskilled white-collar occupations:

"4"	"Clerical support workers"
"41"	"General and keyboard clerks"
"42"	"Customer services clerks"
"43"	"Numerical and material recording clerks"
"44"	"Other clerical support workers"
"5"	"Service and sales workers"
"51"	"Personal service workers"
"52"	"Sales workers"
"53"	"Personal care workers"
"54"	"Protective services workers"

Semiskilled blue-collar occupations:

"6" "Skilled agricultural, forestry and fishery workers"
"61" "Market-oriented skilled agricultural workers"
"62" "Market-oriented skilled forestry, fishery and hunting workers"
"63" "Subsistence farmers, fishers, hunters and gatherers"
"7" "Craft and related trades workers"
"71" "Building and related trades workers, excluding electricians"
"72" "Metal, machinery and related trades workers"
"73" "Handicraft and printing workers"
"74" "Electrical and electronic trades workers"
"75" "Food processing, wood working, garment and other craft and related trades
"8" "Plant and machine operators, and assemblers"
"81" "Stationary plant and machine operators"
"82" "Assemblers"
"83" "Drivers and mobile plant operators"

Elementary occupations:

"9" "Elementary occupations"
"91" "Cleaners and helpers"
"92" "Agricultural, forestry and fishery labourers"
"93" "Labourers in mining, construction, manufacturing and transport"
"94" "Food preparation assistants"
"95" "Street and related sales and service workers"
"96" "Refuse workers and other elementary workers"

Appendix E: Definitions of Variables in Earnings Regressions

Dependent variable:

lnearns = natural log of monthly earnings of all workers, 16-74

Independent variables:

INDIVIDUAL LITERACY AND NUMERACY SCORE

PVlit = continuous standardized literacy proficiency score of 16 and older persons in PIAAC survey

PVnum = continuous standardized numeracy proficiency score of 16 and older persons in PIAAC survey

INDIVIDUAL READING AT WORK AND NUMERACY USE AT WORK

readworkz = continuous standardized reading skill use at work scales score of workers in PIAAC survey

readwork_missing = if reading skill use at work scales score of workers was missing in PIAAC survey

numworkz = continuous standardized numeracy skill use at work scales score of workers in PIAAC survey

numwork_missing = if numeric use skill use at work scales score of workers was missing in PIAAC survey

GENDER

Base group is female

male = a dichotomous gender variable
= 1, if male
= 0, if female

RACE-ETHNICITY

Base group is White

hispanic = a dichotomous race-ethnicity variable
= 1, if Hispanic
= 0, if else

black = a dichotomous race-ethnicity variable
= 1, if Black
= 0, if else

asian_pi_races = a dichotomous race-ethnicity variable
= 1, if Asian/Pacific Islanders/all "other" races
= 0, if else

NATIVITY STATUS

Base group is native-born

foreign_born = a dichotomous nativity status variable
= 1, if foreign-born
= 0, if native-born

EDUCATIONAL ATTAINMENT

Base group is with a high school diploma

no_hsdiploma = a dichotomous educational attainment variable
= 1, if high school diploma or below
= 0, if else

some_college = a dichotomous educational attainment variable
= 1, if some years of college, certification, or associate degree
= 0, if else

bachelors_pl = a dichotomous educational attainment variable
= 1, if Bachelor's or higher degree
= 0, if else

SECTOR OF EMPLOYMENT

Base group is private sector

public_nonprf_sector = a dichotomous sector of work variable
= 1, if worked in public or non-profit sector
= 0, if else

DISABILITY STATUS

Base group is non-disabled

disabled = a dichotomous disability status variable
= 1, if with disabilities (difficulty seeing print, hearing conversation, or diagnosed with a learning disability)
= 0, if else

WEEKLY HOURS OF WORK

weekly_hours = continuous weekly hours of work

YEARS OF WORK EXPERIENCE

experience = continuous years of actual work experience

experience_sq = continuous years of actual work experience squared

OCCUPATION OF WORKERS

Base group is elementary occupation

skilled_occ = a dichotomous skill-based occupation variable
= 1, if skilled occupation
= 0, if else

sem_skilledwc_occ = a dichotomous skill-based white-collar occupation variable
= 1, if semiskilled white-collar occupation
= 0, if else

sem_skilledbc_occ = a dichotomous skill-based blue-collar occupation variable
= 1, if semiskilled blue-collar occupation
= 0, if else

INTERACTION BETWEEN READING SKILL USE AT WORK INDEX QUARTILES AND SKILLED-BASED OCCUPATIONS

Base group is workers in the lowest quartile of reading skill use at work in elementary occupations

skilled_occ_rdqrt1 = a dichotomous skill-based occupation variable *dichotomous lowest quartile of reading skill use at work index
= 1, if workers in skilled occupation whose reading skill use at work is in the lowest quartile
= 0, if else

skilled_occ_rdqrt2 = a dichotomous skill-based occupation variable *dichotomous second quartile of reading skill use at work index
= 1, if workers in skilled occupation whose reading skill use at work is in the second quartile
= 0, if else

skilled_occ_rdqrt3 = a dichotomous skill-based occupation variable *dichotomous third quartile of reading skill use at work index
= 1, if workers in skilled occupation whose reading skill use at work is in the third quartile
= 0, if else

skilled_occ_rdqrt4 = a dichotomous skill-based occupation variable *dichotomous highest quartile of reading skill use at work index
= 1, if workers in skilled occupation whose reading skill use at work is in the highest quartile
= 0, if else

semskl_wc_occ_rdqrt1 = a dichotomous semiskilled white-collar occupation variable * dichotomous lowest quartile of reading skill use at work index
= 1, if workers in semiskilled white-collar occupation whose reading skill use at work is in the lowest quartile
= 0, if else

semskl_wc_occ_rdqrt2 = a dichotomous semiskilled white-collar occupation variable * dichotomous second quartile of reading skill use at work index
= 1, if workers in semiskilled white-collar occupation whose reading skill use at work is in the second quartile
= 0, if else

semskl_wc_occ_rdqrt3 = a dichotomous semiskilled white-collar occupation variable * dichotomous third quartile of reading skill use at work index
= 1, if workers in semiskilled white-collar occupation whose reading skill use at work is in the third quartile
= 0, if else

semskl_wc_occ_rdqrt4 = a dichotomous semiskilled white-collar occupation variable * dichotomous highest quartile of reading skill use at work index
= 1, if workers in semiskilled white-collar occupation whose reading skill use at work is in the highest quartile
= 0, if else

semskl_bc_occ_rdqrt1 = a dichotomous semiskilled blue-collar occupation variable * dichotomous lowest quartile of reading skill use at work index
= 1, if workers in semiskilled blue-collar occupation whose reading skill use at work is in the lowest quartile
= 0, if else

semskl_bc_occ_rdqrt2 = a dichotomous semiskilled blue-collar occupation variable * dichotomous lowest quartile of reading skill use at work index
= 1, if workers in semiskilled blue-collar occupation whose reading skill use at work is in the second quartile
= 0, if else

semskl_bc_occ_rdqrt3 = a dichotomous semiskilled blue-collar occupation variable * dichotomous third quartile of reading skill use at work index
= 1, if workers in semiskilled blue-collar occupation whose reading skill use at work is in the third quartile
= 0, if else

semskl_bc_occ_rdqrt4 = a dichotomous semiskilled blue-collar occupation variable * dichotomous highest quartile of reading skill use at work index
= 1, if workers in semiskilled blue-collar occupation whose reading skill use at work is in the highest quartile
= 0, if else

elementary_occ_rdqrt2= a dichotomous elementary occupation variable * dichotomous second quartile of reading skill use at work index
= 1, if workers in elementary occupation whose reading skill use at work is in the second quartile
= 0, if else

elementary_occ_rdqrt34= a dichotomous elementary occupation variable * dichotomous third/highest quartile of reading skill use at work index

= 1, if workers in elementary occupation whose reading skill use at work is in the third/highest quartile

= 0, if else

INTERACTION BETWEEN NUMERACY SKILL USE AT WORK INDEX QUARTILES AND SKILLED BASE OCCUPATIONS

Base group is workers in the lowest quartile of numeracy skill use at work in elementary occupations

skilled_occ_numqrt1 = a dichotomous skill-based occupation variable *dichotomous lowest quartile of numeracy skill use at work index

= 1, if workers in skilled occupation whose numeracy skill use at work is in the lowest quartile

= 0, if else

skilled_occ_numqrt2 = a dichotomous skill-based occupation variable *dichotomous second quartile of numeracy skill use at work index

= 1, if workers in skilled occupation whose numeracy skill use at work is in the second quartile

= 0, if else

skilled_occ_numqrt3 = a dichotomous skill-based occupation variable *dichotomous third quartile of numeracy skill use at work index

= 1, if workers in skilled occupation whose numeracy skill use at work is in the third quartile

= 0, if else

skilled_occ_numqrt4 = a dichotomous skill-based occupation variable *dichotomous highest quartile of numeracy skill use at work index

= 1, if workers in skilled occupation whose numeracy skill use at work is in the highest quartile

= 0, if else

semskl_wc_occ_numqrt1 = a dichotomous semiskilled white-collar occupation variable * dichotomous lowest quartile of numeracy skill use at work index

= 1, if workers in semiskilled white-collar occupation whose numeracy skill use at work is in the lowest quartile

= 0, if else

semskl_wc_occ_numqrt2 = a dichotomous semiskilled white-collar occupation variable * dichotomous second quartile of numeracy skill use at work index
= 1, if workers in semiskilled white-collar occupation whose numeracy skill use at work is in the second quartile
= 0, if else

semskl_wc_occ_numqrt3 = a dichotomous semiskilled white-collar occupation variable * dichotomous third quartile of numeracy skill use at work index
= 1, if workers in semiskilled white-collar occupation whose numeracy skill use at work is in the third quartile
= 0, if else

semskl_wc_occ_numqrt4 = a dichotomous semiskilled white-collar occupation variable * dichotomous highest quartile of numeracy skill use at work index
= 1, if workers in semiskilled white-collar occupation whose numeracy skill use at work is in the highest quartile
= 0, if else

semskl_bc_occ_numqrt1 = a dichotomous semiskilled blue-collar occupation variable * dichotomous lowest quartile of numeracy skill use at work index
= 1, if workers in semiskilled blue-collar occupation whose numeracy skill use at work is in the lowest quartile
= 0, if else

semskl_bc_occ_numqrt2 = a dichotomous semiskilled blue-collar occupation variable * dichotomous lowest quartile of numeracy skill use at work index
= 1, if workers in semiskilled blue-collar occupation whose numeracy skill use at work is in the second quartile
= 0, if else

semskl_bc_occ_numqrt3 = a dichotomous semiskilled blue-collar occupation variable * dichotomous third quartile of numeracy skill use at work index
= 1, if workers in semiskilled blue-collar occupation whose numeracy skill use at work is in the third quartile
= 0, if else

semskl_bc_occ_numqrt4 = a dichotomous semiskilled blue-collar occupation variable * dichotomous highest quartile of numeracy skill use at work index
= 1, if workers in semiskilled blue-collar occupation whose numeracy skill use at work is in the highest quartile
= 0, if else

elementary_occ_numqrt2= a dichotomous elementary occupation variable * dichotomous second quartile of numeracy skill use at work index
= 1, if workers in elementary occupation whose numeracy skill use at work is in the second quartile
= 0, if else

elementary_occ_numqrt34= a dichotomous elementary occupation variable * dichotomous third/highest quartile of numeracy skill use at work index
= 1, if workers in elementary occupation whose numeracy skill use at work is in the third/highest quartile
= 0, if else

REGION OF RESIDENCE OF WORKER

Base group is South region

northeast = a dichotomous region of residence variable
= 1, if region of residence was Northeast region
= 0, if else

midwest = a dichotomous region of residence variable
= 1, if region of residence was Midwest region
= 0, if else

west = a dichotomous region of residence variable
= 1, if region of residence was West region
= 0, if else

About the Authors

Neeta Fogg is an economist at the Center for Labor Markets and Policy (CLMP) at Drexel University. At Drexel, she has led net impact studies of workforce development programs and school-to-work and school-to-college program initiatives. She has conducted longitudinal research of Philadelphia high school graduates and been deeply engaged in the analysis of the labor market impact of literacy and numeracy skills in the United States.

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Irwin Kirsch is the Ralph Tyler Chair in Large Scale Assessment and director of the Center for Global Assessment at ETS in Princeton, NJ. In his role as director of the center, he oversees several teams of research scientists, assessment designers, and platform developers who are responsible for the development, management, and implementation of large-scale national and international assessments. Over the course of his career, Dr. Kirsch has worked in close collaboration with a number of state, national, and international organizations including the World Bank, UNESCO, the International Association for the Evaluation of Educational Achievement, and the Organisation for Economic Co-operation and Development where he currently has responsibility for the development and conduct of the two largest international assessments that provide policy makers and key stakeholders with national and international comparative data on literacy and workforce preparedness – PIAAC and PISA. In addition to his assessment work, Dr. Kirsch is a member of the ETS research management team, serves on the board of a nonprofit literacy organization, and acts as a reviewer for several journals. He has published numerous research articles and book chapters dealing with issues around designing, developing, and interpreting cognitive-based scales and has written a number of policy reports using large-scale assessment data that focus on the growing importance of skills and their connections to life outcomes.

Anita M. Sands is a lead policy researcher and author in the ETS Center for Research on Human Capital & Education. Her published work covers education equity, economic opportunity, racial and economic segregation, concentrated poverty, research methodology, and program evaluations. Sands has coauthored numerous policy reports for the Center including most recently *Opportunity Across the States* (2021) and *Buttressing the Middle: A Case for Reskilling and Upskilling America's Middle-Skill Workers in the 21st Century* (2021). Prior to joining ETS, Sands taught in the Department of Sociology at Rider University and owned a consulting firm where she directed projects to address racial and economic segregation, poverty, and land-use policy inequities. Sands earned her MA and is ABD from the Department of Sociology PhD program at Temple University.

Endnotes

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16 Nicolas Jonas, *Numeracy Practices and Numeracy Skills Among Adults,* OECD Education Working Paper No. 177 (Paris, France: OECD, 2018), https://www.oecd.org/officialdocuments/publicdisplaydocumentpdf/?cote=EDU/WKP(2018)13&docLanguage=En.

17 The paper focuses on just reading skill use at work and literacy proficiencies. Findings from our analysis of the connections between earnings of workers and their use of numeracy skills at work and their numeracy proficiencies are presented in Appendix A.

18 For a review of the key theoretical underpinnings of human capital earnings functions, see: Jacob Mincer, *Schooling, Experience, and Earnings* (New York: National Bureau of Economic Research, 1974), and Solomon W. Polachek and W. Stanley Siebert, *The Economics of Earnings* (Cambridge, UK: Cambridge University Press, 1993).

19 All tabulations in the paper are replicated in Appendix A with numeracy skill use in place of reading skill use and numeracy proficiencies in place of literacy proficiencies. Our analysis on the use of numeracy skills at work and numeracy proficiencies and earnings are very similar to reading/literacy skills use and skills and earnings.

20 In this paper, we have used quartiles of the skill use index to represent the extent of use of reading skills at work. These quartiles classify workers into four equally sized groups based on their rank of the value of their skill use index. Each quartile contains one-quarter of the 16- to 74-year-old workers included in this paper. Values of the reading skill use index at the 25th, 50th, and 75th percentiles (1.618, 2.153, and 2.729) represent the boundaries of the four quartiles. Appendix B contains details on the reading and numeric tasks included on the PIAAC questionnaire, the construction of skill use indices by the PIAAC consortium and OECD, and quartiles of reading and numeric skill use indices.

21 Details on PIAAC proficiency levels for literacy and numeracy scales are presented in Appendix C.

22 The mean literacy proficiency score of all adults surveyed during PIAAC 2012/2014/2017 surveys was 269, and the standard deviation was 50.5. The mean numeracy score was 256, and standard deviation was 56.5.

23 Madeline J. Goodman, Anita M. Sands, and Richard J. Coley, *America's Skills Challenge: Millennials and the Future* (Princeton, NJ: ETS, 2015), https://files.eric.ed.gov/fulltext/ED589564.pdf; "Asking the Experts: Q&A with Irwin Kirsch," *The Buzz: A PIAAC Update*, September 2021, https://mailchi.mp/01701cf45a55/piaac-buzz-september-2021?e=81cc09c61b.

24 We found a similar relationship between numeracy skills and the use of numeracy tasks at work; see Appendix A.

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26 OECD, *Skills Matter*.

27 Indeed, much of the concern about lagging U.S. performance on international mathematics tests is focused on the central role that numeracy plays in STEM occupational requirements. See Boris Granovskiy, *Science, Technology, Engineering and Mathematics (STEM) Education: An Overview* (Washington, DC: Congressional Research Service, June 2018), https://sgp.fas.org/crs/misc/R45223.pdf.

28 Appendix D contains a detailed list of occupations in each of the four PIAAC skills-based occupational groups.

29 Details on PIAAC proficiency levels for literacy and numeracy scales are presented in Appendix C.

30 The mean literacy proficiency score of all adults surveyed during PIAAC 2012/2014/2017 surveys was 269, and the standard deviation was 50.5. The mean numeracy score was 256, and standard deviation was 56.5.

31 Sample size limitation led to a combining of the third quartile and the highest quartile of reading skill use at work among elementary occupation workers.

32 Fogg et al., *Skills and Earnings in the Full-Time Labor Market*; Fogg et al., *Skills and Earnings of College Graduates*; Fogg et al., *Skills and Earnings in the Part-Time Labor Market*.

33 Fogg et al. , *Skills and Earnings in the Full-Time Labor Market.*

34 Fogg et al., *Skills and Earnings in the Part-Time Labor Market*.

35 Becker, *Human Capital*.

36 All earnings regressions presented in this section were also estimated with the same explanatory variables except with numeracy proficiencies (instead of literacy proficiencies) and the use of numeracy skills at work (instead of the use of reading skills at work). Findings from these (numeracy) earnings regressions are presented in Appendix A.

37 For a review of human capital earnings functions, see Mincer, *Schooling, Experience, and Earnings*; Polachek and Siebert, *The Economics of Earnings*; Jacob Mincer, "Investment in Human Capital and Personal Income Distribution," *Journal of Political Economy* 66, no. 4 (1958): 281–302.

38 Details about the IRT-based reading and numeracy skill use scales are presented in Appendix B.

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40 Fogg et al., *Skills and Earnings in the Full-Time Labor Market*; Fogg et al., *Skills and Earnings of College Graduates*.

41 Fogg et al., *Skills and Earnings in the Part-Time Labor Market*.

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45 The PIAAC measure of disability is not based on activities of daily living criteria. It is limited to persons who report a sensory limitation (hearing and vision) or a learning disability.

46 Estimated regression coefficients and their standard errors are presented in Appendix A.

47 Estimated regression coefficients and their standard errors are presented in Appendix A.

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50 Reder, *Adults' Engagement.*

51 Jonas, *Numeracy Practices*.

52 Kentaro Yamamoto, Lale Khorramdel, and Matthias von Davier, "Scaling PIAAC Cognitive Data," in *Technical Report of the Survey of Adult Skills (PIAAC)* (Paris, France: OECD, 2013), 406–438. https://www.oecd.org/site/piaac/_Technical%20Report_17OCT13.pdf

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