Vanguard

Vanguard Research:

Megatrends

The future of work

About the Megatrends series

Megatrends have accompanied humankind throughout history. From the Neolithic Revolution to the Information Age, innovation has been the catalyst for profound socioeconomic, cultural, and political transformation. The term "Megatrends" was popularized by author John Naisbitt, who was interested in the transformative forces that have a major impact on both businesses and societies, and thus the potential to change all areas of our personal and professional lives.

Vanguard's "Megatrends" is a research effort that investigates fundamental shifts in the global economic landscape that are likely to affect the financial services industry and broader society. A megatrend may bring market growth or destroy it, increase competition or add barriers to entry, and create threats or uncover opportunities. Exploring the long-term nature of massive shifts in technology, demographics, and globalization can help us better understand how such forces may shape future markets, individuals, and the investing landscape in the years ahead.

Vanguard Investment Strategy Group's Global Economics Team

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Megatrend: **The future of work**

- The accelerating pace of technological change has raised the specter of a future without work. Some researchers estimate that half the jobs in the U.S. labor market will vanish in the next decade. These projections reflect a confusion of tasks and jobs. Technology is automating some tasks, but most jobs are not disappearing. They are evolving.

- A job is the sum of its tasks. We examine the 41 work activities (tasks) that make up the nearly 1,000 occupations tracked by the U.S. Department of Labor. We group these tasks into three categories: basic, repetitive, and advanced or "uniquely human." Since 2000, the activities in every occupation have shifted from basic and repetitive tasks toward advanced tasks. We spend less time collecting data and more time solving problems.

- These trends produce a paradox. In the next decade, as the number of jobs focused on uniquely human tasks increases, we are likely to see both rising levels of automation and labor shortages. The key to closing this gap is education and training that cultivate three capabilities essential to the future of work: creative intelligence, technological acumen, and emotional intelligence.

Authors


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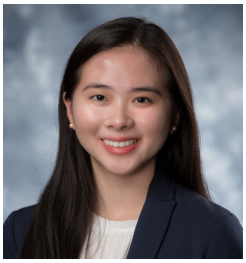
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In 1996, AT&T closed its last telephone operator center in New England. The Peabody, Massachusetts, office was a vestige of a national operation that once employed 40,000 people to provide directory assistance and connect calls through switchboards. "Years ago, you said your name," Rose DiMaggio Trela told *The New York Times* (Rimer, 1996). "You would say, 'AT&T, this is Rose, how may I help you?' It made it so personal."

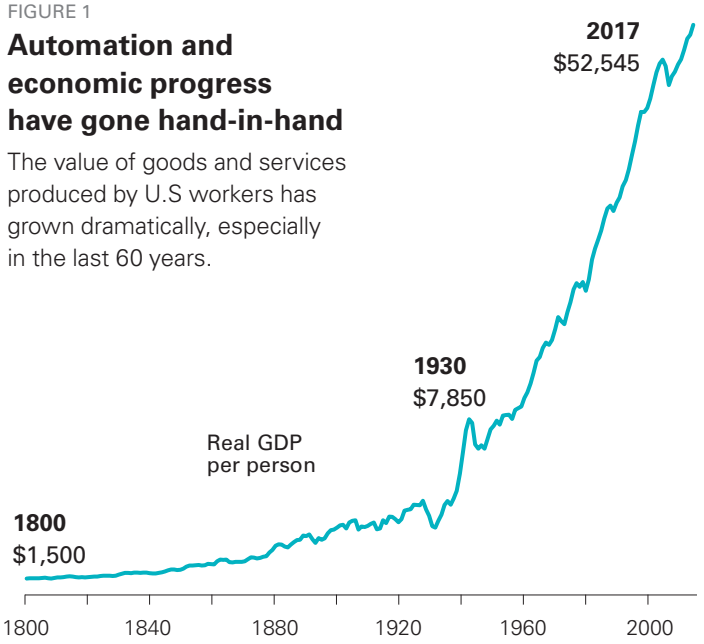
Roughly a century after Alexander Graham Bell patented the telephone, this personal touch and the job that enabled it became obsolete. "Mrs. Trela says she understands why people do not need her help anymore," *The Times* reported. "'It's the automation.'"

Mrs. Trela's experience is one chapter in a story about economic progress. Since 1800, as shown in **Figure 1**, technology-driven gains in U.S. labor productivity—the value of goods and services produced by an hour's work—have raised real per-capita income from $1,500 per year to about $53,000 in 2017. But her experience is also a story about economic anxiety.

FIGURE 1

Automation and economic progress have gone hand-in-hand

The value of goods and services produced by U.S workers has grown dramatically, especially in the last 60 years.



Sources: EH.net and Vanguard.

Automation: Is it different this time?

As we enter *The Second Machine Age* (Brynjolfsson and McAfee, 2014), that anxiety is rising. Advances in robotics, artificial intelligence, and digital technology have raised the specter of a future without work. In light of such remarkable technological advances, this paper aims to answer a simple question: Will there be more jobs ten years from now or fewer?

Our analysis suggests that there will be more. Experts are divided (Pew Research Center, 2014). The optimists acknowledge that while ever-smarter technology may displace certain types of work, technology has historically been a net creator of jobs. Over the past 200 years, the U.S. labor force's migration from the farm to the factory to the service sector has supported this view (Mokyr, 1990). Technology changes human labor but doesn't eliminate it.

The pessimists warn of a future of mass unemployment (Ford, 2015). Given the nature and speed of technological change, they foresee dismal prospects for an increasing number of jobs. Powerful technologies will displace workers not just in retail and manufacturing, but also in professions once thought immune to automation, including law, financial services, education, and medicine (Rotman, 2013). In the next decade, according to Oxford University estimates, 47% of U.S. employment will be at risk of automation (Frey and Osborne, 2013). In less-developed countries, the estimates are higher. Those figures might be 69% for India and 77% for China (Citibank, 2016).

We look at the U.S. Department of Labor (DOL) data that inform these estimates and reach a different conclusion. Jobs don't get automated away, tasks do. Jobs disappear only if they consist of a few repetitive and automatable tasks.

The roughly 1,000 occupations tracked by the DOL, weighted by the employment in each, consist of, on average, seven critically important tasks.[1] The mix of tasks has changed over time. In December 1903, when the Wright Brothers piloted the first flight from Kitty Hawk, North Carolina, "operating a flying aircraft" joined the task lexicon. In all jobs, the importance of repetitive tasks such as entering data has declined. The importance of uniquely human tasks such as interacting with the public has increased. We explore these historical changes to provide insight into the future of work.

1 Critically important tasks are those tasks that are assigned an importance score higher than 4 in the O*Net database where 1 is least important and 5 is most important. Specific details of the O*Net database, including its task taxonomy, can be found at https://www.onetcenter.org/.

Tasks, not jobs

Human employment has always been a race between the acquisition of skills and the development of technologies that render those skills obsolete. The future will be no different. But the race will be faster. The quickening pace reflects the exponential growth in computing power described by Moore's Law—Gordon Moore's 1965 observation that an integrated circuit's computing power per dollar could be expected to double every year. The most alarming employment projections assume that humans will no longer be able to keep up with ever faster machines.

Our analysis shows that pessimistic projections of mass unemployment rest upon three flawed assumptions:

1. that a job consists largely of a single task;
2. that technology is more often a substitute for than a complement to human labor;
3. that the constituent tasks of any job remain fixed in the face of technological innovation.

We evaluate work in a task-based framework that corrects for these flaws. Our model builds on task-based employment models such as those developed by Acemoglu and Restrepo (2017). Rather than treat jobs as indivisible units (as is done in Frey and Osborne, 2013), we model jobs as the sum of their component tasks, weighted by the importance of those tasks (see **Equation 1**).

Equation 1. What is a job?

$$Job = \sum_{i}^{n} task_{i,t} \; x \; weight_{i,t,}$$

Where

i=task category (basic, repetitive, human); t=time period

Over time, *Job* will most likely change as the relative importance, or $weight_{i,t,}$ of its tasks changes, but it won't necessarily disappear. This task-level exploration yields insight into recent changes in the nature of work; it helps us identify the tasks that are least susceptible to automation; and it suggests guiding principles for the education and training that will be critical for the future of work.

The building blocks of our analysis

Our analysis relies on the Occupational Information Network (O*Net), a database maintained by the DOL. The database includes information such as required education, wages, work activities, and work environment for the 966 occupations tracked by the DOL. "Economist" is an example of one occupation. Responsibilities include "conducting research, preparing reports or formulating plans to address economic problems related to the production and distribution of goods and services or monetary and fiscal policy."[2] O*Net summarizes the work of economists across all industries, from mining, to education, to finance. Our analysis uses the following occupation-level data:

- The 41 general work activities, or "tasks," commonly performed in every occupation.
- The importance score for each task in each occupation. Importance is ranked from 1 (least important) to 5 (most). The rankings are estimates, based on input from occupational experts or workers, of a task's contribution to the job's success.

We classify the 41 tasks into three categories of work: basic, repetitive, and human. Our approach is similar to that used by Autor et al. (2003) and, more recently, the McKinsey Global Institute (2017). By consolidating the 41 discrete tasks into categories that draw on similar physical, emotional, and cognitive capabilities, we create more useful and informative explanatory variables for our analysis.

Task classification is more art than science. Is "performing general physical activities" an advanced task, as it is when Serena Williams plays tennis? Or is it a repetitive task, as it is when a shipping clerk moves a package from the scale to the loading dock? (We classify it as "repetitive" to reflect the large number of shipping clerks and small number of professional athletes in the U.S. labor force.) The goal of this exercise is to identify the tasks that are most susceptible to automation. Researchers generally agree that these tasks include "a well-defined set of cognitive and manual activities that can be accomplished by following explicit rules" (Autor et al., 2003).

2 Source: https://www.onetonline.org/link/summary/19-3011.00.

Tasks: A taxonomy

Figure 2 presents our classification of tasks for today's global economy.[3] Basic tasks include "evaluating information to determine compliance with standards" and "documenting/recording information." Consider parking-enforcement workers. Among their responsibilities are to evaluate whether a vehicle is parked in a legal parking zone and to document any infractions. Basic tasks require little advanced training, although they may not be easily automatable.

Repetitive tasks include "controlling machines and processes" and "performing general physical activities." Think of the first assembly lines, with workers attaching windshields to Ford's Model Ts. As their name suggests, repetitive tasks are at the highest risk of automation because they follow simple steps that can be distilled into computer code.

Advanced tasks demand an adaptability to situation and circumstance that can't be codified. Examples include "thinking creatively" and "updating and using relevant knowledge." Of the 966 occupations in O*Net, "thinking creatively" is most important for poets and video game designers. Many advanced tasks also demand interpersonal skills—"coaching and developing others" and "resolving conflicts and negotiating with others." We call these tasks "uniquely human." In performing these tasks, humans have demonstrated an enduring comparative advantage over the machines.

FIGURE 2

Three categories of tasks make up all occupations

Basic

- Getting information
- Monitoring processes, materials, or surroundings
- Estimating the quantifiable characteristics of products, events, or information
- Processing information
- Evaluating information to determine compliance with standards
- Documenting/ recording information
- Communicating with supervisors, peers, or subordinates
- Communicating with persons outside the organization
- Staffing organizational units
- Monitoring and controlling resources

Repetitive

- Controlling machines and processes
- Handling and moving objects
- Operating vehicles, mechanized devices, or equipment
- Inspecting equipment, structures, or material
- Scheduling work and activities
- Performing administrative activities
- Analyzing data or information
- Performing general physical activities
- Drafting, laying out, and specifying technical devices, parts, and equipment

Uniquely human

- Identifying objects, actions, and events
- Repairing and maintaining mechanical equipment
- Repairing and maintaining electronic equipment
- Judging the qualities of things, services, or people
- Making decisions and solving problems
- Thinking creatively
- Updating and using relevant knowledge
- Developing objectives and strategies
- Interpreting the meaning of information for others
- Establishing and maintaining interpersonal relationships
- Assisting and caring for others
- Selling to or influencing others
- Resolving conflicts and negotiating with others
- Performing for or working directly with the public
- Developing and building teams
- Training and teaching others
- Guiding, directing, and motivating subordinates
- Coaching and developing others
- Providing consultation and advice to others
- Organizing, planning, and prioritizing work
- Interacting with computers
- Coordinating the work and activities of others

Sources: U.S. Department of Labor and Vanguard.

3 We emphasize that there is a medium-run horizon over which we are classifying our tasks. Over longer time periods (i.e., generations or centuries), certain tasks can follow a "life-cycle" pattern from advanced (i.e., when a task is introduced or sits at the frontier of technology), to more routine and widely used across multiple professions, to perhaps being done almost exclusively by a machine. Our task-based framework is intended to focus on the medium-run implications of technologies' impact on work over the next 10–20 years.

A subjective but sensible approach to task classification

Despite the subjective element in any task classification system, **Figure 3** suggests that our approach is reasonable. It displays the mean rank correlation for uniquely human, repetitive, and basic tasks. The rank correlation measures the similarity of the ordering of items across groups. In this case, the importance of tasks is sorted from most important to least across every occupation.

If "thinking creatively" is the fifth most important task in every job, for example, its rank correlation will be high (approaching 1). If the task has very different rankings in different jobs, its rank correlation will be low (approaching 0, or potentially less than 0).

We use rank correlation at the task level to assess our basic, repetitive, and uniquely human task classification. If we grouped the tasks reasonably, we should see a relatively higher mean rank correlation within each group. Figure 3 shows that our groupings meet this standard. The correlation within uniquely human tasks (0.54) is much higher than the category's correlation with repetitive (0.24) and basic (0.23). We see similar, though weaker, relationships with repetitive and basic tasks.

Rank correlation can also indicate complementarity among tasks. If tasks have similar importance scores, it's possible that the effectiveness of one depends on the performance of another, much as a left shoe is useful only with the matching right shoe. Consider nurses. Besides "assisting and caring for others," a nurse's responsibilities also include other uniquely human tasks such as "establishing and maintaining interpersonal relationships" with patients, "providing medical consultations," and "applying relevant knowledge" as the patients' conditions change. A nurse would not be effective without performing these four tasks.

On the flip side, the tasks in different categories can be thought of as "substitutes" for one another. Basic and repetitive tasks are less likely to be required when there is a high degree of importance placed on uniquely human tasks. The relatively low rank correlations between these groups and uniquely human tasks hint at this possibility.

FIGURE 3

Rank correlation matrix of task importance scores, mean by group

	Uniquely human	Repetitive	Basic
Uniquely human	0.54		
Repetitive	0.24	0.30	
Basic	0.23	0.22	0.37

Sources: Vanguard calculations, using data from the U.S. Department of Labor O*Net OnLine (2000–2015).

How jobs have changed

The DOL released the first "vintage" of O*Net in 2000. It has since made 33 updates to the data, most recently in 2018. We used big-data analytics to connect (or "cross-walk") these various O*Net vintages into a continuous panel of task-by-occupation-by-year data set. Over this period, the mix of tasks in every occupation has changed, as shown in **Figure 4**.

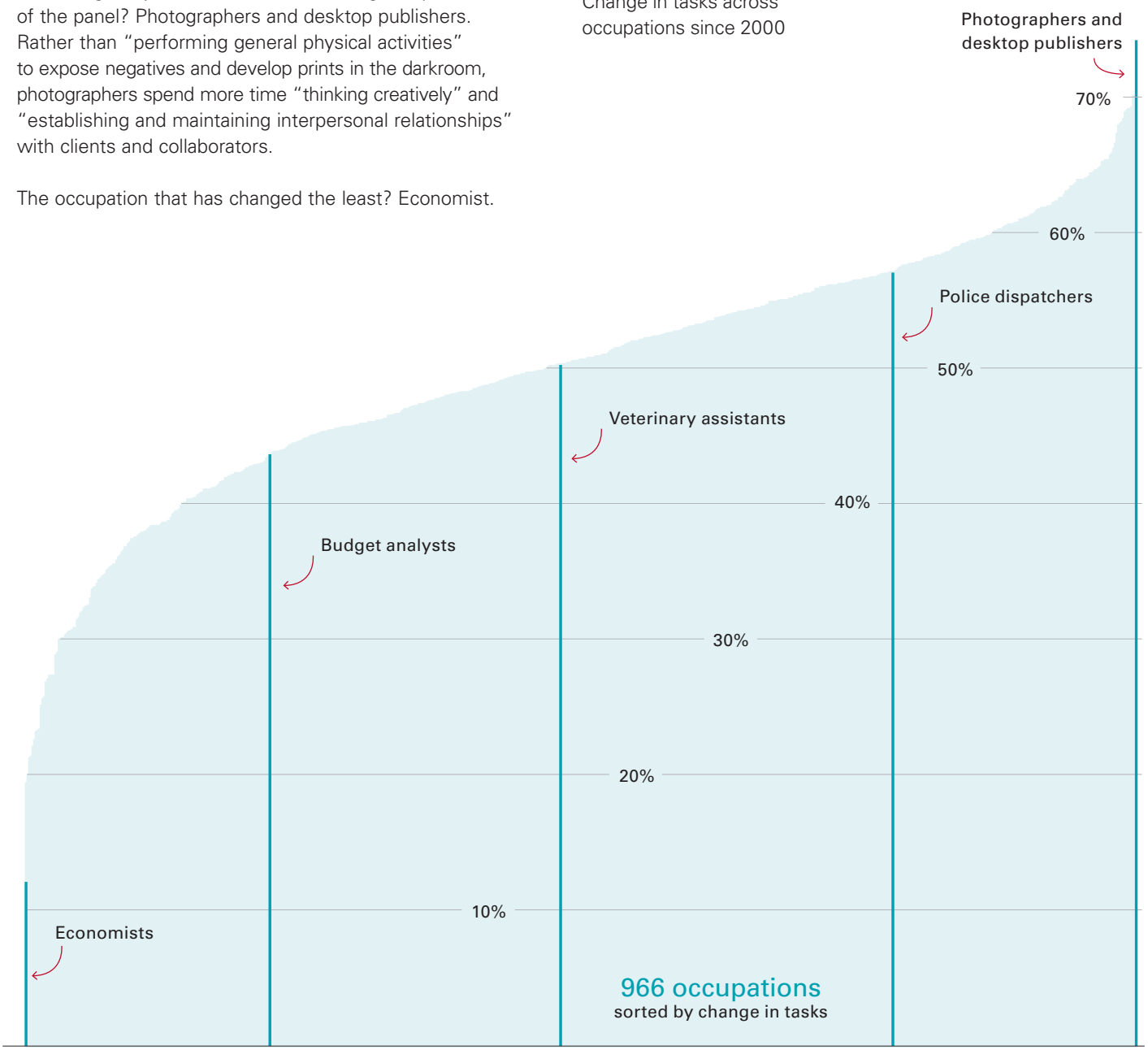
At the right side of the chart are jobs whose mix of tasks has changed by as much as 80%. The highest portion of the panel? Photographers and desktop publishers. Rather than "performing general physical activities" to expose negatives and develop prints in the darkroom, photographers spend more time "thinking creatively" and "establishing and maintaining interpersonal relationships" with clients and collaborators.

The occupation that has changed the least? Economist.

FIGURE 4

Changing tasks: Less rote, more human

Change in tasks across occupations since 2000



Notes: In this chart, we use Kendall rank correlation to determine the degree of similarity across the 41 tasks in each occupation based on the importance score of each task in the periods between 2000 and 2015. We then rank each occupation by its degree of change as measured by (1-rank correlation)%. The ranking proceeds from the occupation that experienced the least change to the one that experienced the greatest.

Sources: Vanguard calculations, using data from U.S. Department of Labor O*Net OnLine (2000–2015).

These changes have reduced the importance of repetitive tasks and increased the importance of uniquely human tasks.[4] This transformation has taken place in every occupation, across all wage levels, and in every part of the United States. **Figures 5** and **6** chart the changes by wage levels and geography.

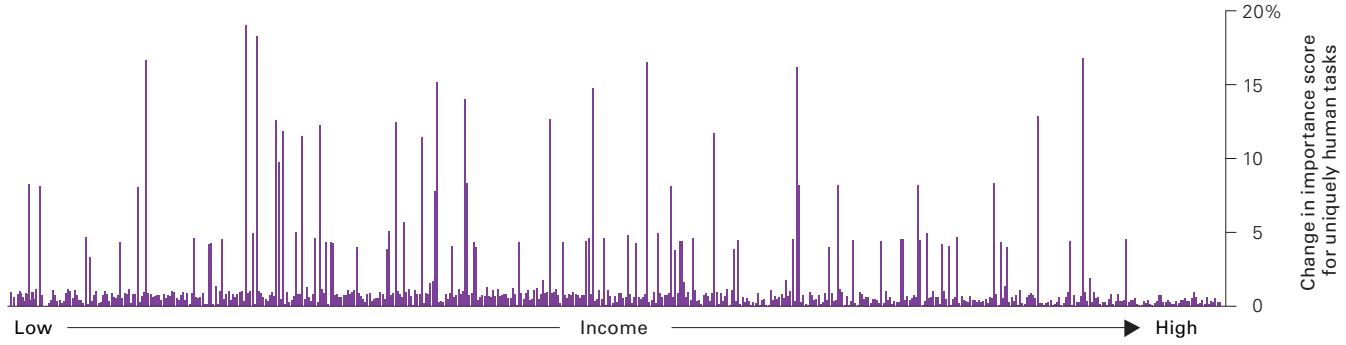
Figure 6 presents two job-level views of geographical employment. On the left, the highlighted states, including California and Massachusetts, represent more than 50% of the U.S. economy's technology jobs. This concentration might suggest that the "future of work" is unfolding in just a few locations. But a task-level view presents a more realistic picture of the ways in which jobs are changing in response to technological change.

The map on the right shows that job tasks are changing in every state. We highlighted all states because the measure of task change used in Figure 4, weighted by each state's mix of occupations, was at least 50% everywhere. A North Dakota "oil field roustabout" may not be a technology job, but as oil producers use drones and electronic monitors to inspect pipelines, the roustabout spends less time walking the lines and more time making decisions and solving problems.

FIGURE 5

The mix of tasks has changed across all income levels

Rising importance of uniquely human tasks

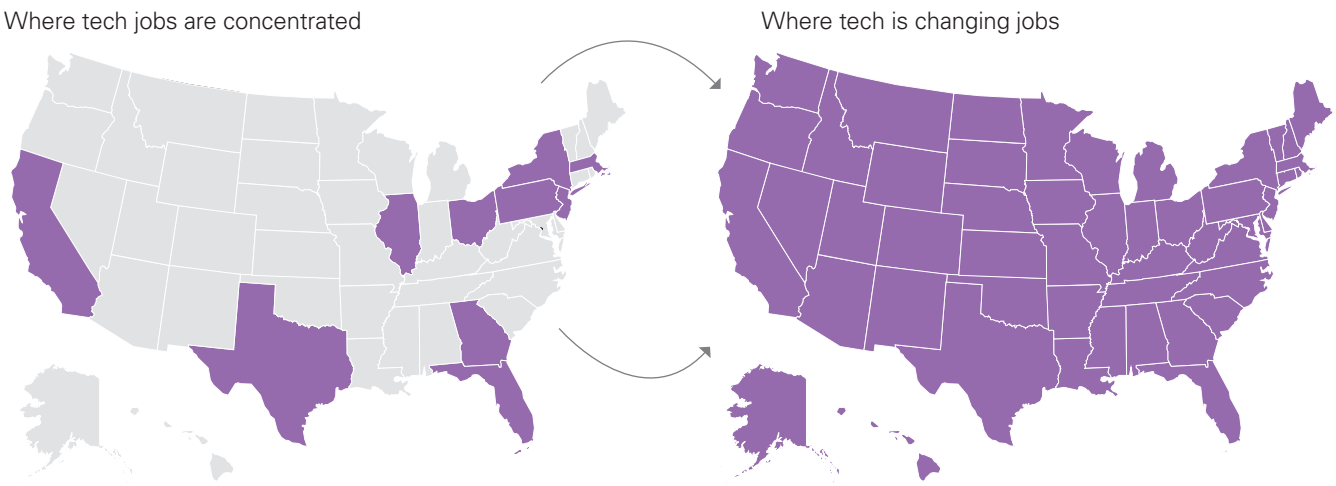


Notes: Bars on the x-axis represent the percentage increase in importance of advanced tasks, by occupation, ordered from left to right by income level. The sample includes occupations that have experienced a rise in advanced tasks between 0% and 20%. The small percentage of occupations that fell outside that range are not represented.

Sources: Vanguard calculations, using data from U.S. Department of Labor O*Net OnLine and U.S. Bureau of Labor Statistics.

FIGURE 6

It's not just Silicon Valley, Cambridge, and Austin. Work is changing everywhere.



Sources: Vanguard, using data from the U.S. Census Bureau American Community Survey and Department of Labor O*Net OnLine.

4 In rolling regressions of task importance on labor's contribution to growth in economic output, we observe a decline in the coefficients associated with repetitive activities and an increase in the coefficients associated with human activities.

The future of employment

Today, the U.S. labor force spends about 50% of its time on uniquely human tasks, up from just 30% in 2000. We use our analysis of the changes in job tasks in the 15 years through 2015 to project changes for the decade ahead. We perform regressions over two periods: 2003–2007 and 2010–2015. In both periods, we look at the relationship among tasks, technology, and labor's contribution to growth in economic output. (We exclude 2008–2009 to mitigate the bias in output statistics produced by the global recession.) The historical analysis yields three conclusions:

1. **Task mix is an indicator of labor's contribution to economic output.**[5] Before the financial crisis, repetitive and basic tasks made the largest marginal contributions to economic output. After the financial crisis, uniquely human tasks emerged as the most powerful engine of marginal output growth.
2. **The race is afoot.** We use a measure of technology's contribution to economic output to chart the race between human and machine. In repetitive tasks, the machines are outracing humans. In advanced tasks, humans are setting the pace.
3. **Technology is making humans more valuable.** As an industry's investment in technology increases, basic and repetitive tasks contribute less to economic output and uniquely human tasks contribute more.

1. Task mix is an indicator of labor's contribution to economic output

In our first regression, we look at the relationship among tasks and labor's contribution to output over time. This result is a quantitative confirmation of changes in the nature of work discussed earlier. Our model assumes that the higher the importance of a task in an occupation, the greater its contribution to economic output, meaning we weight the tasks in each occupation according to their relative importance. We detail the model in **Equation 2**. (See the Appendix for the regression coefficients associated with this and the other equations in our analysis.)

Equation 2. A task's contribution to economic output

$$Labor\ Contribution_{i,j,t} = \alpha + \beta_1 Basic_{i,j,t} + \beta_2 Repetitive_{i,j,t} + \beta_3\ Uniquely\ Human_{i,j,t} + \varepsilon_{i,j,t}$$

i=task; t = time period; and j = sector, which is made up of the different pairs of occupation and industry groups.

Where

$$Basic_{i,j,t} = \sum task\ importance_{Basic} * weights$$

is the average of the importance scores for basic, repetitive, or human tasks.

Similarly

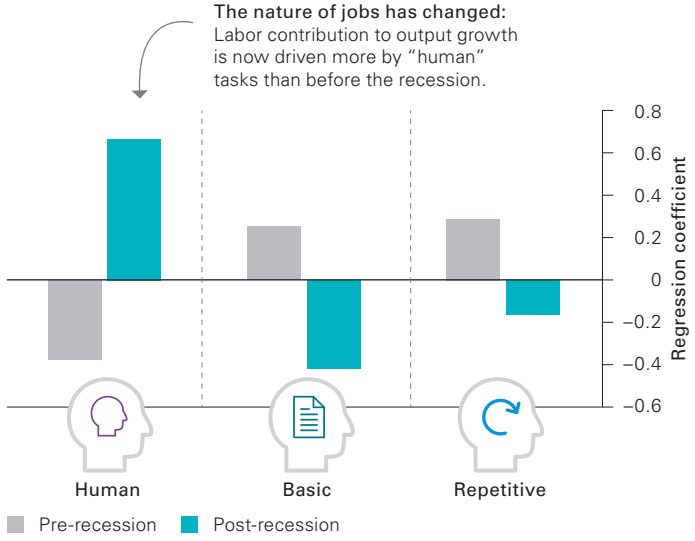
$$Repetitive_{i,j,t} = \sum task\ importance_{Rep} * weights$$

$$Human_{i,j,t} = \sum task\ importance_{Human} * weights$$

Before the financial crisis, as displayed in **Figure 7**, a 1 percentage-point increase in the importance of uniquely human tasks was associated with a 0.37 percentage-point reduction in labor contribution to output. In other words, as a job's mix of tasks shifted toward uniquely human tasks, this shift was associated with a decline in the job's contribution to economic output. After the financial crisis, the effect reversed: As a job's mix of tasks became more uniquely human, the occupation made a greater contribution to gross output. An increase

FIGURE 7

The tasks contributing to labor output have changed since the 2008–2009 recession



Notes: We regress basic, repetitive, and human task importance on contribution of IT capital to total output growth to get coefficients. The regression indicates the inverse relationship between human tasks and IT contribution across sectors in the economy. Refer to appendix equations (Models 1 and 2) for significance levels and exact coefficients.

Sources: Vanguard calculations, using data from U.S. Department of Labor O*Net OnLine, U.S. Bureau of Economic Analysis, and U.S. Bureau of Labor Statistics.

5 The U.S. Bureau of Economic Analysis in collaboration with the Bureau of Labor Statistics publishes the integrated industry-level production account data that allow us to trace the source of U.S. economic growth and the specific components—labor, capital, and so on—that contribute to this growth. In the first regression, we consider solely labor contribution to growth. In the second and third regressions, we consider the contributions of labor and technology investment. and third regressions, we consider the contributions of labor and technology investment.

in a job's mix of basic and repetitive activities, by contrast, is associated with a decline in its contribution to output.

These findings suggest that the recession accelerated the changes in work described in our analysis. This acceleration is consistent with macroeconomic research on the relationship between labor market shocks such as recessions and changes in lower- and middle-skill employment. As Foote and Ryan (2015) explain, "It is reasonable to speculate that middle-skill job matches, which have the least encouraging long-run prospects, would be the most quickly dissolved when a recession occurs."

Our task framework suggests a more optimistic interpretation: The financial exigencies created by the global recession both hastened the automation of basic and repetitive tasks and "uncovered" the value of uniquely human work. Some jobs disappeared, of course, but many evolved. There are 9.2 million more jobs today than in 2007.

Hershbein and Kahn (2017) offer some support for this interpretation. They analyze electronically posted job advertisements to document changes in occupational skill requirements since the Great Recession. Since the recession, technology has displaced many workers in routine-manual jobs. In routine-cognitive occupations such as clerical and administrative jobs, however, technology has emerged as a complement, and employment and wages in these jobs have increased modestly. According to Hershbein and Kahn, "Rather than disappearing entirely, surviving routine-cognitive occupations appear to have become both relatively higher-skilled and more productive."

2. The race is afoot

If human employment is a race against the machines, our second regression shows the two competitors in action. We model the relationship between an occupation's task mix and technology's contribution to economic output with **Equation 3**.

Equation 3. The relationship between IT investment and labor tasks

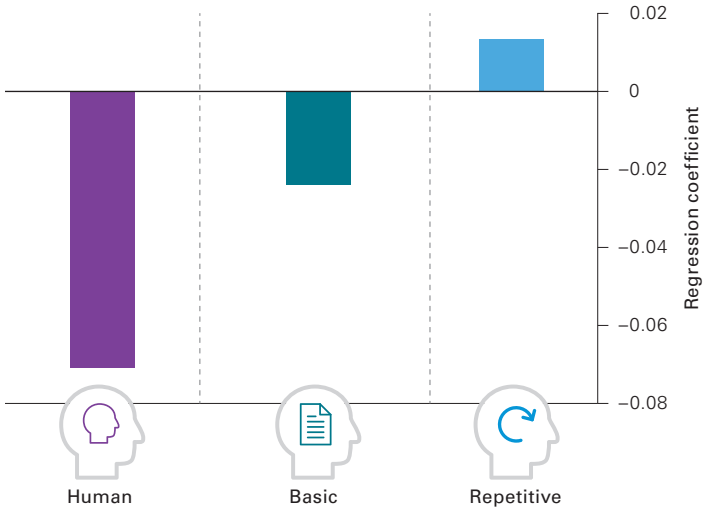
$$IT\ Contribution_{i,j,t} = \alpha + \beta_1 Basic_{i,j,t} + \beta_2 Repetitive_{i,j,t} + \beta_3\ Uniquely\ Human_{i,j,t} + \varepsilon_{i,j,t}$$

The coefficients displayed in **Figure 8** can serve as an indicator of an occupation's susceptibility to automation. The more human a job, the less technology contributes to economic output. We chart this relationship in **Figure 9**. If a job's human tasks become 10% more important, technology's contribution to the job's output declines by about 0.1%. Basic tasks also have a negative, though weaker, relationship with technology output. Only in jobs made up largely of repetitive tasks is the relationship with technology positive, a consequence of the tasks' high potential for automation. In other words, as the importance of a job's repetitive tasks increases, technology becomes a bigger contributor to output.

FIGURE 8

The more human a job, the less technology contributes to output

Repetitive jobs attract automation: Contribution of IT capital to output is highest for jobs with the most repetitive tasks.



Notes: We regress basic, repetitive, and human task importance on contribution of IT capital to total output growth to get coefficients. The regression indicates the inverse relationship between human tasks and IT contribution across sectors in the economy. Refer to appendix equation (Model 3) for significance levels and exact coefficients.

Sources: Vanguard calculations, using data from U.S. Department of Labor O*Net OnLine, U.S. Bureau of Economic Analysis, and U.S. Bureau of Labor Statistics.

3. Technology is making humans more valuable

As technology grows more sophisticated, jobs are being reinvented, not destroyed. Here in **Equation 4**, we build upon Conclusions 1 and 2 to look at how the relationship between task mix and technology investment determines labor's contribution to output.

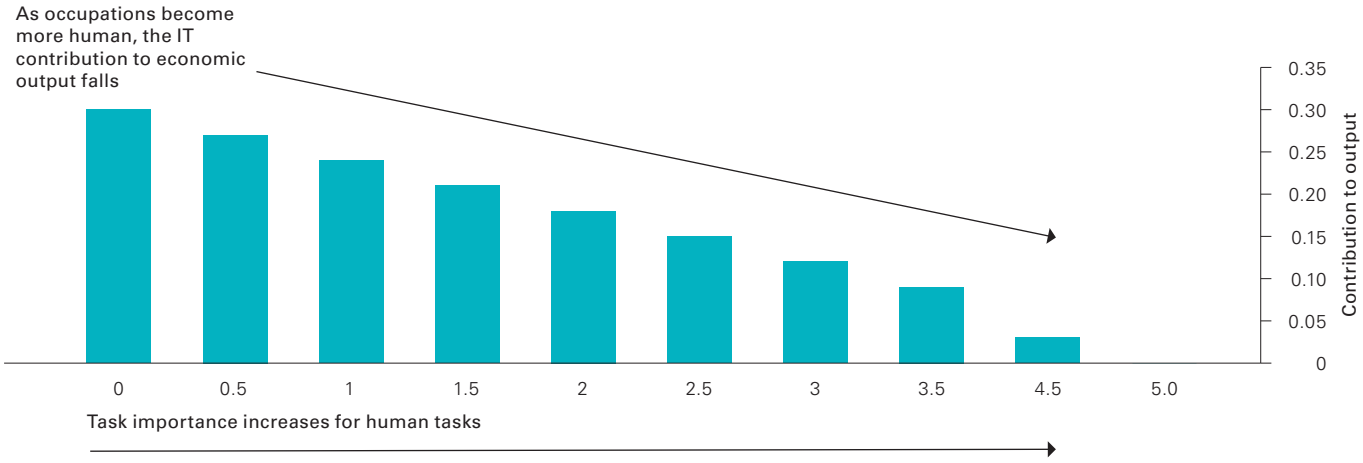
Equation 4. The relationship among tasks, technology, and labor's output

$$Labor\ Contribution_{i,j,t} = \alpha + \beta_1 Basic_{i,j,t} + \beta_2 Repetitive_{i,j,t} + \beta_3\ Uniquely\ Human_{i,j,t} + \beta_4\ IT\ Capital_{i,j,t} + \varepsilon_{i,j,t}$$

As an industry's investment in technology increases (**Figure 10**), labor's contribution to gross output decreases, as expected. This effect intensifies from the pre- to post-recession samples as technology unlocked further productivity gains. What is noteworthy, however, is that the coefficient on uniquely human activities remains significant and positive in our post-crisis sample. In fact, its magnitude is comparable to the uniquely human coefficient in our first regression, which did not include a technology variable. We interpret this result to mean that uniquely human activities continue to add value to labor's output, even as technology's ability to substitute for labor increases.[6]

FIGURE 9

An increase in the importance of a job's human tasks produces a decline in technology's contribution to output

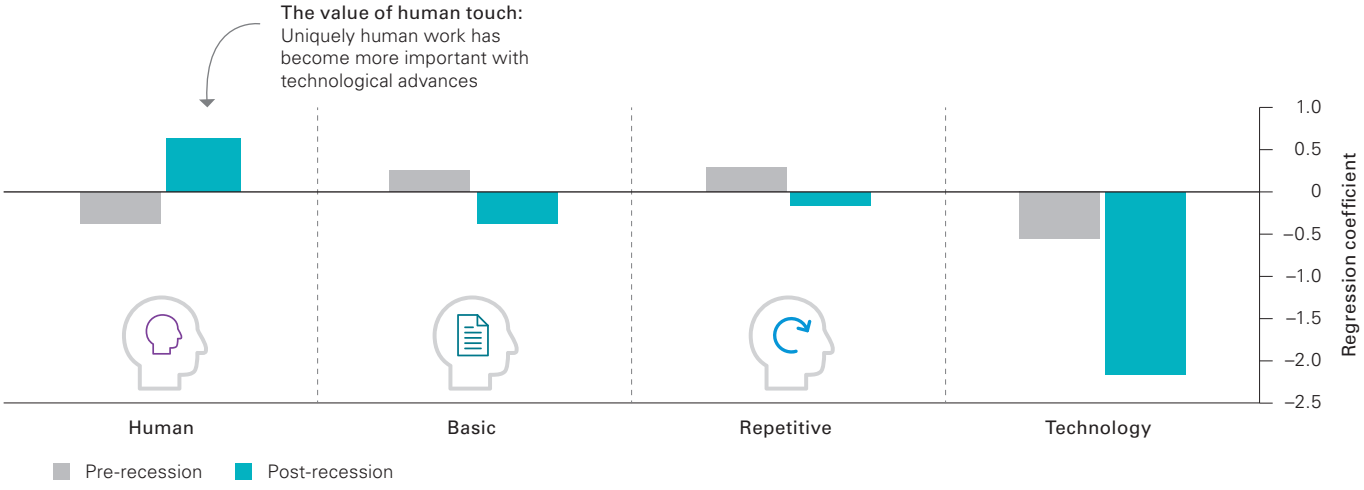


Notes: We use the coefficients from regression of Equation 2 to construct a scale of what it means for IT contribution in an occupation as the human component of the occupation gains in importance.

Sources: Vanguard calculations, using data from U.S. Department of Labor O*Net OnLine, U.S. Bureau of Economic Analysis, and U.S. Bureau of Labor Statistics.

FIGURE 10

Technology's rise has not substituted for uniquely human work



Notes: We regress basic, repetitive, and human tasks as well as IT investment on labor's contribution to total output growth to get coefficients. The time period is divided into two sections to capture the pre-recession (2003–07) and post-recession (2010–15) difference in task mix and technology's investment influence on labor's contribution to output. Refer to appendix equation (Models 4 and 5) for details on significance levels and exact coefficients.

Sources: Vanguard calculations, using data from U.S. Department of Labor O*Net OnLine, U.S. Bureau of Economic Analysis, and U.S. Bureau of Labor Statistics.

6 We also tested (but do not show here) whether IT's contribution exhibits a separate relationship with our three task types ("interaction" effects, accomplished by multiplying two variables together). The results of these regressions were inconclusive (and were not statistically reliable). The type of work that labor performs does not tell us anything more about how tasks and technology affect labor output.

A task perspective on a job's potential for automation

The relationships among task mix, labor's contribution to output, and technology give us some insight into the jobs that are most susceptible to automation in the next 10 to 20 years. In **Figure 11**, we plot O*Net's 966 occupations along two dimensions: the average importance of a job's uniquely human tasks and the number of a job's critically important tasks. We define tasks as "critically important" if their importance score is higher than 4. This cutoff helps us identify the most important tasks for each occupation and look for patterns among the tasks themselves.

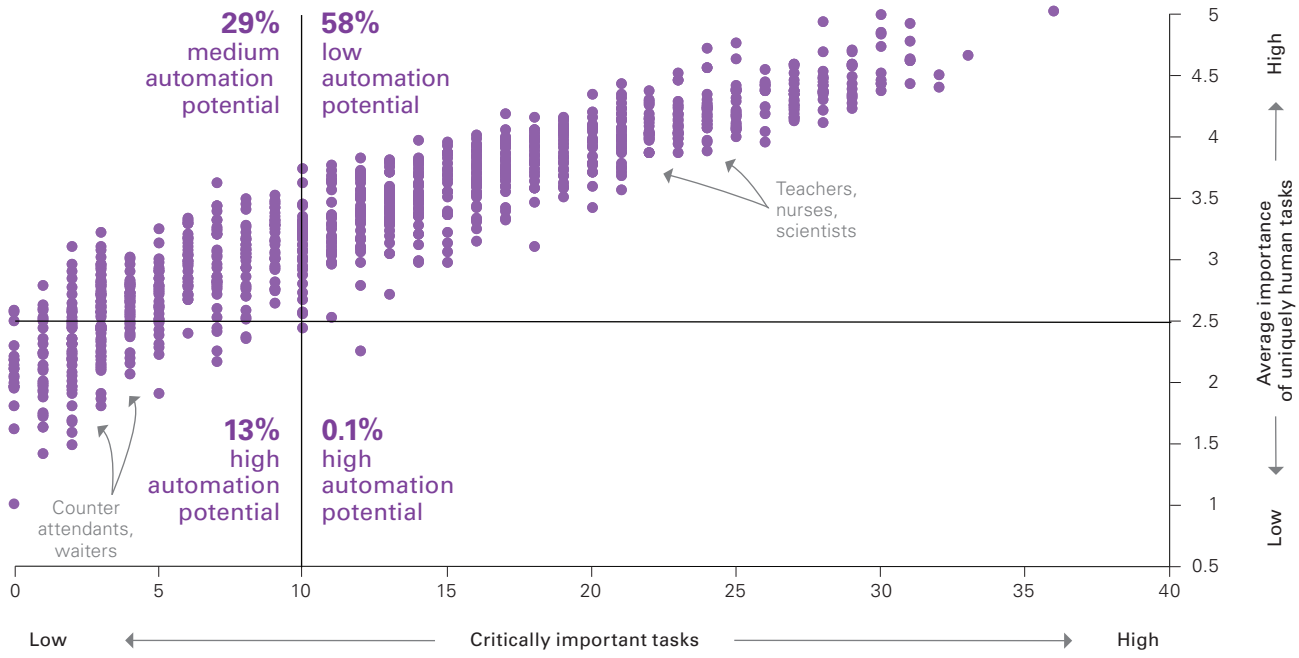
In the lower-left quadrant are jobs with a small number of critically important tasks and low scores for the importance of human tasks. These jobs, which make up 13% of all occupations, are at the greatest risk of automation. "Parking lot attendant" falls into this quadrant. In the upper-right quadrant are jobs with a high number of critically important tasks and high scores for the importance of human tasks. These jobs, which make up 58% of all occupations, are at the lowest risk of automation. "Surveyors" and "science teachers" fall into this quadrant.

There are few jobs with both a large number of critically important tasks and low importance scores for the human tasks, the lower-right quadrant. The 29% of jobs in the upper left include jobs with a small number of tasks and middling scores for the importance of human tasks. "Roofers" and "baristas" fall into this quadrant. These jobs most likely have medium automation potential.

FIGURE 11

A large number of critically important human tasks limits potential automation

The occupation quadrant



Notes: The graph maps the average importance of human tasks in an occupation against the number of critically important tasks in that occupation. We observe that the occupations with a higher proportion of critically important tasks are associated with higher average importance of uniquely human tasks.

Sources: Vanguard calculations, using data from U.S. Department of Labor O*Net OnLine, U.S. Bureau of Economic Analysis, and U.S. Bureau of Labor Statistics.

Help wanted in the age of automation

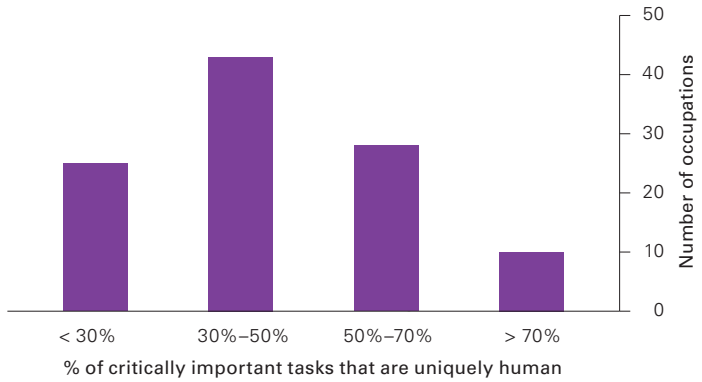
Human tasks account for at least 30% of the critically important tasks in most jobs, as shown in **Figure 12**. This mix suggests most jobs can't be completely replaced by technology. More likely is an acceleration of the shift in the task composition of work. Today, "uniquely human" tasks account, on average, for 50% of a job's critically important tasks. In the decade ahead, it could rise to 80%.

This shift will produce a labor market paradox: more automation, yet rising labor shortages. In the best case, workers who today specialize in basic and repetitive tasks will develop the skills to perform the rising number of "uniquely human tasks" demanded by more jobs. Today's labor shortages raise doubt that this will happen.

Since 2009, as illustrated in **Figure 13**, the labor force participation rate has declined even as the U.S. economy has recovered to a historically low level of unemployment. Throughout the recovery, the labor market created increasingly human jobs. Declining participation and labor shortages in some industries suggest that the working population may not be prepared to perform the tasks that are increasingly driving economic output. Demographic changes such as the aging of the workforce add to the pressures on economic growth and improved productivity.

FIGURE 12

Distribution of critically important activities that are uniquely human



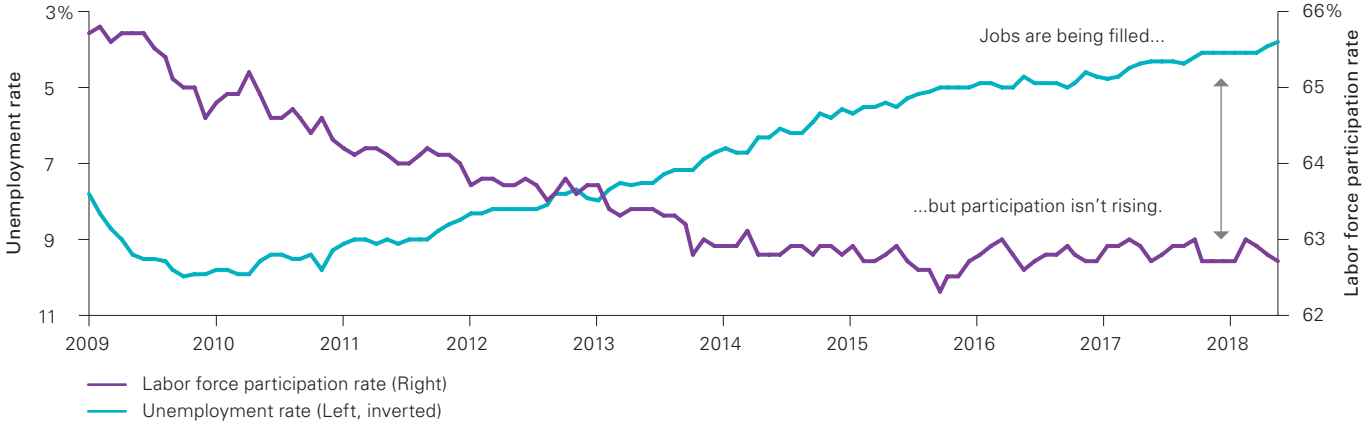
Notes: Critically important activities are defined as tasks that have an importance score of more than 4 in a ranking scale of 1 to 5. We then use the framework detailed in Figure 2 to determine which critically important tasks are uniquely human.

Sources: Vanguard calculations, using data from U.S. Department of Labor O*Net OnLine.

FIGURE 13

Even as unemployment falls, workers are dropping out of the labor force

Trends point to a potential labor shortage



Sources: Vanguard, using data from the Federal Reserve Bank of St. Louis. Data are as of June 22, 2018.

To bridge the supply-and-demand gap, policymakers need to consider changes in education and training that can help people cultivate uniquely human skills. Critical capabilities for the future of work include:

- **Creative intelligence:** The ability to generate new ideas and connect seemingly unrelated dots.
- **Technological acumen:** The ability to develop or use technology to solve business problems.
- **Emotional intelligence:** The ability to recognize and manage emotions to motivate and collaborate with others.

Employers will need to explore new approaches to workforce planning and development. Individuals will need to develop new capacities to adapt to the accelerating pace of change. **Figure 14** includes research and reading that can help policymakers, employers, and individuals consider systems and strategies to meet these challenges.

FIGURE 14

More on how we can prepare for the future of work

Audience	Research	Insight
Policymakers	Deming, David J. 2016. *The Growing Importance of Social Skills in the Labor Market.*	Finds that growth in jobs requiring high levels of social interaction has outpaced overall employment growth. What, if anything, can policymakers do to cultivate these increasingly valuable social skills?
	Tom M. Mitchell and Erik Brynjolfsson. 2017. "Where Are We and Information Technology and the U.S. Workforce. Where Do We Go From Here?" National Academies Press.	Outlines a national research agenda to help policymakers, employers, and educators respond to technological progress most effectively.
Employers	McKinsey Global Institute. 2017. *Jobs Lost, Jobs Gained: Workforce Transitions in a Time of Automation.*	Proposes investments in artificial intelligence and organizational design to help companies capitalize on technological disruption while managing workforce transitions to fill emerging needs.
	Deloitte Insights. 2017. *Forces of Change: The Future of Work.*	Reviews the interaction of technology and "alternative" work arrangements, shifting demographics, and job design.
Individuals	Brynjolfsson, Erik, and Andrew McAfee. 2014. *The Second Machine Age*, W.W. Norton & Company.	Explores the technologies that will reshape the future and the implications for educational and social systems built for an earlier era.
	Carol Dweck. 2017. *Mindset: The New Psychology of Success,* Ballantine Books. Angela Duckworth. 2016. *Grit: The Power of Passion and Perseverance,* Scribner.	Leading psychology researchers translate experimental findings into insights and strategies that individuals can use to achieve goals and develop new skills and capacities.

Source: Vanguard.

Conclusion

We live in an age of technological disruption. Increasingly capable technologies such as autonomous vehicles and artificial intelligence can seem to set the stage for an apocalyptic future without jobs.

The reality is more encouraging. Our analysis of Labor Department data shows that over the past two decades, the tasks that make up any one job have changed. Some tasks have disappeared, but job growth has continued. We spend less time on the repetitive, rules-based tasks that can be captured in an algorithm and more on uniquely human tasks.

These trends will continue to reshape employment in the next ten years, and the pace will accelerate. The result will be a labor market paradox: more robots, but not enough people. We suggest principles for education and training to prepare the workforce for jobs that demand more of us as humans and less of us as machines.

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Appendix

Figure A-1. Regression results

	Model 1	Model 2	Model 3	Model 4	Model 5
Dependent variable	Labor contribution to gross output	Labor contribution to gross output	IT capital contribution to output	Labor contribution to gross output	Labor contribution to gross output
Human task importance	–0.373**	0.667***	–0.071***	–0.370**	0.629**
	(0.125)	(0.181)	(0.010)	(0.126)	(0.182)
Basic task importance	0.254*	–0.417**	–0.024**	0.251*	–0.379*
	(0.121)	(0.163)	(0.007)	(0.122)	(0.163)
Repetitive task importance	0.289**	–0.165	0.013	0.289**	–0.162
	(0.101)	(0.113)	(0.007)	(0.101)	(0.112)
IT capital contribution to output	–	–	–	–0.558	–2.17***
				(0.716)	(0.509)
Constant	0.321	0.574	0.348***	–0.404	0.641
	(0.321)	(0.344)	(0.030)	(0.342)	(0.343)
No. of observations	1,578	1,980	3,558	1,578	1,980
Time period	2003–2007	2010–2015	2003–2015, excl. 2008–2009	2003–2007	2010-2015
Groups	367	367	369	367	367

stars denote significance levels.

*p<0.05

**p<0.01

***p<0.001

Notes: Heteroskedasticity- and autocorrelation-robust standard errors clustered by industry-occupation group included in parentheses. All regressions estimated using industry-occupation fixed effects. Integrated industry-level production account and contribution tables (Bureau of Economic Analysis) were used in our analysis.

Sources: Vanguard calculations, using data from the U.S. Department of Labor, O*Net, and U.S. Bureau of Economic Analysis.

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ISGTFW 082018