How will automation affect jobs, skills, and wages?

As the nature of work changes with automation, millions of people may need to switch occupations and acquire new skills.

Automation will displace many jobs over the next ten to 15 years, but many others will be created and even more will change. Jobs of the future will use different skills and may have higher educational requirements. In this episode, we ask experts how we can retrain workers for the new world of work and what the shifts might mean for occupations and wages.

Podcast transcript

Peter Gumbel: Welcome to our latest podcast in the series on the new world of work. I'm Peter Gumbel at the McKinsey Global Institute (MGI). Today we're going to be examining the outlook for occupations, skills, and wages. We're here with Susan Lund, who is a partner at MGI and is based in Washington, DC, and Michael Chui, who is also a partner at MGI and is based in San Francisco.

Our starting point is the new MGI report on the future of work, which is called *Jobs lost, jobs gained: Workforce transitions in a time of automation*. One of the major findings of the report is that between 75 million and 375 million people around the world may need to change occupational categories and acquire new skills by the year 2030. Let's start off by discussing that in some detail. First, perhaps Michael, you'd like to start. How did we arrive at these numbers?

Michael Chui: This is built on previous work that we did on the potential effects of automation. These are technologies including artificial intelligence [AI] and physical robotics. What we tried to do is to understand which activities in the global workforce potentially could be automated. We looked at not only every occupation in the global workforce but also all of their constituent activities, about 2,000 of them, and tried to understand the pace at which those could potentially be automated by adapting technologies that exist today and technologies that might be developed in the future.

We modeled those activities that might be automated out to the year 2030 and considered those that the machines might take over for things that people do.

We also tried to understand what the impact might be of other catalysts—for additional demand for human labor. We looked at seven different catalysts that could significantly increase the demand for human labor even net of those activities that might be automated. They include the following:

- **Rising incomes or rising prosperity around the world.** We'll have another one billion people entering the consuming class during the next couple of decades.
- **Aging around the world.** This drives the need for additional labor in healthcare, for instance.
- **The need to develop and deploy technologies.** Digitization, automation, robotics, and artificial intelligence—these actually require people.
- **Investment in infrastructure, such as real estate, buildings, and bridges.** All that construction could drive the additional need for human demand, even though our own MGI productivity research says more and more of that could potentially be automated.
- **Changes in the energy mix.** We'll have smart grids. We'll need to change the generation of energy.
- **Decreasing amounts of unpaid labor in the global workforce.** This is, in many cases, domestic work that's often done by women, whether it's childcare, cleaning, cooking, et cetera. More and more of that could enter the market as well.

We look at the net of that—all of the potential jobs lost, those things that machines might take over, and the potential jobs gained—and the additional demand for human labor that can come from these seven catalysts.

Peter Gumbel: Is that an exhaustive list in your mind? Or are there other factors out there that could create new labor demand in the future?

Michael Chui: We know we can't predict the future completely. We do think those seven catalysts of additional labor demand are very important. We started with a list of 20 and filtered down to the ones that we thought would be the most significant. But we also know we can't imagine every job that could possibly be developed.

For example, right now we have a bunch of people whose job it is to be an app developer for mobile smartphones. This isn't a job that anyone necessarily imagined a couple decades ago. In fact, there's an academic research report that says around half of 1 percent of jobs created every year are entirely new. By 2030, we could be looking at another 8 to 9 percent of jobs in that time period that simply don't exist today.

How many more new jobs and new types of occupations might get generated? It's starting and could change over time depending on how innovative the economy is and how much we invest in innovation and research development. And so, that's something that's potentially new.

Susan Lund: It's important to note that the seven catalysts that we looked at, they aren't all the sources of future labor demand. For example, we don't use a dynamic model that takes into account the fact that when somebody gets a job, they then go out and start to spend money on

all sorts of goods and services. That indeed creates other jobs. We find that, in most countries, the problem is not that there won't be enough work by 2030 for people to do.

Peter Gumbel: Let's look at what this actually means for some specific occupations. Susan, perhaps you could give us some examples. On the one hand, what jobs may decline because of these trends? On the other hand, what jobs may grow because of them?

Susan Lund: This is a big fear out there right now—that the robots are coming. They're going to take all the jobs. There's going to be nothing for people to do.

In fact, our results show quite convincingly that the problem is not if there will there be jobs. There is a big question about will the workers today, given their existing skill sets, be qualified to get the jobs that that will be there.

Where do we see job growth? It depends very much on the country you're looking at. In developing countries that are growing rapidly, like India, there is job growth across virtually all occupations. And there will be demand for all sorts of different types of labor.

In advanced economies, the impact of automation over the next ten to 15 years will very likely be higher. And that's simply because of the wage structure. We make the reasonable assumption that companies don't adopt automation technologies until the cost of buying them and deploying them at least equates to the cost of labor. In advanced economies, we see much bigger turnover in future jobs.

On one hand, given what Michael told us about the catalysts, we can see that many types of occupations will grow—for instance, all sorts of care providers. Aging populations will mean that there will be growth and demand for doctors, nurses, eldercare workers—all sorts of healthcare-related occupations.

We also see that managers and executives are going to be needed everywhere, including a whole range of professionals. This includes IT- and computer-related professionals but also engineers, scientists, account managers, et cetera. This is because automation technologies today are much better at doing some things rather than others. Applying expertise is something that, at least in the time frame we're looking at, humans will still have a comparative advantage.

We also see some interesting categories of job growth that may be less obvious: creative occupations like artists, entertainers, painters, and writers. This is because, while there have been some gains in the emotional and creative aspects of artificial intelligence, humans still hold a clear advantage. Other jobs like that of a CEO, legislator, or psychiatrist also don't look to be very automatable.

Peter Gumbel: Michael, what about your view of these jobs of the future?

Michael Chui: We're going to see different catalysts for additional demand for labor. If you look at additional investment in infrastructure and buildings, we'll see more on the construction side. If we continue to see an increasing need for healthcare, we'll see those types of skilled workers in the healthcare professions.

We also see that there are some types of activities that have a greater propensity to be automated, for instance, physical activities in predictable environments. We'll probably see that the amount of demand for workers on assembly lines is likely to go down. Collecting data, processing data, office-support jobs, processing financial and other transactions—that's very predictable work. And even though it's not physical work, it's predictable work. On balance, we would likely see less of that, particularly when the technology reaches a stage at which it is lower-cost than deploying human labor for those activities.

Peter Gumbel: One of the themes of the report is that jobs will also change. Perhaps, Susan, you can tell us about that. In what way will jobs actually change as this technology takes hold?

Susan Lund: There are going to be big shifts in which occupations grow and which decline. I think an even more important, or at least equally important, trend is that all of our occupations are going to change.

Overall, we find that, for instance, in 60 percent of jobs, 30 percent of the activities that people do in that job could be automated. This means that what people do will shift.

A good example is what happened to bank tellers in the United States after the introduction of ATM machines. Back in the 1980s, bank tellers spent a large portion of their time simply collecting cash from customers to deposit into accounts or handing out cash. This was automated by the growth of ATMs. You might think that the number of bank tellers declined dramatically. In fact, the number of bank tellers increased. But what they do is very different. The reason the number increased is that ATMs made bank branches much less costly to operate. And so, the number of bank branches exploded across the country. That required more tellers, even though there were fewer bank tellers in each branch.

What the tellers do, though, is very different. Today, they spend a small portion of their time handing out cash and doing transactions. Instead, they help customers sign up for different sorts of financial products and services like credit cards, mortgages, or different types of savings or deposit accounts. Today, with the growth of Internet banking, the number of bank tellers is starting to decline. But for a good period of 20 years, the number of bank tellers grew even as ATMs took off.

Peter Gumbel: Michael, do you want to add anything? Do you see other types of occupations changing?

Michael Chui: As Susan said, historically we've seen this over and over again. There was a time when secretaries, as we called them, did things like take dictation, type out things that somebody said, et cetera. Now they're doing much more complex tasks that involve negotiation—negotiating about schedule, or procurement, or many other tasks.

Going forward, we expect to see the same thing. Even for computer coders, the practice of coding is different now than it was a couple decades ago. We will see that continue to change over time. We see more and more of these software-tool vendors who are in fact automating pieces of a software developer's job, which previously someone would have to do manually. We expect to continue to see that over and over again, this idea of tooling our occupations.

That applies in the physical realm as well. We're seeing more and more automation on a factory floor and, again, machines and people doing complementary things. As Erik Brynjolfsson and Andy McAfee have said, it's a great thing for machines to complement what humans are doing.

Susan Lund: I would also point out, though, that there will be differences in how fast automation and AI technologies are adopted based on social norms. Even today, for instance, airline pilots spend only a small fraction of their time actually flying the airplane. And yet every flight we get on has two pilots in the cockpit. Social norms are dictating that pilots need to be there in case of an emergency. That may continue to be the case even as autopilot technologies get better and better. Or maybe there won't be two but at least one.

Same thing for things like a radiologist. Today, there are AI algorithms that can read X-rays and make diagnoses better than the best experts in the world. And yet it doesn't mean that there won't be radiologists. We'll still need a doctor to explain the results to a patient and then talk about what the different options are for further diagnosis or treatment.

Peter Gumbel: One specific question about the report: one of the headline numbers in that report was about people having to change occupational categories. Can you explain what you mean by that?

Susan Lund: We categorize 800 options into 58 categories. This is our shorthand way of showing, with a more limited taxonomy, how work might shift. For instance, there's a whole classification around customer-interaction jobs that includes cashiers, call-service representatives, et cetera. By grouping occupations into these categories, we can then start to talk about which ones are growing and which are declining.
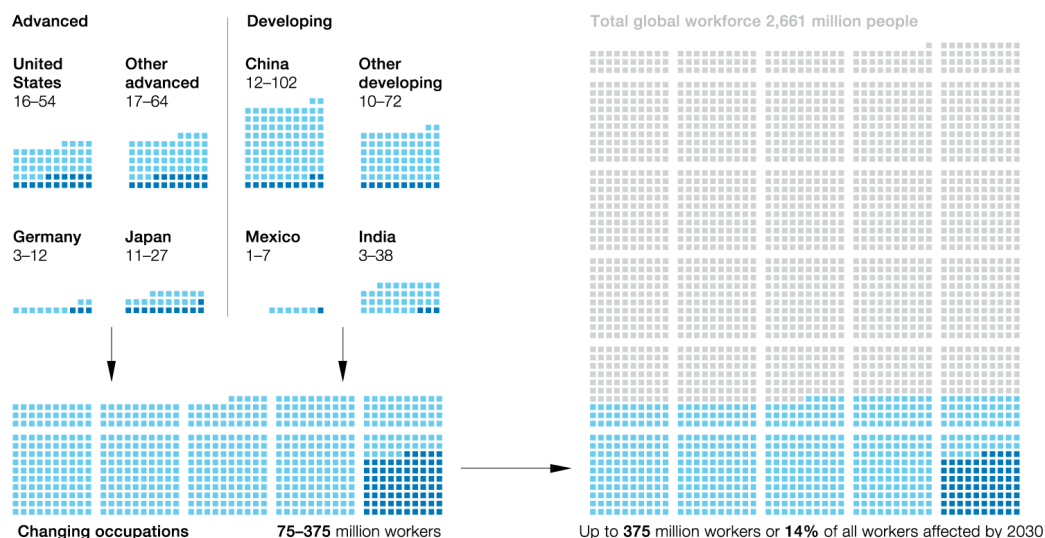
The number that you refer to in the beginning, Peter, that somewhere between 75 million and 375 million people may need to switch occupational categories, means that they're in an occupation, or in a set of occupations, that's shrinking in number [Exhibit 1]. Some of those people are going to have to shift to one of the growing occupational categories.

Exhibit 1

Globally, up to 375 million workers may need to switch occupational categories.

Number of workers needing to move out of current occupational category to go find work, 2016–30 (trendline scenario)[1]
■ Midpoint automation ■ Additional from rapid automation adoption (each block = 1 million workers)

Advanced

United States 16–54 | Other advanced 17–64

Germany 3–12 | Japan 11–27

Developing

China 12–102 | Other developing 10–72

Mexico 1–7 | India 3–38

Total global workforce 2,661 million people

Changing occupations | 75–375 million workers

Up to **375** million workers or **14%** of all workers affected by 2030

1 Some occupational data projected into 2016 baseline from latest available 2014 data.

This is a big shift. It's different than saying, "Well, I'm one type of specialty nurse, and now I need to become a different type." That would be a shift within an occupational category. So here, the changes we're talking about are very significant. It's about somebody who may have been working in trucking or manufacturing learning to do something entirely different—possibly a job in construction, or healthcare, or other types of things.

This will require more than simply applying for that job. It will require some level of formal training to learn the new skills to become qualified to get that new job. This will be the defining challenge of our generation, we think: creating the programs, tools, and opportunities for somebody who's midcareer with a mortgage and with children that can't afford to go back to school for two years to get an associate's degree or four years to get a bachelor's. Instead, we'll need to help that person get the bare minimum skills to get his or her foot in the door, in an entirely different occupation, and start off on a career ladder in an entirely new direction.

Peter Gumbel: Susan, you just brought up the issue of skills. Obviously, this is a huge topic that's very much in the news. Michael, in your work on automation, you've looked to what machines can and can't do very well. Perhaps you can talk to us about that. Where are we in terms of the actual technical capabilities of machines?

Michael Chui: Every day we seem to be seeing headlines about these amazing things that machines can do. Indeed, we do see the big technical advances over time. We know that there are places where machines do things very well. For instance, in some sensory capabilities, machines can detect light in different spectra that people can't. In some ways, that's even superhuman. But the ability to categorize different objects in the physical field, that's something machines are still working on. We are still working on building machines that can do that.

Similarly, in terms of physical activities, we do have machines that can lift more than any human being can. But, again, the ability to do fine motor skills—to have all of the sensory abilities and flexibility of the human hand, to be able to move things like fabrics—it's very difficult to have robots do that. And so that's a challenge.

On the cognitive side, you know Andrew Ng, who's a famous machine-learning expert, has said that almost anything that a person can do with his or her brain within one second is something that machine learning is able to do. We're finding that to be increasingly true—[for machine learning] to be able to categorize very quickly. We can talk to our machines and our phones, but they don't understand natural language at the level of median human performance. Natural language, understanding and recognizing human emotions—we're teaching machines how to do these things, but they can't do it as well as humans, yet. In all these categories, we sometimes see surprising advancements in the technology, and we recognize and we should celebrate just how hard these things are. Because any person, in many cases, does some of these activities better than machines do.

Peter Gumbel: What does that mean in terms of the workplace skills that we're going to be needing in the next 15 to 20 years? Susan, how do you view that? Are there specific skills that we're going to need more of in order to essentially compete better with machines?

Susan Lund: The demand for humans is going to be for the skills that machines aren't good at doing: that's social and emotional skills, creativity, and applying high levels of cognitive function and expertise.

Let's take social and emotional skills. There is a whole range of jobs—in healthcare, teaching, care provision, therapy—that rely on a lot of social and emotional cues and being able to read how other people are feeling. These skills are going to be more and more needed.

It's interesting that schools don't really focus on this. We still talk a lot about IQ but much less about somebody's emotional quotient, or EQ. That EQ is going to become more and more important in any field.

We also see that school curricula, for now, don't seem to be taking into account these changes. In fact, most public-education systems in the United States look very similar to what they looked like 30 years ago. Students can graduate with two years of calculus but have no requirements, for instance, to learn computer coding or engineering.

I think that for people looking forward, anyone with an aptitude for math and science, that's going to be a good bet. STEM [science, technology, engineering, and mathematics] fields will be growing—and maybe even what we call STEAM fields, adding the arts to that. Creative thinking and the ability to learn from a pattern in one field and applying that analogously to a different field—these are all things that humans are still much better at doing than machines.

Michael Chui: If I could add to that, in addition to understanding STEAM, I think there's another lesson. If we look at the potential impact of these technologies changing what everyone does over time, there are metaskills to be learned here—this ability to learn how to learn. What we'll need to do is recognize that everyone's job is going to change. What everyone does, how we work alongside the machines, is going to change over time. These skills of flexibility, agility, grit, resilience, and continuing to learn how to learn—we need to instill these in people as an expectation and something that you can train to do over time.

Susan Lund: Michael, what you said is absolutely right about lifelong learning. It's something that has been a bit of a mantra in the educational field—that everyone's going to have to be a student for life and embark on lifelong learning.

But the fact is, right now, it's still mainly a slogan. Even within jobs in companies, there's not lifelong training. In fact, what we see in corporate-training data, at least in the United States, is that companies are spending less. Right now, people expect that they will get their education in their early 20s or late 20s. And then they're done. They're going to go and work for 40 to 50 years. That model of getting an education up front, and then working for many decades, without ever going through formal or informal training again, is clearly not going to be the reality for the next generation.

Michael Chui: Absolutely. We have to ask the questions: Is that something that needs to change? How do we actually get that done? We always say we need to improve K through 12 [kindergarten through 12th grade] education; we don't include college education. But, if everyone's job is going to change, how do we actually fund and successfully create programs that allow people to retrain over time?

Susan Lund: Here is where technology might provide some of the solutions, because right now we can take online courses. There are a number of companies that have started to partner with universities to enable their entire workforce to take online courses. It might be to learn a new skill that's applicable within that company or just to learn new skills and make a

career shift. AT&T is an example of a company that set up a program to enable its workforce to learn the digital skills that are going to be needed, through online courses with Georgia Tech [Georgia Institute of Technology]. Whereas Starbucks and Amazon are enabling baristas and warehouse workers, those who reach a certain period of tenure with the company, to go earn online degrees and have the tuition paid for, to prepare for careers that may be outside of that company. This type of experimenting, of people working but also learning either at night or online, might be more of a model for the future.
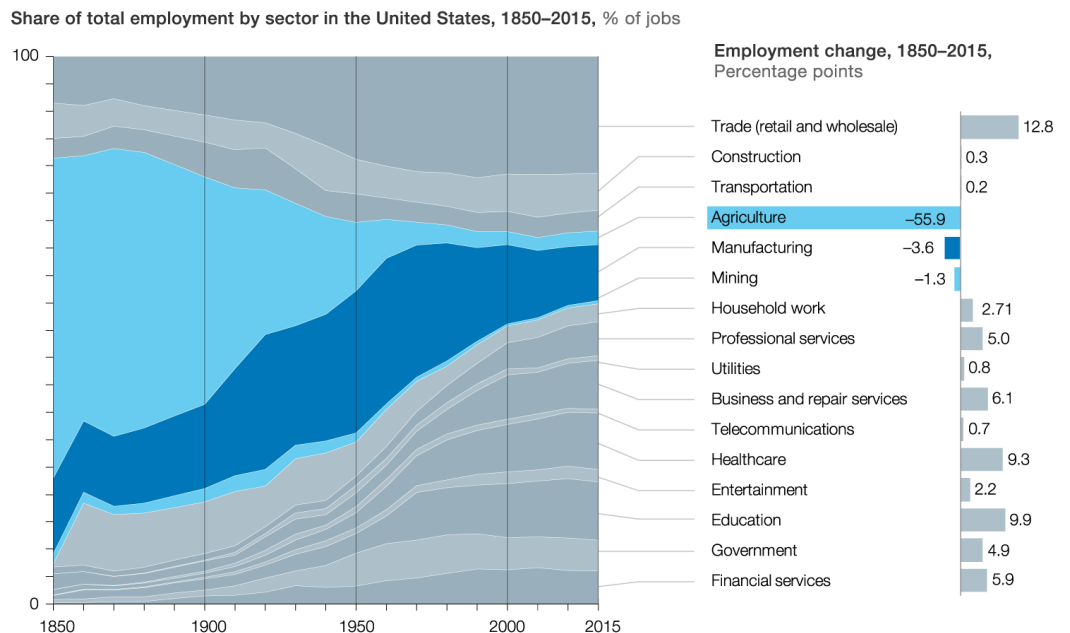
Michael Chui: I absolutely agree. What's interesting is that, for online courses, you can apply some artificial intelligence and analytics to improve the education or the training people get—in order to figure out what educational pathway is going to be most effective. In teaching math, for instance, is it better to learn trigonometry or algebra first, in order to be successful in calculus or statistics? These kinds of questions might be different for individual learners, not only for online courses but also for mixed-mode courses, which combine some live-teacher training along with the online course. Oftentimes they are quite effective. There's some interesting recent research that says that the people who need the education the most, the most challenged learners, need more of that live connection with an instructor. Mixing those modes in an appropriate way, and customizing the education or learning for an individual learner, could be one way in which we use technology to try to solve these problems that technology is causing.

Peter Gumbel: You're both students of the history of technology and the role of technology in changing employment. When you look at the situation today, and the challenges that that you've outlined in this report, how do you place the challenge of retraining the workforce into a historical context? Have we seen this before?

Michael Chui: There's no guarantee the future is going to be like the past, but we are encouraged by some of what we've seen in the past. We've seen the percentage of people in agriculture in the US go from 40 percent in 1900 to less than 2 percent a century later [Exhibit 2].

Exhibit 2

History shows that technology has created large employment and sector shifts, but also creates new jobs.

Share of total employment by sector in the United States, 1850–2015, % of jobs

Employment change, 1850–2015, Percentage points

Sector	Value
Trade (retail and wholesale)	12.8
Construction	0.3
Transportation	0.2
Agriculture	−55.9
Manufacturing	−3.6
Mining	−1.3
Household work	2.71
Professional services	5.0
Utilities	0.8
Business and repair services	6.1
Telecommunications	0.7
Healthcare	9.3
Entertainment	2.2
Education	9.9
Government	4.9
Financial services	5.9

We don't have 35 percent unemployment in the US. In fact, we've been able to create new jobs, new occupations, and new demand for labor. But at the same time, we've had to make great investments in education for that to happen. There was a high-school movement that occurred. At the beginning of 1900, there was no universal secondary schooling in the United States. But because of social movement, it was created.

We also had the GI Bill for veterans coming back from the Second World War. Millions of Americans then were enabled to go to college. One of the questions is: Going forward, what are the analogous sets of investments that have to be made? As we go through this new trend of disruption, how can we retrain people so that they continue to do work that there will be demand for?

Susan Lund: This situation today is challenging though, Michael. You see corporate-training spending has been declining. You can look across the OECD [Organisation for Economic Co-operation and Development] and see that government spending on workforce training has also been declining. You might argue that spending wasn't terribly effective, which is a different question. But the fact is that we're moving in the wrong direction on raising workforce skills. And certainly, in the United States, since 1980, the educational attainment of the population has changed very little. It's not like we're still on an upward trajectory of the workforce becoming more and more educated over time. That's something that we're going to need a concerted effort to reverse—both the trend in less spending and the plateauing of the educational attainment in the US.

Michael Chui: And the effectiveness of education as well. The only reason I'm optimistic is because the future is made up of choices we can make today. If we choose to work on creating more effective and efficient retraining systems, I'm hopeful that we'll be able to shift the workforce.

But this is a real challenge. There are times in history that didn't turn out that well. We sometimes joke about the Luddites and how much they hated technology. At the same time, they weren't wrong. In fact, during that time, there were a few decades during which wages stagnated for people who were displaced by automation. And so, how do we make sure that doesn't happen in this wave of technology?

Peter Gumbel: You've raised the issue of wages, Michael. What, in your research, are you seeing about the implications for wages from this current wave of technology automation?

Susan Lund: We don't model how wages might change for any given occupation. But we can say two things. When we look at the growth or decline of specific occupations at today's wage levels, we see that in some countries, including the United States, the polarization of opportunities may continue. So we see growth in high-wage occupations and growth in the lowest-wage occupations. But we see net declines in all the occupations that are in the middle of the income distribution. That's problematic.

The second thing we know is that, if a lot of workers are displaced in particular occupations, and if they don't get the skills needed to get those high-wage, higher-skill jobs, we may see a glut of people chasing a shrinking pool of low-skill work. And as an economist, I'd have to believe that supply and demand means wages may fall. It's a real issue that we're going to have to address. One of the most important solutions is to make sure we develop short-term training

programs for midcareer people to get the skills they need to get the good jobs that are being created and not chase after a shrinking pool of low-skill, low-wage jobs.

Michael Chui: It's also important that where wage rates sit is not something that's just magically determined. There are jobs that in the United States may not pay very much, but where in other places they've decided, "These are important, valuable jobs. We want to have the best people working them, at a higher level." So they choose to pay more, whether it's for teachers, for public-sector executives, or nursing. I think part of it involves choices that we can make as a society about how much people should be paid.

Peter Gumbel: Let's come to an end with the big question, which is: Should we be optimistic, or should we be pessimistic about what's going to happen in the next ten or 15 years?

Susan Lund: I would say we should be cautiously optimistic. On one hand, all these new technologies do offer a lot of benefits to society. We're in a period where productivity growth has been very low. Adoption of some of these new automation and AI technologies could raise productivity growth and create a new era, maybe like the late 1990s, where we started to see the economic benefits of all these new digital technologies. That would be welcome.

We also can see, as Michael pointed out, machines and AI can now do some things better than humans, and we have a shot at solving some of society's greatest challenges. However, as we've discussed now in this podcast, the big challenge is going to be changing our thinking about how we help workers adjust to these transitions and how we make lifelong learning and shifting careers a reality, not just a mantra. That's going to be a challenge that we haven't seen any country face yet. We're in uncharted territory, so it's concerning. But if we grapple with the issue now and make the right choices, this could be a great boon to humanity and workers.

Michael Chui: Like Susan, I'm concerned because we don't necessarily know exactly how to get through this transition. We do know that people are going to lose their jobs. And that's painful, and it's difficult. And unfortunately, it will happen.

But I'm enthusiastically optimistic because we need this productivity badly. Because of aging, we don't have enough workers to achieve the economic growth that we all want to have. We need all the robots and AI that we can get. We just need to be able to redeploy labor to the jobs of the future. We've been able to do that in the past. I'm hopeful, but it's necessary that we figure out how to do that in the future.

Peter Gumbel: Thank you very much, both of you. You've been listening to Susan Lund and Michael Chui. They've been discussing automation, occupations, skills, wages, and what the next ten to 15 years could look like. ☐

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