

JUNE 2015

BUSINESS
LEADERSHIP FOR
AN INCLUSIVE
ECONOMY

Good Jobs in the Age of Automation

Challenges and Opportunities for
the Private Sector



BSR[®]

The Business of a Better World

About This Brief

This issue brief shares emerging analysis and perspectives on the challenges and opportunities for business of generating and preserving quality employment in an era of rapid and pervasive technological change. It is focused on the impact of automation and major technology trends on low-skilled workers and vulnerable groups, particularly in labor-intensive industries like manufacturing.

This research is part of BSR's thematic initiative, Business Leadership for an Inclusive Economy, which seeks to promote business action to ensure that individuals and communities are able to participate in, benefit from, and contribute to the economy. As such, this brief also offers insight into how BSR plans to strengthen the capacity of companies and key stakeholders to prepare and respond to major technology trends in a way that creates more opportunity and benefits for more people and business. With this brief, we seek to initiate a dialogue with companies and partners on how to embrace the inevitable age of automation in a way that benefits a larger segment of society and creates value for business.

It is based on a literature review and several interviews with technology makers and users as well as experts in the field of automation and labor trends. It also draws on BSR's industry expertise in manufacturing and agriculture and our experience working on issues including sustainable supply chain management, women's empowerment, community engagement, and human rights.

This brief was written by Jessica Davis Pluess with contributions from Aron Cramer, Racheal Meiers, and Katie Abbott. The author wishes to thank BSR and external interviewees, as well as BSR colleagues who provided feedback including Dunstan Allison Hope, Marshall Chase, David Korngold, Jeremy Prepscius, and Lin Wang. Any errors that remain are those of the author. Please direct comments or questions to Jessica Davis Pluess (jdavispluess@bsr.org).

DISCLAIMER

BSR publishes occasional papers as a contribution to the understanding of the role of business in society and the trends related to corporate social responsibility and responsible business practices. BSR maintains a policy of not acting as a representative of its membership, nor does it endorse specific policies or standards. The views expressed in this publication are those of its authors and do not reflect those of BSR members.

BSR briefs are narrowly scoped pieces of research circulated to stimulate timely discussion and critical feedback and influence ongoing debate on emerging issues.

ABOUT BSR

BSR is a global nonprofit organization that works with its network of more than 250 member companies to build a just and sustainable world. From its offices in Asia, Europe, and North America, BSR develops sustainable business strategies and solutions through consulting, research, and cross-sector collaboration. Visit www.bsr.org for more information about BSR's more than 20 years of leadership in sustainability.

Contents

Executive Summary	3
Introduction	6
Automation Trends and Production	9
Implications for Good Jobs	14
Challenges and Opportunities for Business	21
BSR's Approach to an Inclusive Economy in the Age of Automation	26
References	28

Executive Summary

This era of technological change is like nothing seen in the past. Technology is getting “smarter,” taking on more cognitive abilities and tasks once thought to be reserved for people. This sophistication combined with the global reach and speed of change and adoption of technology is changing the way goods are produced and services are delivered, with a range of implications for labor markets around the world. It is essential that we approach this wave of innovation in a way that creates widespread benefits for people, society, and business.

Technology Trends and Labor Implications

This second machine age, as it has been called, is defined by a number of significant technological developments, including Big Data, 3D Printing, the Internet of Things, remote connectivity, and industrial and autonomous robots. Companies across various industries are embracing these technologies to improve operational efficiency and performance, reduce waste and conserve natural resources, reach new markets and audiences with speed and convenience, and support product and process innovation.

These forces can be powerful drivers of economic opportunity and improved well-being. They can also carry a host of risks for people and business, most significantly the elimination of large numbers of jobs. Many experts cite labor’s declining share of GDP in many advanced economies, structural unemployment, and rising economic inequality in many countries as indicators that a transformation in the labor market is already underway, with technology as a key contributor. This is particularly concerning for low-skilled workers who make up a large portion of the workforce in global manufacturing and agriculture value chains and whose jobs are becoming increasingly cost effective to replace with machines.

The pace, nature, and ubiquity of technological change will have significant impacts on job availability, access, and quality. Some jobs will be replaced by machines while new jobs are created and existing jobs take on new and different tasks. While the picture varies in different countries and industries, some research estimates that more than 47 percent of the U.S. workforce is at high risk of automation, including both middle- and lower-skill-level jobs. At the same time, millions of jobs are anticipated to be created by technology, including those involved in designing, creating, and repairing robots. Other jobs will be created in burgeoning industries and by new business models, such as the sharing economy and circular economy that are enabled by advances in these technologies.

However, access to these new jobs may be more difficult for people without the requisite skills. New jobs won’t be a one-to-one substitute for old jobs, which will result in the displacement of many workers. As in other eras of systemic change, overall employment figures may mask the extent of displacement or will fail to measure changes in job quality, particularly for more vulnerable groups. In light of this, it is particularly important to consider the implications for women, who make up the majority of the light manufacturing workforce and a significant portion of the agriculture workforce and have lower education levels in many countries. At the same time, technology could make jobs more accessible as they lower some of the physical and social barriers to entry.

Technology will also affect the quality of existing and new jobs. Automation could make certain jobs more attractive and advance the well-being of workers. Rather than expose humans to health and environmental risks, robots could fill the least attractive, most physical, and unsafe jobs. Technology could also make people more productive and, in turn, lead to higher incomes. If workers have the right skills to fill these higher-paying manufacturing jobs and the benefits of improved efficiency are returned to workers, these could offer significant hopes for improving incomes and overall well-being. At the same time, as machines become more cost effective it may be harder for human capital to compete, which could lead to downward pressure on wages.

Challenges and Opportunities for Business

Enabling more people to benefit from this era of technological change is in the best interest of business. Continuing to invest in technology and automation without considering the impacts on the current and future labor force could lead to a host of operational and reputational risks as well as missed opportunities for business growth, productivity, and innovation.

One of the most important labor considerations for business is how automation will impact on companies' access to talent. Many companies are already facing a shortage of skilled workers, a situation that could worsen with the introduction of advanced automation if investments aren't made in building the right skills.

Automation is anticipated to change some fundamental ways of working and with it the relationship between employers and employees. Considering the happiness and satisfaction of the workers who fill existing and new jobs will determine how well companies are able to capture the productivity, quality, and innovation gains possible through automation.

Companies are already facing challenges in terms of community relations and license to operate in light of a stagnant economy. Surging unemployment would further damage social cohesion and erode community trust. If automation leads to a shift away from labor-intensive manufacturing, there could also be significant macro-level, long-term impacts on the economy and business. Exacerbating existing jobless growth would contribute to additional downward pressure on consumer demand, creating a vicious cycle depressing economic vitality.

Trends show that more companies are viewing labor and technology as opposite sides in a zero-sum game that has major short and long-term implications. Adopting a more mutually reinforcing relationship whereby automation augments and extends the capabilities of workers could make automation a win for both workers and business.

BSR's Approach to an Inclusive Economy in the Age of Automation

Businesses have a strong interest in ensuring that they, and their workforce, are prepared for an era of massive change. This means not only mitigating the negative impacts of technology but also harnessing it as a powerful driver of economic opportunity and improved well-being.

Under our Inclusive Economy initiative, BSR will be investigating how major technological forces will affect employment and the role and opportunities for companies and other stakeholders in creating and

ensuring good jobs in the age of automation. It will initially focus on lower-skilled and vulnerable workers and groups in labor-intensive industries like manufacturing and food/agriculture production.

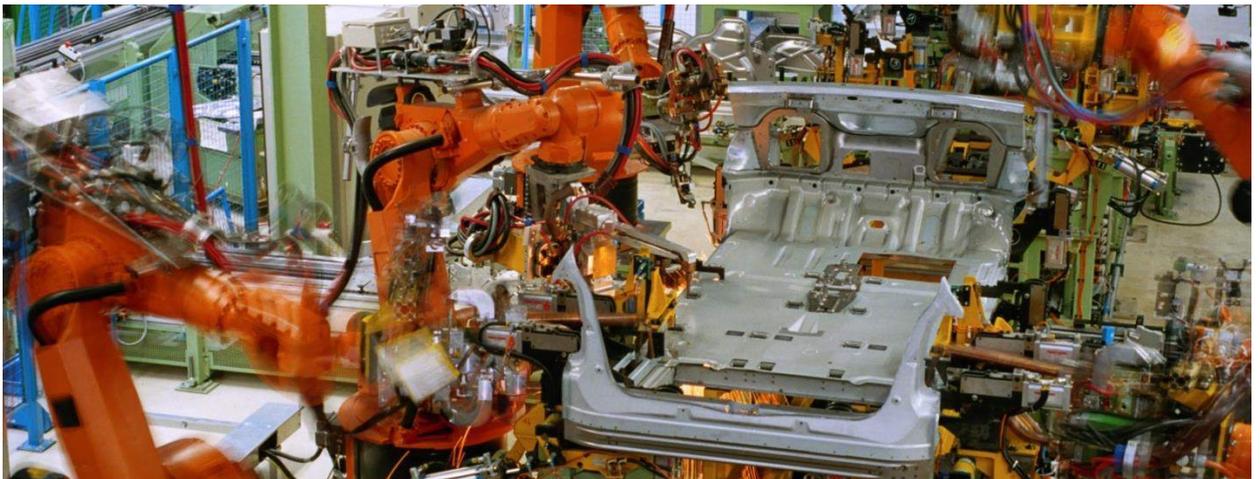
BSR will be establishing a research and engagement platform that looks at several key industries and geographic regions that are likely to see increasing automation over the coming decades. For each industry, we will investigate:

- » How automation is changing production
- » How automation is impacting the creation of good jobs and worker well-being
- » How business and labor can capture the opportunities and mitigate the risks created by automation

This issue brief is the first step of this investigation into how companies can embrace the inevitable age of automation in a way that benefits a larger segment of society and creates value for business.

Introduction

It is being called the “Second Machine Age.”¹ An era when work, home, and leisure are increasingly automated, networked, and digitized with far-reaching effects on consumers, employees, businesses, and communities. These advancements in technology will have significant impacts on job availability and quality in the global economy—eliminating jobs, creating new jobs, and demanding new skills from workforces worldwide.



Companies across various industries are embracing emerging technologies to improve operational efficiency and performance, reduce waste and conserve natural resources, reach new markets and audiences with speed and convenience, and support product and process innovation.

These technological forces can also be powerful drivers of economic opportunities for individuals. Over the last few decades, technology has helped bring millions of people into the formal economy and accelerated and strengthened the positive impacts of globalization by lowering communication and transaction costs. This, among other factors, contributed to the rise of manufacturing in Asia that has helped lift hundreds of millions out of poverty.²

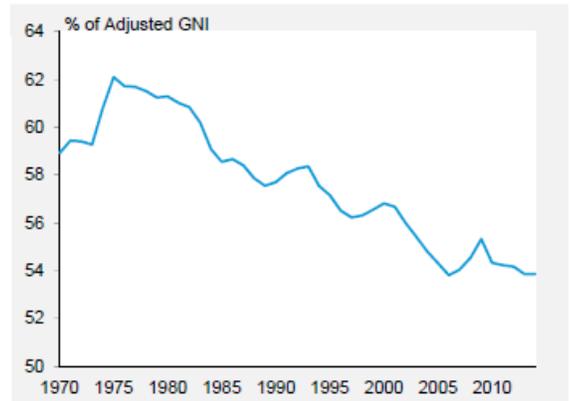
¹ Brynjolfsson and McAfee, 2014

² Asian Development Bank, 2013

Just as technology helped enable many of the economic gains over the last half-century, it could make it more difficult to sustain them going forward. Many experts cite labor's declining share of GDP in many advanced economies, structural unemployment, and rising economic inequality in many countries as indicators that a transformation in the labor market is already underway, with technology as a key contributor.³ (See Figure 1) Particularly troubling is the decoupling of wage growth from productivity, which indicates that the benefits of technology are not being widely shared. While this trend is already happening in advanced economies, it could be a foreshadowing of what is to come for other countries following a similar development trajectory.

The second machine age is sure to cause major disruptions—and just as easily as it could erode many of the last century's economic gains, it could also serve to enhance them.

Figure 1: Labor share of GDP weighted average for 19 advanced economies



Source: Frey and Osborne, 2015

Making the Economy Work for Everyone in the Age of Automation

As part of BSR's Inclusive Economy initiative, BSR is developing a research and engagement platform to investigate how major technological forces will affect employment and the role and opportunities for companies in creating and ensuring good jobs in the age of automation. BSR defines a good job as one which respects the rights of employees, enables a strong livelihood, enhances well-being, offers opportunities for career mobility, and supports diversity and equal opportunity.⁴

We will be focusing much of this work on how major technology trends will impact the creation and preservation of good jobs in company operations and supply chains, particularly in the production of goods that have traditionally relied upon large pools of low-skilled labor. The service sector is also likely to be impacted directly by automation and indirectly by the adoption of wide-scale automation in other industries like manufacturing. While this sector is not the focus of our research, it is referenced in this brief and will be explored in subsequent research.

In pursuing this work, we recall the lessons from a prior era of business model innovation that initially overlooked social implications and acceptance. When the logic of outsourcing and contract manufacturing gained unstoppable momentum in the 1990s, many companies were late to consider fully the social and environmental impacts of these changes. We believe it is crucial to approach the next wave of innovation in a fundamentally different way, to maximize the broad benefits of these new models and to avoid the mistakes that could also result. This is necessary when the business logic of enterprise-specific innovation and the economic logic of preserving a vibrant macro-economic environment collide. Failing to

³ Karabarounis and Neiman, 2014

⁴ Davis Pluess and Meiers, 2015

address this collision risks undermining the economic benefit of technology and the political support and economic stability needed to sustain technological innovation over the long term.

Over the next year, BSR will be investigating the opportunities for companies across several key industries to mitigate the negative impacts and maximize the benefits of automation on employment and the creation of good jobs. To do so, we will be developing a research and engagement platform for inclusive automation that is global in scope and balances in-depth research with practical advice and insights for companies.

This issue brief is the first step of our investigation and shares emerging analysis and perspectives on the challenges and opportunities for business to create and preserve good jobs during an era of rapid technological change. With this brief, we seek to initiate a dialogue with companies and other partners on how to embrace the inevitable age of automation in a way that benefits a larger segment of society and creates value for business.

INCLUSIVE ECONOMY

BSR's Definition of an Inclusive Economy

BSR defines an inclusive economy as one in which all individuals and communities are able to participate in, benefit from, and contribute to global and local economies. In particular, an inclusive economy contributes to individuals' ability to lead prosperous, dignified lives while supporting broad-based economic growth. BSR defines businesses' role as focusing on three pillars of an inclusive economy:

- (1) Creating and supporting good jobs across the value chain
- (2) Facilitating access to critical goods and services, especially for marginalized groups
- (3) Investing for prosperous communities

For more information see BSR's Inclusive Economy initiative: <http://www.bsr.org/en/topics/all-channels/Inclusive-Economy>.

Automation Trends and Production

Many experts argue that this era of technological change is different than anything experienced in the past. While the technology associated with the industrial revolution transformed the labor market, experts predict that this second machine age will have even more profound effects on everyday life and industry.⁵

Technology is getting “smarter,” taking on more cognitive abilities and tasks once thought to be reserved for people. This sophistication, combined with the global reach and speed of change and adoption of technology, is changing the way goods are produced and services are delivered with a range of implications for labor markets around the world.⁶

This Era of Machine Capital

Automation in light and heavy manufacturing is nothing new. Even agriculture has seen its fair share of automation in areas such as irrigation, feeding systems, and mechanical harvesting. However, in the last few years declining costs, combined with advances in computing power, have made automation more accessible to small and large companies—particularly in developing and emerging markets—increasing the speed and scale of technology uptake.

At the same time, more disruptive technological changes are being introduced and changing the way goods are produced.⁷ This is affecting a wide range of industries, from heavy and light manufacturing to retail and food service. Some of the key trends defining this era of automation that are particularly relevant to labor-intensive industries like manufacturing include:

- » *Intelligent Robotics:* As they become smarter, faster, and cheaper, robots are doing tasks beyond the traditional repetitive, onerous, or even dangerous tasks such as welding and materials handling. Robots now have heightened cognitive abilities and greater dexterity and sensing, enabling them to do a great range of tasks and raising new questions about human capabilities versus machines and areas where they work side by side or collaborate.⁸

⁵ Institute for Public Policy Research, 2015

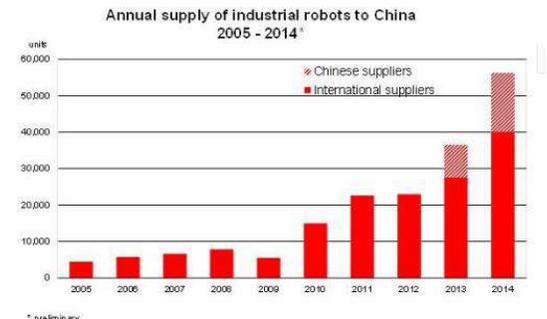
⁶ Anderson and Smith, 2014

⁷ This list draws from two major sources, including the 12 disruptive technologies identified by McKinsey Global Institute and the Oxford Martin School's Carl Benedikt Frey and Michael Osborne's major technology trends of the 21st Century. Some people may include other trends and classify these technologies differently. In fact, in many cases, these technologies are applied in tandem

⁸ PwC and the Manufacturing Institute, 2014

There are an estimated 1.5 million robots around the globe—including about 230,000 in the United States alone—enabling great gains in productivity and performance, particularly in manufacturing.⁹ According to the International Federation of Robotics, China is the fastest-growing market for robots and is anticipated to install more manufacturing robots than any other country by 2017.¹⁰ According to McKinsey, the number of industrial robots installed globally by 2025 could reach 25 million.¹¹

Figure 2: Annual Supply of Industrial Robots to China



Source: International Federation of Robotics

- » **Additive Manufacturing:** This includes 3D printing and other technologies that enable sequential layering of materials to create prototypes as well as final products. Manufacturers across a broad spectrum of industries, including automotive, aerospace, dental, high tech, and medical products, are actively piloting 3D printing technologies as costs decrease and demand for customized products increase.¹² By making small-scale production as efficient as large-scale production, this technology could enable micro-manufacturing sites where businesses operate in small-batch production with shorter lead times.¹³ This has the potential to transform labor-intensive manufacturing and undo the logic of global supply chains, as labor cost advantages become less important in determining production locations.

Although the jobs replaced by 3D printing are not anticipated to be of the same magnitude as many other technologies, at least for the foreseeable future, it could significantly reduce the human involvement in the manufacture and assembly of finished goods. At the same time, additive manufacturing has already proven to enhance worker capabilities and productivity by producing tools customized to worker needs or parts replacement.¹⁴ Sales of personal 3D printers grew between 200 and 400 percent per year between 2007 and 2011.¹⁵ This growth is expected to continue, with estimates that sales will total \$3.1 billion worldwide by 2016 and more than \$5 billion by 2020.¹⁶

⁹ PwC and the Manufacturing Institute, 2014

¹⁰ International Federation of Robotics, 2015

¹¹ Auschitzky et al., 2014

¹² Manyika et al., 2013

¹³ Chambers, 2013

¹⁴ *The Economist*, September 7, 2013.

¹⁵ Manyika et al., 2013

¹⁶ McCue, 2012

- » *Remote Connectivity*: Remote connectivity with the help of wireless devices, Virtual Private Networks, and mobile applications is helping everyone from small-scale farmers to boardroom executives access information and connect with buyers, sellers, and production managers in distant locations with incredible speed and minimal incremental costs. In doing so, it is eliminating the need for extensive travel to support remote locations to monitor production. It is also allowing employers to access specialized skills and 24-hour productivity by leveraging people from around the world. This can lead to downward pressures on wages due to the ease of shifting remote jobs to lower-cost locations; on the other hand, it can also boost job opportunities in rural economies.

Today, three billion people are connected to the web and more than 1.1 billion people currently use smartphones and tablets.¹⁷ By 2020, some experts estimate that 90 percent of the world's population over the age of six will have a mobile phone.¹⁸ By bringing millions more into the connected world, mobile connectivity and the internet could enable more people to participate in the formal economy.

- » *Advanced Analytics*: Companies across many industries are employing advanced analytics, also known as Big Data, to automate complex tasks. In manufacturing, operations managers can use advanced analytics to identify patterns and relationships among discrete process steps and inputs, and then optimize factors that have the greatest effect on outputs. Some companies report that trends like advanced analytics are improving operational performance by helping diagnose and correct process flaws, increase yields, and reduce waste and the need for certain material inputs.¹⁹ The availability and processing of large and complex data sets are also increasing the types of work susceptible to computerization as they substitute for some of the implicit knowledge of human workers.²⁰

Research by IDC for the ICT company, EMC, projects that from 2013 to 2020, the digital universe will grow by a factor of 10—from 4.4 trillion gigabytes to 44 trillion gigabytes. It also predicts that by 2020, developing economies will create and replicate more data than mature markets.²¹

- » *Internet of Things*: In the coming decade, sensors and actuators may be embedded in almost every type of machine and physical asset. This is enabling new ways of monitoring and managing all the “moving parts” that make up a business, from air temperature and quality to the flow of goods or materials through plants, distribution centers, and even onto store shelves.²² This provides manufacturers a number of benefits in terms of operational efficiency, precision, and transparency. It could also create new jobs as well as improve existing jobs by enhancing worker productivity.²³

¹⁷ Manyika et al., 2014

¹⁸ Tett, 2015

¹⁹ Auschitzky et al., 2014

²⁰ Frey and Osborne, 2015

²¹ IDC, 2014.

²² Frey and Osborne, 2015

²³ Chiu, Löffler, and Roberts, 2010

Sales of sensors have grown by 70 percent annually since 2010. In 2013, an estimated nine billion “things” were connected around the world. The estimates of what this number will be by 2025 vary from 50 billion to one trillion.²⁴ It is estimated that 80 to 100 percent of all manufacturing could be using Internet of Things applications by 2025.²⁵

The Changing Nature of Production

These technologies are helping companies respond to increasing competition, growing scarcity of natural resources, rising labor and material input costs, fill labor shortages, and increasing consumer demand for products that can be customized and delivered without long lead times. Interviewees highlighted automation’s particularly important role in raising productivity and precision in manufacturing.

However, just because automation is possible doesn’t mean it will necessarily happen on a massive scale. Company decisions depend on a number of factors including wages, regulation, and ease with which tasks can be automated. In many cases the benefits of human labor for many tasks will outweigh the costs and benefits of machine capital, at least for a period of time, particularly in developing countries. According to David Autor, an economist at the Massachusetts Institute of Technology (MIT), “the mere fact that a job can be automated does not mean that it will be; relative costs also matter. When Nissan produces cars in Japan, he notes, it relies heavily on robots. At plants in India, by contrast, the firm relies more heavily on cheap local labor.”²⁶

Many of our interviewees indicated that the decision to automate varies significantly by industry and country. For example, about 80 percent of all the work involved in manufacturing a car is said to be done by machines.²⁷ In some industries, however, the volume is too low to make automation worthwhile or the product line changes too rapidly in response to new demand or innovation.²⁸

Garment manufacturing has had a slower rate of adoption partly due to lower wages in production locations but also the detailed and delicate nature of dealing with fabrics and the difficulty in automating tasks like assembling various pieces of fabric. However, this is slowly changing as companies test machine vision systems and other machines to track stitching and maneuver materials.²⁹

As many of the above technologies become more cost effective, convenient, and sophisticated, automation will become a more viable option in production. Moreover, increasingly volatile shipping costs and rising wages in many manufacturing countries are also changing the equation. Between 2000 and 2010, wages rose by 6 percent in developed countries but surged 86 percent in Asia.³⁰ Our research

²⁴ Manyika et al., 2014

²⁵ Ibid., 2013

²⁶ *The Economist*, January 18, 2014

²⁷ Knight, 2012

²⁸ Ibid

²⁹ *The Economist*, May 30, 2015

³⁰ ILO, 2012

revealed that China and Malaysia are automating quickly in response to rising wages and the need to maintain a competitive edge, particularly in ICT manufacturing.

With greater adoption of automation will come transformations in sourcing strategies, production processes, facility design and locations, and human resource strategies, among other essential business decisions. For example, some experts predict that as the total cost of ownership continues to fall for many technologies, the eventual result could be a “reshoring” and revival of local manufacturing, bringing production closer to the end buyer.³¹ Some speculate that General Electric’s decision to move some of its manufacturing of washing machines and heaters from China to a factory in Kentucky is a sign that these changes are already happening.³²

There are a host of other changes that are anticipated to occur. Some interviewees indicated that they could foresee smaller, modular factories designed to be more flexible to changing customer demands and the introduction of new technology. Other technologies could enable consumers to become producers or licensees for some products, creating a new network of small-scale, disaggregated manufacturers.

Automation is changing how, when, and where goods are produced and reshaping labor markets in the process. While technology is likely to enhance economic opportunities for many, viewing labor and technology as part of a zero-sum game could lead to short-term losses for workers and longer term implications for the economy and business.

³¹ Frey and Osborne, 2015

³² *The Economist*, January 17, 2013

Implications for Good Jobs

The pace, nature, and ubiquity of technological change will have significant impacts on job availability and quality, as well as on human capital needs and expectations of employers. However, not all technological changes are created equal, nor are the impacts of these changes likely to impact industries, regions, companies, and individuals equally.

This section provides some emerging perspectives and questions on how this era of technological change could impact the availability, access, and quality of jobs, particularly for lower-skilled workers in the production of goods. This is not intended to be a comprehensive summary of all of the ways automation will affect labor but rather to call attention to some of the key considerations worthy of further investigation for individual companies, industries, and countries.

Availability of Jobs

As with every era of technological change, some jobs will be replaced by machines while new jobs are created and existing jobs take on new and different tasks. Although experts argue that it is difficult to predict exactly which jobs will be affected, there is now greater clarity about the type of tasks automation will be able to perform in the near future, shedding new light on which categories of workers are at greatest risk.³³

Researchers at the Oxford Martin School predict that 47 percent of the U.S. workforce is at high risk of automation and that, after several years of decline in middle-income jobs, there is now a wider range of skill levels that are likely to be affected. In particular, low-skilled jobs beyond some of the already automated routine tasks are now at risk of being automated.³⁴ Similar trends are expected to occur in Europe.³⁵

For many countries that serve as sourcing locations for light manufacturing, the declining costs of automation applications could threaten millions of entry-level jobs.

A few years ago, Foxconn CEO Terry Gou anticipated that the Taiwanese contract manufacturing company, which has gained prominence as a crucial supplier to Apple, among others, will use robots and machines to complete 70 percent of its assembly line work.³⁶ Chinese electrical appliance manufacturer,

³³ Frey and Osborne, 2015

³⁴ Ibid., 2013

³⁵ Institute for Public Policy Research, 2015

³⁶ Kan, 2015

Midea, plans to cut 6,000 of its 30,000 workers by the end of 2015, and another 4,000 workers by 2018.³⁷ While these numbers are significant, it is important to put them into the context of the anticipated losses of manufacturing jobs in China due to labor cost competitiveness. By some estimates, China could lose up to 85 million manufacturing jobs to other countries. Within this broader context, it is highly possible that automation, by reducing labor costs, could actually serve as a factor in maintaining some manufacturing jobs in China.³⁸

Figure 3: Employment Share at Risk by Industry (United States)

Industry	Low Risk (%)	Med. Risk (%)	High Risk (%)
Accommodation & Food Services	2.8	10.5	86.7
Administrative & Support Services	1.6	36.2	62.2
Construction	21.6	19.8	58.6
Manufacturing	19.9	18.4	61.7
Mining, Quarrying, Oil & Gas Extraction	7.8	46.3	45.9
Real Estate and Rental & Leasing	0.7	32.0	67.2
Retail Trade	14.5	18.9	66.6
Transportation & Warehousing	5.5	19.4	75.0
Wholesale Trade	15.9	18.4	65.7

Source: Frey and Osborne, 2015

While the risk of job elimination is significant, automation will also create jobs—albeit different types of jobs—with a wide range of implications for different industries and geographies. It is anticipated that millions of jobs will be created or adapted to design, build, and maintain many of the machines that will be used in the economy. According to one study, global “robot-driven” job creation could reach 1.5 million through 2016.³⁹ While this number is small relative to the number of jobs expected to be eliminated, it represents part of a burgeoning industry with potential for growth.

According to a PricewaterhouseCoopers (PwC) survey of U.S. manufacturers, over one-third of manufacturers said that the biggest impact robots will have on the manufacturing workforce in the next three years is that they will lead to “new job opportunities to engineer advanced robots and robotic operating systems.”⁴⁰ Foxconn, highlighted above, has been producing its own industrial robots for several years, employing upwards of 1,600 employees in two factories producing 10,000 “Foxbots” a year.⁴¹

³⁷ Xuena, Li et al., 2015

³⁸ Ruan, 2013

³⁹ International Federation of Robotics, 2013

⁴⁰ PwC and the Manufacturing Institute, 2014

⁴¹ Luk, 2015

A survey of more than 4,800 enterprises revealed that the internet creates 2.6 jobs for every job that it has destroyed.⁴² This includes direct jobs created but also the indirect jobs that are created to support new industries and technology applications. In the United States, occupations such as Computer Network Specialists and Web Developers currently employ nearly 300,000 workers, respectively, and are expected to add another 94,200 jobs before 2022.⁴³

New jobs will also be created as a result of new business models such as the sharing economy and the circular economy that are aided and enabled by technology. A recent report from the Green Alliance and WRAP, a U.K.-based nonprofit organization dedicated to a sustainable resource efficient economy, predicted that a shift to the circular economy could create 200,000 new jobs in the U.K.⁴⁴ These leverage different skill sets and in some cases, promote new forms of work in remanufacturing and closed-loop recycling systems.

Access to Jobs

Determining whether automation will be a net job creator is only helpful to a certain extent. In the majority of cases, new jobs won't be a one-to-one substitute for old jobs, leaving many workers at a loss if they don't have the requisite skills. As in other eras of systemic change, overall employment figures could mask even deeper changes between different populations with different abilities to access new opportunities or be left behind as old models fade. One interviewee said that "new factories with a higher degree of automation aren't hiring line workers but rather industrial engineers."

On the one hand, automation trends are making the means of production accessible to more people, creating new economic opportunities. By enabling more people to access the same information, automation can level the playing field for people to enter the economy and access opportunities. Facilities such as "makerspaces" and tech incubators, for example, provide affordable, shared access to new technologies, tools, and mentorships, to support innovation and small-scale manufacturing.⁴⁵ This, alongside the sharing economy, is bringing more people into the economy through self-employment.⁴⁶

At the same time, as many of the jobs require more and complex skill sets, it could be difficult for lower-skilled, less-educated workers to access opportunities. This is concerning for men who no longer have easy entry to decent paying work but also to women, who make up the majority of the light manufacturing workforce and a significant portion of the agriculture workforce. While the number of female college graduates is growing in many countries, there remain significant gender gaps in education, particularly in areas of science, technology, engineering, and mathematics in both mature and development markets.⁴⁷

⁴² Pélissié du Rausas et al., 2011

⁴³ Frey and Osborne, 2013

⁴⁴ Morgan and Mitchell, 2015

⁴⁵ Tierney, 2015

⁴⁶ Frey and Osborne, 2015.

⁴⁷ ILO, 2013

Figure 4: Some Potential Labor Implications of Automation

	Positive	Negative
Job Availability	<p>New jobs are likely to be created to design, build, and repair new technology, particularly robots.</p> <p>New business models and industries are being created that could lead to both direct and indirect job creation, e.g., sharing economy.</p>	<p>A significant number of jobs are likely to be made redundant, including predictable, routine tasks but increasingly some higher cognitive tasks.</p> <p>New industries are expected to be less labor intensive or provide less reliable employment, thus reducing net job creation.</p>
Job Access	<p>Jobs may become more accessible for certain groups, such as women and people with disabilities, by overcoming social, cultural, and physical barriers to work. Technology could make the means of production more accessible to small-scale producers.</p>	<p>Lower-skilled and less-educated groups could face particular challenges in filling new higher-skilled roles if efforts are not made to help them grow needed skills.</p>
Job Quality	<p>Factory spaces may become cleaner and safer, and some of the most difficult and dangerous tasks may be mechanized.</p> <p>Repetitive motion injuries may be reduced, and sensors and other tools may be used to monitor health and air quality.</p> <p>Productivity gains, if passed on to workers, could drive higher wages.</p> <p>Technology can augment human skills, enabling workers to extend their own capabilities and learn new skills, providing more mobility.</p>	<p>More part-time work and contractor work could mean less access to formal employer benefits and weakened job security</p> <p>Downward pressure on wages as a result of competition with “cheap” machine capital could lead to income losses</p> <p>Reduction of available low-skill jobs could reduce negotiating power of workers in remaining low-skill positions</p>

Michael Osborne and Carl Benedikt Frey at Oxford Martin School, leading experts on technological change and work, argue that “the extent to which an individual gains or losses from automation will depend on their level of skill as well as the degree of “skill bias” embedded in new technology.”⁴⁸ Skill-biased technology refers to how much the technology favors higher skills.

Some jobs will remain beyond the reach of automation, at least for now. This includes, for example, work that requires creativity or moving in unpredictable settings and performing tasks requiring tactile feedback like placing fiberglass panels inside airplanes, boats, or cars.⁴⁹

⁴⁸ Frey and Osborne, 2015

⁴⁹ Markoff, 2012

Quality of Jobs

Automation could make certain jobs more attractive and advance the well-being of workers.

Rather than expose humans to health and environmental risks, robots could, for example, fill the least attractive, most physical, and unsafe jobs.⁵⁰ In agriculture, robots are already taking on some of the most physically demanding work and tasks that deal with hazardous materials.⁵¹ One interviewee shared how automated fabric-cutting machines have helped reduce hand injuries in garment manufacturing. There is evidence that automation, particularly if conceived from the very beginning, can make factories cleaner and safer.

“

We need to find a balance—there are things that technology can do to improve workers’ lives but we need to help them keep the benefit of the productivity and efficiency gains from automation.

– Garment manufacturing supplier

”

Interviewees noted that as sensors are increasingly being used on product lines to pinpoint problems and improve efficiency, they could also be used to prevent repetitive motion injuries. One interviewee argued that “from a management perspective these sensors are not necessarily being used to make workers’ lives easier but rather to get production out the door. However, there is so much potential to improve workers’ well-being with these sensors.”

However, the benefits of automation for workers’ health and safety aren’t always evident. Interviewees noted that many of the intricate yet physically grueling jobs such as the cleaning and grinding of castings in manufacturing still require humans.⁵² Although there is evidence that more robots are being designed for human-machine collaboration with various safety systems, there are still plenty of risks of injuries or exposure to hazardous waste that could come from greater automation in factories. Robots had previously been surrounded by cages, but as this generation of robots takes on more autonomy and mobility, there is some increased risk of injury due to collisions or machine malfunctioning.⁵³

⁵⁰ Knight, 2014

⁵¹ *The Economist*, December 10, 2009

⁵² Thakkar, 2009.

⁵³ Markoff and Miller, 2014

By increasing individual productivity, technology could lead to higher incomes. While there can often be a lag of several years between the introduction of new technology and productivity gains, adopting automation technology has shown to increase productivity and revenue per employee,⁵⁴ particularly when technology is augmenting and extending human skills.⁵⁵ If employers pass on these gains to employees, this could increase income levels.

Figure 5: BSR's Definition of a Good Job



Moreover, jobs in the technology industry may offer higher salaries. As part of its Digital Jobs in Africa initiative,⁵⁶ the Rockefeller Foundation found that in countries like Zambia and Ghana jobs in the ICT sector provide higher than average wages. For example, youth wages for jobs in one of Ghana's technology programs are 5.5 times higher than the official minimum wage and are less volatile than much of the informal work available for most youth.⁵⁷ While these aren't necessarily in manufacturing or other labor-intensive industries, this could apply to many of the jobs needed to support greater automation in manufacturing. However, capturing these opportunities requires significant investments in education and skills.

⁵⁴ Frey and Osborne, 2015.

⁵⁵ Davies, Fidler and Gorbis, 2011

⁵⁶ Digital Jobs in Africa Initiative, The Rockefeller Foundation, 2015

⁵⁷ Dalberg and The Rockefeller Foundation, 2013

As machines become more cost effective, however, it may be harder for human capital to compete, which could lead to downward pressure on wages. Real median wages have stagnated in about half of all OECD countries since 2000 and, as noted earlier, many countries have witnessed significant declines in labor's share of GDP.⁵⁸ With many companies viewing automation as a way to lower labor costs, workers may find themselves in the position of having to choose between unemployment and lower wages. In advanced economies, the hollowing out of employment has caused middle-skilled workers to seek lower-skilled and lower-paid jobs, creating more competition for these jobs⁵⁹.

With automation, companies may look for more agile workforces that can change roles or locations easily. Technology has enabled much more “on-demand employment,” which in the majority of cases is part-time or contractor work that can be unreliable and offer limited access to employer-sponsored benefits and weak protection under traditional employment law. According to the U.S. Bureau of Labor Statistics, the number of “temporary-help services” workers has grown by 50 percent since 2010.⁶⁰ Recent legal battles in the United States around the status of Uber drivers as employees or contractors highlights the importance of sorting out thorny issues around ensuring respect for workers' rights.⁶¹

At the same time, technologies like remote connectivity allow workers to work from anywhere, providing independence and potentially better work-life balance. For example, online work has enabled women in India to earn cash while caring for children and elderly family members. Egyptian women from traditional households report using online freelancing as an alternative to working in male-dominated workplaces.⁶²

It is clear that technology will have significant impacts on workers and the nature of work. Just as it could eliminate many jobs, it could potentially create new and possibly better jobs. Whether and how lower-skilled people access those jobs remains to be determined. Technology is also creating new models of informal or contract work that can enhance people's livelihoods, but it can also serve as an inadequate replacement for previously held jobs in the formal sector.

⁵⁸ Frey and Osborne, 2015

⁵⁹ Autor and Dorn, August 24, 2013

⁶⁰ Thompson, 2015

⁶¹ Isaac and Singer, 2015

⁶² Kuek et al., 2015

Challenges and Opportunities for Business

Enabling more people to benefit from this era of technological change is in the best interest of business. Ensuring automation provides broad-based benefits to society—including the creation and preservation of good jobs—is essential to creating a strong talent pipeline that can foster innovation and capture the productivity gains presented by automation. Moreover, good jobs are a fundamental part of prosperous and resilient communities and vibrant economies, which are conditions for business success.

Continuing to invest in technology and automation without considering the impacts on the current and future labor force could lead to a host of operational and reputational risks as well as missed opportunities for business growth, productivity, and innovation. This section provides some perspectives on why it is important for companies to prepare and respond to this era of technology change in a way that creates broad-based benefits for society.

Accessing Talent and Innovation

As noted earlier, major automation trends will likely require new or enhanced skills among current and future workers. The Institute for the Future (ITFF) has identified 10 skills that are essential for the future workforce. It includes sense-making and social intelligence skills, which it believes will be in high demand as smart machines take over rote, routine manufacturing and services jobs. Workers that can harvest critical insights to inform decision-making and assess the emotions of those around them and adapt their words, tone, and gestures accordingly will also be in high demand. ITFF also identified quantitative reasoning skills and design mindset as increasingly attractive.⁶³

Finding people with the right skills to fill many of the jobs created by technology could present human capital challenges for companies, particularly for certain industries that are already facing talent pipeline issues. PwC's latest Manufacturing Barometer survey found that difficulty finding/hiring skilled workers with robotics experience was the second greatest barrier to acquiring more robotics systems after cost.⁶⁴ The McKinsey Global Institute projects that the United States alone faces a shortage of 140,000 to 190,000 people with analytical expertise and 1.5 million managers and analysts with the skills to understand and make decisions based on the analysis of Big Data.⁶⁵

⁶³ Davies, Fidler, and Gorbis, 2011

⁶⁴ PwC, 2015

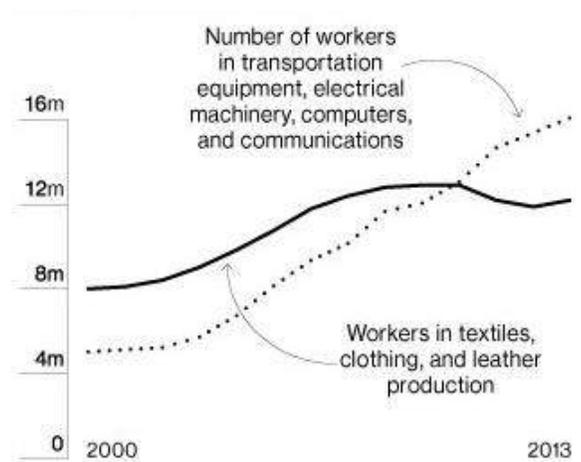
⁶⁵ McKinsey Global Institute, 2015

While Asia and the Pacific accounts for almost half of global unemployment, 45 percent of employers in the region face difficulty in finding suitable talent in their markets, according to the Asian Development Bank.⁶⁶

Chinese policymakers have set a target of 9 percent annual growth in the production of more sophisticated goods under its strategy of *tenglong huanniao*, which is intended to move away from low-cost manufacturing.⁶⁷ However, there are difficulties in recruiting enough skilled technicians to fill these jobs. The Chinese machinery sector alone projected a gap of 600,000 computer-automated machine tool operators in 2014, according to Reuters.⁶⁸

In an interview with BSR, Liang Xiaohui of the China National Textile and Apparel Council noted that investments in building skills are an important part of China's strategy. "We have to evolve to a higher stage of the supply chain to compete," he argued. "Getting there will take two critical elements: The first one is to be innovative, for instance, upgrading technologies in manufacturing, and the second is building a workforce of people that can effectively work with and work for innovations. To support our efforts to upgrade our industry, we have to build up our human resources potential and give people, especially existing textile workers, more opportunities to learn expertise and skills."

Figure 6: Job Shifts in China



Source: Bloomberg Business

The existence of high unemployment while jobs remain unfilled raises serious questions about the need for structural changes to ensure a better match of talent to the changing needs of the economy. Most academic experts believe that our current educational system is not adequately prepared to meet these needs. According to the European Commission, some 47 percent of European workers have insufficient digital skills and 23 percent have none at all.⁶⁹ In California, computing-related jobs outnumber annual Computer Science graduates by 16 to 1.⁷⁰

As a source of innovation and productivity, companies that don't invest in building the right skills for current and future workforces could find it difficult to stay competitive.

⁶⁶ Asian Development Bank, 2012

⁶⁷ Roberts, 2013

⁶⁸ Blanchard and Li, 2014

⁶⁹ Frey and Osborne, 2015

⁷⁰ Code.org, <http://code.org/promote/ca>

“

We tend to think that new technology can only be operated by new people in school. However, we should be thinking about how to retrain workforces while also addressing the education system.

– Technology designer

”

Maintaining Positive Community Relations and Social License to Operate

The anticipated elimination of jobs could lead to “stranded human assets,” workers who are displaced by changes to existing production models. Rising unemployment and a smaller share of workers capturing a larger share of the pie could affect social cohesion and pose reputational and operational risks for companies in the communities where they operate.

The World Bank has documented numerous cases where unemployment and/or downsizing of operations in communities (not necessarily as a result of automation) led to mistrust and disengagement in community life, all of which have implications for company relations with communities and social and economic progress.⁷¹ While not directly the result of automation, any downward pressure on wages or cost-saving labor cuts can threaten community trust and civic engagement and challenge companies’ social license to operate.

Cities like Youngstown, Ohio and Detroit, Michigan show how once bustling communities and vibrant local economies can suffer both economic disruption and social and cultural breakdown from a broad-scale decline in manufacturing employment. *The Atlantic* recently reported how Youngstown went from one of the highest median income and homeownership rates in the United States, during the height of steel manufacturing, to chronic economic depression after jobs moved to new manufacturing locations. Within five years, the city lost 50,000 jobs and \$1.3 billion in manufacturing wages and saw depression, spousal abuse, and suicide become more prevalent.⁷² While this wasn’t driven by automation, if offshoring is “a way station on the road to automation,” as some experts have argued,⁷³ it is not unreasonable to anticipate that some current manufacturing centers around the world could see similar fates.

⁷¹ World Bank, World Development Report 2013

⁷² Thompson, 2015

⁷³ Brynjolfsson, McAfee, and Spence, 2014

This is important for companies who are considering eliminating jobs because they could see a rapid erosion of the goodwill established with communities. It is also important for companies that wish to install new operations or facilities that offer few employment opportunities. It is highly likely that these companies could face both regulatory and community resistance. The importance of creating income-generating opportunities in local economies has long been and will remain an important part of gaining local community support for large-scale capital investments and securing contracts with local governments.

This could also affect companies that are expected to absorb workers who are displaced. Interviewees indicated that many of the manufacturing workers who have lost their jobs due to changes in factory location most likely moved into low-skilled retail jobs or informal work. An influx of workers in these industries could change the broader dynamic between business and local stakeholders.

Assessing and mitigating the impacts of automation on communities and local economies is critically important to maintaining reputation, ensuring compliance with local laws, and contributing to prosperous local communities.

Changing Employee Engagement and Productivity

Automation has the potential to significantly increase productivity, employee communication, and engagement, particularly if linked to higher wages and opportunities to build skills and enhance mobility potential. However, capturing these gains will only happen if a conscious effort is made to address the needs and issues facing employees. At a broad level, helping workers adjust to a new work environment that is being automated will be important to maintain worker morale, engagement, and productivity.

Automation will inevitably result in some job elimination. While the amount of labor on factory floors and in agricultural production is likely to decline with widespread automation, workers will not disappear entirely. In many cases, jobs will be eliminated over time, thus affecting the morale and engagement of employees who remain, especially in cases where machines replace workmates.

Further adjustments will be required to build the skills of remaining workers, particularly if they are in limited supply in the labor market. Companies taking a thoughtful, balanced approach to reducing workforces, alongside retention strategies bolstered by technical training and upskilling, will navigate the process most effectively.

To enhance engagement and morale of remaining employees, a conscious effort should be made to share productivity gains with employees. One interviewee noted that “if you are trying to increase productivity and reduce costs, the obvious people who will suffer are the factory workers. We need to think of productivity in larger terms to keep employees happy.” When productivity gains happen, there is a tendency to reinvest them in capital improvements and expect more in terms of efficiency; passing on such gains to workers in form of higher wages is less common.

Promoting Consumer Demand and Long-Term Growth

Labor-intensive manufacturing has been an important engine of economic growth for many economies. It was essential to China's economic transformation and provided a route out of poverty for millions of people. In Bangladesh, the textile and Ready-Made-Garments industry is the largest employer in the country, employing more than 3 million people, the majority of whom are women. This has played a significant role in reducing the poverty rate in the country from 56 percent in 1992 to less than 32 percent just two decades later.⁷⁴ If automation leads to a shift away from labor-intensive manufacturing and contributes to rising unemployment, there could be significant macro-level, long-term impacts on the global economy.

In its "Outlook on the Global Agenda 2015," the World Economic Forum calls out rising income inequality and persistent jobless growth as the two most important economic trends facing the global economy.⁷⁵ These factors can have a corrosive effect on the economy and on business success, partly by depressing purchasing power of the majority and undermining the tax base.⁷⁶

This context could present significant challenges for business if total net employment declines. The International Labor Organization estimates that in the next 10 years, the world will need more than 600 million more jobs to avoid a further increase in unemployment.⁷⁷ The situation is particularly concerning for women and youth who make up the majority of the more than 200 million currently unemployed.

While technology has traditionally tended to be a net job creator, this era of technology change appears to be creating more labor-efficient industries, which limits opportunities for millions of existing and potential low-skilled workers. Automation could thus exacerbate the current economic ills, lowering aggregate demand with significant impacts on business.⁷⁸

Viewing human capital as a cost rather than an investment could pose short- and long-term challenges for companies. At the same time, viewing automation as a way to augment and extend the capabilities of workers could make automation a win for both workers and business.

⁷⁴ World Bank, World Bank Data Bank, <http://databank.worldbank.org/data/home.aspx>

⁷⁵ World Economic Forum, 2015

⁷⁶ Davis Pluess and Racheal Meiers, 2015

⁷⁷ ILO, 2012

⁷⁸ Frey and Osborne, 2015

BSR's Approach to an Inclusive Economy in the Age of Automation

We believe that business has a responsibility, opportunity, and self-interest in ensuring the economy works for everyone. Business benefits when the economy continues to create good jobs and build prosperous communities while also promoting technological innovation that creates new forms of value for business and society.

Ensuring that companies and current and future workforces are prepared for this era of major technological change is essential for creating an inclusive economy. This means not only mitigating the negative impacts of technology but also harnessing it as a powerful driver of economic opportunity and improved well-being.

Under our Inclusive Economy initiative, BSR will be investigating how major technological forces will affect employment, particularly related to lower-skilled and vulnerable workers and groups, and the role and opportunities for companies and other stakeholders in creating and ensuring good jobs in the age of automation. Our approach includes three key elements:

- » **INSIGHTS on risks and opportunities for business and labor:** Strengthen private sector awareness and understanding of the potential risks and opportunities for workers and business of major trends in automation.
- » **INTEGRATION into business strategy and operations:** Develop practical tools and resources to enable companies to generate innovative business solutions while also mitigating the negative impacts on workers and harnessing the opportunities of automation to advance worker well-being and business value.
- » **COLLABORATIVE action:** Create a platform for dialogue and cross-sector collaboration to prepare current and future workforces to manage transition and embrace the opportunities presented by automation.

We intend to focus this work on agriculture and light and heavy manufacturing—all sectors that have traditionally relied upon large pools of low-skilled labor and that currently generate significant employment around the world through direct operations and supply chains. By focusing here we will be able to most effectively leverage BSR's expertise and networks and prioritize some of the most vulnerable workers in our global economy.

A first step of this work will be providing **insights** through a research and engagement platform that looks at several key industries and geographic regions that are likely to see increasing automation over the coming decades. For each industry, we will investigate:

1. **How automation is changing production:** This includes understanding *at an operational level* the nature and pace of technological change and adoption, policy and other incentive structures that are supporting adoption, and how this is reshaping (or could reshape) production processes, systems, and sourcing strategies. Through interviews and stakeholder workshops with technology creators and distributors, technology users (e.g., manufacturers, agricultural producers), and user influencers (e.g., international buyers, governments), we will seek to answer questions such as: What are the major technology trends changing the shape of production in our priority industries? How are workforce implications (e.g., skill upgrading, job elimination) being considered (or could be considered) in the design, development, and adoption of these technologies?
2. **How automation is impacting the creation of good jobs and worker well-being:** Drawing on BSR's rich history of promoting fair employment conditions, we will seek to understand the potential impact of identified changes to production on the well-being of the current workforce and the creation of good jobs in the future. This will include engagement with government, civil society organizations, and workers themselves to help answer questions such as: What are the likely impacts of automation on the quality of employment? What are the key needs of the workforce to enable them to capitalize on technological change? What safeguards and incentives are needed to ensure workers' rights are protected?
3. **How business and labor can capture the opportunities and mitigate the risks created by automation:** BSR will use the results above to identify key priorities for various industries and engage in dialogue with companies and other key stakeholders on practical and action-oriented solutions. This includes identifying ways that companies can use their policies, investments, capabilities, and influence to embrace the inevitable age of automation in a way that creates more opportunity and benefits for more people, and value for business. Some questions we plan to explore include: What internal and external incentives are needed for companies to adopt labor-augmenting technology? How could a human-rights impact assessment identify and mitigate risks to labor from the introduction of automation at scale?

We look forward to working with BSR companies and partners to ensure that the benefits of this era of technological change are shared widely by society and strengthen economic and social progress.

References

- Anderson, Janna and Aaron Smith. 2014. "AI, Robotics, and the Future of Jobs." <http://www.pewinternet.org/2014/08/06/future-of-jobs/>
- Asian Development Bank. 2012. "Asia Must Close Skills Gaps, Go High Tech to Sustain Future Growth." <http://www.adb.org/news/asia-must-close-skills-gaps-go-high-tech-sustain-future-growth-ADB>
- . 2013. "Beyond Factor Asia: Fueling Growth in a Changing World." Background Paper for the Asian Development Bank. 2013 Annual Meeting Governors' Seminar. <http://www.adb.org/sites/default/files/publication/30223/beyond-factory-asia-fuelling-growth.pdf>
- Auschitzky et al. 2014. "How big data can improve manufacturing." McKinsey Global Institute. http://www.mckinsey.com/insights/operations/how_big_data_can_improve_manufacturing
- Autor, David and David Dorn. 2013. "How Technology Wrecks the Middle Class." New York Times. August 24. http://opinionator.blogs.nytimes.com/2013/08/24/how-technology-wrecks-the-middle-class/?_r=0
- Blanchard, Ben and Hui Li. 2014. "China taps tech training to tackle labour market mismatch." *Reuters*. June 8. <http://in.reuters.com/article/2014/06/08/uk-china-labour-education-idINKBN0EJ01Q20140608>
- Brynjolfsson, Erik and Andrew McAfee. 2014. *The Second Machine Age: Work, Progress, and Prosperity in a Time of Brilliant Technologies*. New York: W.W. Norton & Company.
- Brynjolfsson, Erik, Andrew McAfee, and Michael Spence. 2014. "New World Order." *Foreign Affairs*. <https://www.foreignaffairs.com/articles/united-states/2014-06-04/new-world-order>
- Chalmers, Jim. 2013. "3D printing: not yet a new industrial revolution, but its impact will be huge." *The Guardian*. <http://www.theguardian.com/commentisfree/2013/dec/11/3d-printing-not-yet-a-new-industrial-revolution-but-its-impact-will-be-huge>
- Chui, Michael, Markus Löffler, and Roger Roberts. 2010. "The Internet of Things." McKinsey Global Institute. http://www.mckinsey.com/insights/high_tech_telecoms_internet/the_internet_of_things
- "Coming Home." 2013. *The Economist*. January 17. <http://www.economist.com/news/special-report/21569570-growing-number-american-companies-are-moving-their-manufacturing-back-united>
- Dalberg and the Rockefeller Foundation. 2013. "Digital Jobs in Africa: Catalyzing Inclusive Opportunities for Youth." <http://www.rockefellerfoundation.org/report/digital-jobs-in-africa-catalyzing-inclusive-opportunities-for-youth/>
- Davies, Anna, Devin Fidler, and Maria Gorbis. 2011. "Future Work Skills 2020." Institute for the Future. <http://www.iff.org/futureworkskills/>
- Davis Pluess, Jessica and Racheal Meiers. 2015. "Business Leadership for an Inclusive Economy." BSR Working Paper. <http://www.bsr.org/en/our-insights/report-view/business-leadership-for-an-inclusive-economy-a-framework-for-collaboration>
- Deloitte. 2014. "Value of Connectivity: Economic and Social Benefits of Expanding Internet Access." http://www2.deloitte.com/view/en_GB/uk/industries/tmt/extending-internet-access/index.html
- Digital Jobs in Africa Initiative, The Rockefeller Foundation. 2015. <http://www.rockefellerfoundation.org/our-work/initiatives/digital-jobs-africa/>

- Farrel, Michael. 2014. "New Lawsuit Claims Uber Exploits its Drivers." Boston Globe. <http://www.bostonglobe.com/business/2014/06/26/uber-hit-with-class-action-lawsuit/JFITJLMuBoXuEmMU3eITAI/story.html>
- "Fiels of Automation." 2009. *The Economist*, December 10. <http://www.economist.com/node/15048711>
- Frey, Carl Benedikt and Michael Osborne. 2013. "The Future of Employment: How Susceptible Are Jobs to Computerization?" http://www.oxfordmartin.ox.ac.uk/downloads/academic/The_Future_of_Employment.pdf
- . "Technology at Work: The Future of Innovation and Employment." 2015. Oxford Martin School and Citi. <http://www.oxfordmartin.ox.ac.uk/downloads/reports/Technology%20at%20Work.pdf>
- IDC. 2014. "The Digital Universe of Opportunities: Rich Data and the Increasing Value of the Internet of Things." <http://www.emc.com/leadership/digital-universe/2014iview/executive-summary.htm>
- ILO. 2012. "Global Employment Trends 2012: Preventing a deeper jobs crisis." http://www.ilo.org/wcmsp5/groups/public/@dgreports/@dcomm/@publ/documents/publication/wcms_171571.pdf
- . 2013. "Women and Technology – the attitude gap."
- Institute for Public Policy Research. 2015. "Technology, Globalization, and the Future of Work in Europe: Essays on Employment in a Digitized Economy." http://www.oxfordmartin.ox.ac.uk/downloads/academic/technology-globalisation-future-of-work_Mar2015.pdf
- International Federation of Robotics. 2013. "Positive Impacts of Industrial Robots on Employment." International Federation of Robotics and Metra Martech.
- . 2015. Global Survey 2014. <http://www.ifr.org/news/ifr-press-release/global-survey-703/>
- International Labour Organization (ILO). 2012. Global Wage Report 2102/13. Geneva: ILO. <http://www.ilo.org/global/research/global-reports/global-wage-report/2012/lang--en/index.htm>
- Isaac, Mike and Natasha Singer. 2015. "California says Uber driver is employee not a contractor." New York Times. http://www.nytimes.com/2015/06/18/business/uber-contests-california-labor-ruling-that-says-drivers-should-be-employees.html?_r=0
- Kan, Michael. 2015. "Foxconn expects robots to take over more factory work." PCWorld. <http://www.pcworld.com/article/2890032/foxconn-expects-robots-to-take-over-more-factory-work.html>
- Karabarounis, Loukas and Brent Neiman. 2014. "The Global Decline of the Labor Share." University of Chicago. http://faculty.chicagobooth.edu/loukas.karabarounis/research/labor_share.pdf
- Knight, Will. 2012. "This Robot Could Transform Manufacturing." MIT Technology Review. <http://www.technologyreview.com/news/429248/this-robot-could-transform-manufacturing/>
- . April 23, 2014. "Increasingly, Robots of All Sizes Are Workmates." MIT Technology Review. <http://www.technologyreview.com/news/526691/increasingly-robots-of-all-sizes-are-human-workmates/>
- Kuek, Siou Chew et al. 2015. "The Global Opportunity in Online Outsourcing." World Bank. <http://pubdocs.worldbank.org/pubdocs/publicdoc/2015/6/212201433273511482/Global-OO-Study.pdf>

- Luk, Lorraine. 2015. "Foxconn's Robot Army yet to Prove Match for Humans." Wall Street Journal. <http://blogs.wsj.com/digits/2015/05/05/foxconns-robot-army-yet-to-prove-match-for-humans/>
- McCue, T.J. 2012. "3D Printing Industry Will Reach \$3.1 Billion Worldwide by 2016." Forbes. <http://www.forbes.com/sites/tjmccue/2012/03/27/3d-printing-industry-will-reach-3-1-billion-worldwide-by-2016/>
- McKinsey Global Institute. 2015. "Big Data: The next frontier for competition." McKinsey Global Institute. http://www.mckinsey.com/Features/Big_Data
- Manyika et al. 2013. "Disruptive technologies: Advances that will transform life, business, and the global economy." McKinsey Global Institute. http://www.mckinsey.com/insights/business_technology/disruptive_technologies
- .2014. "India's Tech Opportunity: Transforming Work, Empowering People." McKinsey Global Institute. http://www.mckinsey.com/insights/high_tech_telecoms_internet/indias_tech_opportunity_transforming_work_empowering_people
- Markoff, John. 2012. "Skilled Work, Without the Worker." The New York Times. August, 18. <http://www.nytimes.com/2012/08/19/business/new-wave-of-adept-robots-is-changing-global-industry.html>
- Markoff, John and Claire Miller. 2014. "As Robotics Advances, Worries of Killer Robots Rise." New York Times. http://www.nytimes.com/2014/06/17/upshot/danger-robots-working.html?_r=0
- Morgan, Julia. and Peter Mitchell. 2015. "Opportunities to tackle Britain's labor market challenges through growth in the circular economy." WRAP and Green Alliance. <http://www.wrap.org.uk/content/employment-and-circular-economy>
- "The Onrushing Wave." 2014. The Economist. January 18. <http://www.economist.com/news/briefing/21594264-previous-technological-innovation-has-always-delivered-more-long-run-employment-not-less>
- Pélissié du Rausas, Mattieu et al., 2011. Internet matters: The Net's Sweeping Impact on Growth, Jobs and Prosperity. McKinsey Global Institute. http://www.mckinsey.com/insights/high_tech_telecoms_internet/internet_matters
- PwC. 2015. "Manufacturing Barometer April 2015. PwC. <http://www.pwc.com/us/en/industrial-manufacturing/barometer-manufacturing/index.jhtml>
- PwC and the Manufacturing Institute. 2014. "The New Hire: How a new generation of robots is transforming manufacturing." http://www.themanufacturinginstitute.org/~/_/media/4A8E6F46F17A48D6A1CA03D800F7A2C0/Robotics_Final_Report.pdf
- Roberts, Dexter. 2013. U.S. Electronics Maker Knowles Adapts to a Changed China." *Bloomberg Business*. December 13. <http://www.bloomberg.com/bw/articles/2013-12-19/u-dot-s-dot-electronics-maker-knowles-adapts-to-a-changed-China>
- Ruan, Victoria. 2013. "Robots on the Rise in China." South China Morning Post. <http://www.scmp.com/news/china/article/1249953/robots-rise-china>
- "A robotic sewing machine could throw garment workers in low-cost countries out of a job." 2015. The Economist. May 30. <http://www.economist.com/news/technology-quarterly/21651925-robotic-sewing-machine-could-throw-garment-workers-low-cost-countries-out>

- Siddhartha et al. 2013. "Connecting to Work." World Bank.
<http://www.worldbank.org/en/news/feature/2013/09/10/how-icts-are-expanding-job-opportunities>
- Tett, Gillian. 2015. "The Changing Face of Employment." Financial Times.
<http://www.ft.com/intl/cms/s/0/da7d15a2-a73f-11e4-8a71-00144feab7de.html>
- Tierney, John. 2015. "How Makerspaces help Local Economies." The Atlantic.
<http://www.theatlantic.com/technology/archive/2015/04/makerspaces-are-remaking-local-economies/390807>
- Thakkar, Ashwin, 2009. "Automation in Garment Manufacturing: Its likely impact on advanced and emerging economies." Presentation at the Conference on Steering Mature Business. A Leadership Challenge to the Textile Industry. <http://www.fibre2fashion.com/industry-article/22/2167/2167.pdf>
- Thompson, Derek. "A World Without Work." The Atlantic.
<http://www.theatlantic.com/magazine/archive/2015/07/world-without-work/395294/>
- "3D Printing Scales Up." 2013. *The Economist*. September 7.
<http://www.economist.com/news/technology-quarterly/21584447-digital-manufacturing-there-lot-hype-around-3d-printing-it-fast>
- The World Bank. 2013. "World Development Report 2013: Jobs."
<http://siteresources.worldbank.org/EXTNWDR2013/Resources/8258024-1320950747192/8260293-1322665883147/Chapter-4.pdf>
- World Economic Forum. 2015. "Outlook on the Global Agenda 2015." <http://reports.weforum.org/outlook-global-agenda-2015/>
- Xuena, Li et al. 2015. "China's Factories Are Building a Robot Nation." Caixin Online.
<http://english.caixin.com/2015-03-05/100788376.html>

About BSR

BSR is a global nonprofit organization that works with its network of more than 250 member companies to build a just and sustainable world. From its offices in Asia, Europe, and North America, BSR develops sustainable business strategies and solutions through consulting, research, and cross-sector collaboration. Visit www.bsr.org for more information about BSR's more than 20 years of leadership in sustainability.