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The Future of Work and the Trans-Atlantic Alliance

The State of Play and Pathways for U.S. German Cooperation

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I. Preface

In their not-so-distant predictions, futurists often foretell a world in which artificial intelligence (AI), big data, machine learning and automation dictate our lives. To some, this technological disruption leads to the elimination of work altogether or, at worst, robot domination. To others, this same change births a newly empowered professional class that derives its prosperity from coding and the servicing of robots. While neither of these visions has yet to come to fruition, momentous disruption has transcended national borders and is advancing across industries, regions and labor markets.

Less often discussed are the intermediate policy challenges and responses that lie on the path to the jobs and labor markets of the future. Indeed, labor market shifts are already making it more difficult for low- and semiskilled workers to find jobs and support families. Without swift action to prepare workers for the labor markets of the future, society may be forced to grapple with ever-spiraling unemployment and inequality, which could ultimately lead to geopolitical destabilization. But how exactly will labor market shifts play out in the short and medium term? How can public policy adapt to generate sound solutions in an era of ever-present technological disruption? Where can policymakers source best practices and tested initiatives?

Continued stability and prosperity hinge on rethinking public policy and redesigning institutions to mitigate this coming disruption. Policymakers face a rapidly narrowing window of opportunity to head off the existential challenges posed by the changing nature of work. The coming transition demands not only sheer political will but also awareness-raising among policymakers and the public. Indeed, recent scholarship highlights the crucial role of public policy – and engaged policymakers and citizens – in planning for coming labor market shifts.[1] At the same time, the consequences of those shifts will not respect borders, necessitating a discussion that extends beyond individual states' domestic policy arenas.

To set the stage for trans-Atlantic lesson-learning and collaboration regarding the key policy challenges related to the future of work, the Bertelsmann Foundation North America and the Stiftung Neue Verantwortung have partnered to produce this discussion paper, The Future of Work and the Trans-Atlantic Alliance: The State of Play and Pathways for U.S. – German Cooperation. The highly industrialized economies of the United States and Germany are the world's second and fourth largest producers of manufactured goods, respectively. They benefit from highly productive and well-trained workforces and a history of collaboration on topics ranging from trade to security, but they are also striving to understand the impact of new technologies and labor market shifts on their societies. With up to 47 percent of jobs in the United States and 42 percent of German employment threatened by "computerization," the two will be at the vanguard of coming labor market disruption. [2]

Recently, trans-Atlantic exchange on topics related to the future of work has broadened to include Germany's apprenticeship and vocational training models, elements of which are being implemented in the states of Florida, North Carolina and Iowa. [3] In addition, President Donald Trump and Chancellor Angela Merkel convened a White House roundtable on vocational education on March 17, 2017. From the U.S. side, trans-Atlantic exchange has included in-person and firm-to-firm exchanges on topics ranging from autonomous vehicles to 3-D printing.

While these exchanges are an encouraging first step, far greater cooperation will be needed to generate innovative policy. As the trans-Atlantic relationship evolves over the coming years, new pathways for the exchange of best practices vis-à-vis the future of work will be critical to ensure not only trans-Atlantic leadership, but also domestic peace and prosperity. As in years past, trans-Atlantic collaboration can serve as a crucial hedge against instability.

To frame the scope of future exchange between the United States and Germany, we first compare the dominant philosophies on and policy responses to the changing nature of work in both countries. By cataloguing these approaches, we illuminate underappreciated threats facing both cases. Next, we use two case studies to examine how labor market disruption is playing out in retail and advanced manufacturing, or Industry 4.0. Finally, we outline 10 "pathways forward" for future trans-Atlantic collaboration and exchange.

A) PHILOSOPHY AND DEBATE

In the United States, philosophical debate concerning the future of work has revolved around whether technology is replacing or displacing workers. The replace camp holds that – after hundreds of years of technological innovation and corresponding job creation – the labor market has reached a tipping point in which technology is substituted for workers. [4] On the other hand, supporters of the displace camp argue that technology merely shifts workers to other jobs, necessitating forward-looking public policy to retrain and educate the workforce. Nested between these two schools of thought, several overlooked yet significant trends are shaping debate and nascent policy responses.

In the United States, as in other liberal market economies such as the United Kingdom, debate over the future of work has been colored by the country's relatively early – and sharp – transition from manufacturing to services. [5] In 1960, one in four American workers was employed in manufacturing. Today, it's just one in 10, with the number of manufacturing jobs having dipped by 5 million since the year 2000. [6-7]

The blow to manufacturing employment has been softened by the creation of large numbers of jobs in the service sector, which now employs the lion's share of the American workforce. From 1960 to 2016, service employment skyrocketed from around 50 percent of the labor force to more than 71 percent. Most of these jobs have been created in the bourgeoning, knowledge-intensive service sector, which employed 102.6 million Americans in 2016. [8] This job growth has been fueled by David Autor's observation that "tasks that cannot be [directly] substituted by automation are generally complemented by it." [9]

While the transition from manufacturing to services has generated pockets of painful labor market disruption in the South and Midwest, the net number of jobs has increased due to the exponential growth in service sector employment, leading policymakers and citizens to expect continued (positive) labor market trends. Yet while the American economy has generated enough service jobs for the unemployment rate to stand at just 4.4 percent, these gains are increasingly failing to deliver stable incomes and sustained prosperity. [10] Since 2010, more than half of new jobs have been concentrated in positions that pay less than $52,000 a year. [11] As a consequence, academic and popular debate has drifted away from the effect of automation on the total number of jobs created or eliminated, and toward the quality – and wages – of jobs on offer. [12]

With the transition from a manufacturing- to a service-centered economy, firms have a built-in incentive to seek cost efficiencies across the sector through the introduction of technology. This has led to the acceleration of "job polarization" first articulated by Good and Manning in 2003, wherein the automation of routine tasks leads to a simultaneous growth in high-education, high-wage jobs and low-education, low-wage jobs. These gains come at the expense of middle-wage, middle-education jobs that have powered service sector employment since World War II. Recent scholarship has expanded to include the effects of labor and wage polarization on the American workforce and its consequences for the future of work. [13]

In taking stock of the shift from manufacturing to services and the continued bifurcation of the American labor market, it becomes clear that the immediate challenge posed by automation or computerization may not be the wholesale elimination of jobs. Rather,

automation and technology may decrease the availability and value of work itself by pushing down wages and the number of full-time jobs. Therefore, bifurcation in the labor market and ever-increasing automation may pose "distributional challenges" affecting legions of employed workers, necessitating the mobilization of public policy to chart a path forward. [14]

Somewhat paradoxically, the continued gravitation of the U.S. labor market to high-skill, high-wage and low-skill, low-wage jobs has, in the short term, focused public discourse – and early public policy responses – on the panacea of traditional and "smart" manufacturing. As a consequence, the public and most policymakers remain largely unaware of the looming threat posed to swaths of low- and mid-level jobs in the service sector.

B) FORCES SHAPING DEBATE AND POLICY RESPONSES

It is evident that digitization and automation will radically transform the American economy and workforce over the coming years. While automation and technology will increase productivity and create churn in the labor market, they will also reshape the range of skills and education demanded by employers. But, as outlined in a report by the Executive Office of the President in 2016, these shifts will have an "uneven distribution of impact, across sectors, wage levels, education levels, job types, and locations." [15] The challenge for policymakers at all levels is clear: to update and create public policy that responds not only to the economic effects created by the future of work, but also to the complex social, political and ethical side effects that will accompany the transition.

To date, forward-looking policy responses in the United States have sought to address present and future disruption in the manufacturing and service sectors. In response to the economic downturn and collapse of U.S. automakers in 2008, then-President Barack Obama unveiled the Manufacturing USA strategy, geared toward developing workforce skills and creating 15 advanced manufacturing (Industry 4.0) institutes by the end of his administration. Much of this strategy was aimed at incubating and scaling so-called Industry 4.0 technologies, the job creation merits of which are discussed in Section IV of this paper.

Under the Obama administration, federal research and policy responses were driven by a recognition of U.S. dependence on the service sector as an engine of job creation, in addition to a broad acceptance that technological change and subsequent labor market disruption would reach far beyond the manufacturing sector. Therefore, beginning in 2016, the White House released a flurry of reports outlining the potential effect of automation on the U.S. economy. A White House report on "Artificial Intelligence, Automation, and the Economy," released in December 2016, notes that AI-driven automation will "be a significant policy challenge for the next Administration and its successors," and that it will be difficult to predict which sectors would be most affected.[16] The report's recommendations range from buttressing unemployment insurance to increasing the minimum wage, modernizing tax policy and introducing the German concept of work sharing as a hedge against labor market disruption.

However, the chief response from the U.S. government – and civil society – has been to focus on how skills and education can be "upgraded" to develop human capital for the jobs of the future. Under Obama, White House proposals ranged from long-term

strategies to increase preschool enrollment and teach computer science in high school, to making post-secondary education more accessible and affordable. [17] The Obama administration also placed heavy emphasis on workforce retraining and on doubling the number of apprenticeships available through the awarding of $225 million in grants in 2015 and 2016.

Since taking office on January 20, 2017, the Trump administration has included funding for apprenticeships within its 2018 budget request, and Trump himself has challenged CEOs such as Salesforces' Marc Benioff to generate up to 5 million apprenticeships within five years. [18] While it remains unclear if any of the Obama administration's proposals related to the future of work (other than apprenticeships) will move forward under the new administration, Trump's treasury secretary, Steven Mnuchin, has dismissed the threat posed by automation, stating that its labor market effects are likely to be "50 to 100 more years away." [19]

With a sea change in policy from the White House concerning automation and the future of work, civil society, states and cities will seize the initiative in crafting policy and implementing programs to ease the challenges posed by the future of work. For example, the Markle Foundation has launched Skillful, which aims to connect workers lacking four-year degrees to jobs in the digital economy. [20] Other efforts have focused on workers in the on-demand economy [21] and imagining scenarios for the future of work in cities. [22] This work has been complemented by research from organizations such as the National League of Cities, which has proposed specific recommendations ranging from improving the social safety net to adapting physical infrastructure in preparation for the future of work. [23]

Over the past several years, the U.S. government, states and civil society have come to recognize the breadth of the challenge posed by the future of work and have begun proposing broad policy frameworks and specific solutions. However, most of these policy proposals have come from the federal level and have been elite-driven, with little successful "bottom-up" policymaking. This is especially surprising as the responsibility for workforce development in the United States is mostly decentralized, with cities, counties and states taking the lead in equipping workers with more advanced skills. Furthermore, policy solutions have largely been generated within the vacuum of the U.S. context, creating a wealth of opportunity for international exchange and the cross-border exchange of best practices regarding the future of work. Finally, while high-level reports noting the coming effects of automation on the American workforce have raised awareness among elites, the future of work remains at most a blip in the constellation of policy challenges facing firms, individuals and local officials. Therefore, the first step to crafting sustainable solutions may be an awareness-raising campaign targeting these populations.

A) PHILOSOPHY AND DEBATE

In Germany, the future of work debate sits at the nexus of a much larger conversation involving technological change and digitization. As in the United States, the main drivers of structural change in the German labor market are automation and technology that increasingly leverage computing power, big data, AI and algorithms. Although the conversation in Germany is heavily influenced by scholarly and public debate in the United States and U.K. (referenced in Section II), there is one primary difference: whereas the U.S. debate tends to examine the evolution of the labor market through the prism of ongoing transitions in manufacturing and services, the German debate is fixated primarily on the threats – and opportunities – posed to manufacturing, the traditional driver of the German economy.

In contrast to the United States, Germany's economy is more geared toward the export of innovative manufactured goods with high value added, such as motor vehicles, chemicals, and machinery and equipment.[24] In 2016, Germany exported $1.327 trillion in goods, leaving the country with a record-high trade surplus of $277 billion. [25] Manufacturing accounts for roughly 30.4 percent of the German economy, a much larger share than in comparable OECD states such as France (19.5 percent), the U.K. (20.2 percent) and the United States (20.7 percent). [26] This cross-country comparison is frequently cited by policymakers in the future of work debate to emphasize the importance of manufacturing, [27] which is also a significant generator of employment: in 2016, the sector employed nearly 8.1 million workers, or 18.6 percent of the workforce (24.2 percent when employment in construction is included). [28-29]

The German debate and policy agenda concerning the future of work, therefore, has been driven primarily by industry, which sees a strategic, long-term interest in maintaining a globally competitive, export-oriented manufacturing sector. Through intensive lobbying and the use of well-established networks, industry representatives have ensured that the digitization of manufacturing is inseparable from larger questions of technological change and labor market disruption in, for example, the service sector. Indeed, until the Federal Ministry of Labor and Social Affairs launched its dialogue process on the future of work in 2015,[30] industry was the main force shaping debate on the topic.

To maintain its edge in manufacturing, Germany has aggressively pursued the digital transformation of the sector through initiatives such as Industry 4.0, which had its seeds in a 2011 essay by Kagermann, Lukas and Wahlster that urged German policymakers to pursue an industrial concept wherein traditional manufacturing would be ". . . replaced in the next decade with the Internet of Things through cyber-physical systems [Industry 4.0]." [31] Six years on, the Industry 4.0 concept, considered vital to future economic prosperity, has been incorporated into the Digital Agenda, through which the federal government shapes policy concerning technological change. Industry 4.0 has also been woven into the High Tech Strategy, [32] through which the government channels funding for applied research to move Germany toward "becoming a worldwide innovation leader." [33]

Although manufacturing – specifically Industry 4.0 – has disproportionately influenced German debate on the future of work, it should be evident that, as in the United States, the labor market disruption caused by technology and automation will extend far beyond

manufacturing. Yet the narrow focus on manufacturing has meant that policymakers and the public have largely ignored the impact of technology and automation on the service sector, which in 2016 employed 32.3 million workers, or 74.3 percent of the German workforce.[34] Service subsectors such as finance and insurance generate as much as 26 percent of gross value added (GVA) – matching and even exceeding the share of GVA produced by manufacturing.[35] Policymakers and the public have only recently started to recognize the potential impact of automation, computerization, algorithms and AI on service sector jobs. [36]

In Germany, automation and technological change have recently generated a great deal of literature and debate among policymakers and the public. Frey and Osborne's 2013 study concluding that 47 percent of U.S. employment could be subject to automation elicited a strong reaction from German policymakers and catalyzed domestic research into the effect of automation on the German workforce.[37] Since 2013, several publications analyzing the impact of automation and technological change on the German labor market have calmed initial fears generated by Frey and Osborne's study.

First, a follow-up study by the Centre for European Economic Research in Mannheim – commissioned by the Ministry of Labor and Social Affairs – recalibrated Frey and Osborne's methodology to use a task-based approach, taking into account the dynamics under which tasks are shaped, reshaped or automated, thus reaching significantly lower probabilities of automation.[38] Whereas economists from the Centre found that up to 42 percent of German employment could be subject to automation when applying Frey and Osborne's original methodology, using their bespoke task-based approach, they found only 12 percent of employment to be at risk.[39] Second, in 2015, Dengler and Matthes used a similar approach and found 15 percent of German employment to be under serious threat from automation.[40] The study also predicted that automation would most affect low-paid workers with minimal qualifications.[41] Lastly, the study found that employment in several highly skilled professions could be automated, with only specialized staff and expert professions facing a small risk of automation.[42]

Yet, despite various studies foreshadowing some degree of labor market disruption, policymakers in Germany remain fixated on providing the manufacturing sector with an ecosystem that spurs innovation. However, as in the United States, net employment in manufacturing has been in long-term decline since the 1970s.[43] Although great faith has been placed in the ability of Industry 4.0 to increase overall output, productivity and jobs (the merits of which are discussed in Section IV), scant attention has been paid to the potential for labor market disruption in the service sector.

Early warning signs of service sector disruption have already appeared in the United States, with the 2007-2008 financial crisis presaging the rapid introduction of technology, especially software.[44] As a consequence of the adoption of technology and data-driven business models, Wolter et al. (2016) have projected job losses for service sector occupations that had been considered relatively safe. In addition to displacing service sector workers, technology has created new demands on workers' skills, with companies instituting degree and computer skills requirements for jobs previously held by low-skilled workers.[45] Thus, the recession not only spurred the adoption of novel technologies aimed at boosting efficiency and trimming costs, but helped speed up the bifurcation of the la-

bor market detailed in Section II.[46] In addition, there is evidence that American workers directly displaced by automation and technology have found it difficult to find employment in their local labor market, causing sharp regional disparities in employment. [47]

These same forces could buffet the German labor market in the coming years, especially if current trends are accelerated by an economic downturn. For example, service sector fields such as administration, finance and accounting could be as vulnerable as segments of the manufacturing sector. [48-49] In order to understand the effects of digitization on the German labor market, it is therefore critical that policymakers attach the same importance to the service sector as they do to manufacturing and the institution of Industry 4.0.

B) FORCES SHAPING DEBATE AND POLICY RESPONSES

In Germany, policies to address current labor markets shifts and the future of work are primarily driven by the upper echelons of government, with the participation of umbrella organizations such as unions, employers' associations, social insurance carriers and foundations at certain stages of the process. The Ministry of Labor and Social Affairs has led the charge in analyzing the impact of digitization on the German labor market. In April 2015, it launched the Arbeit 4.0 (Work 4.0) dialogue process including unions, companies, the scientific community and government officials in an attempt to broaden the debate beyond the industry-driven Industry 4.0 narrative. The output of the dialogue process is broken down into a green paper (containing midterm goals) and a white paper (containing policy recommendations and best practices), aimed at fostering understanding of ongoing technological developments and mapping the challenges posed to the German labor market.

At a conference held midway through the process, Minister for Labor and Social Affairs Andrea Nahles, citing a study on how Germans perceive the evolving nature of work, stated that current government policy was incapable of responding to all forms of employment equally. [50] In summer 2016, the ministry uploaded its findings into the Unemployment Insurance and Further Education Strengthening Act, aimed at improving access to vocational training for low-skilled and elderly workers and the long-term unemployed. In addition, Nahles announced a comprehensive training campaign. In advance of the white paper's official release, the ministry implemented some of the paper's recommendations by, for example, amending the law on the prevention of the misuse of contracts for work and services and temporary employment.

In late 2016, the results of the dialogue process were published in a white paper highlighting several areas for further action. In regard to the digital economy, it suggests giving workers more autonomy, representation and voice in management decisions. Should collective bargaining between workers and employers fail, the white paper notes the need for legislative action by policymakers. For example, the white paper calls for legislative changes to create "experimental spaces" that allow for more flexible working arrangements.

Lastly, under the Work 4.0 umbrella, the Federal Employment Agency would begin to provide workers with tailor-made information on the labor market challenges affecting specific occupations. The Confederation of German Employers' Associations, however, has complained that this reorientation of the agency's mission potentially replaces or duplicates employers' efforts, worth 33.5 billion euros annually, to qualify and (re-)train their workers.[51] Peter Clever, a member

of the confederation's executive board, said vocational training "must remain the responsibility of employers and employees. No one can provide better training than companies. They know what employees need to be well-qualified for the job and for future developments." [52-53]

Another important actor in the debate on technological change and labor market shifts is the NEW Quality of Work initiative. Founded in 2002, it is a self-described "nonpartisan alliance of federal and state-level government, business associations, trade unions, the Federal Employment Agency, companies, social insurance providers and foundations" [54] that encourages debate on how to improve working conditions. As the future of work debate heats up, the initiative is facilitating the exchange of knowledge and best practices among SMEs, with a heavy focus on preparing human resources and auditing departments. [55] The NEW Quality of Work initiative also promotes projects that generate forward-looking models in workplace safety and health.

Finally, FairCrowdWork Watch [56] highlights the mounting pressures traditional actors in labor politics – most notably trade unions – face from changes wrought by digitization. Hit by declines in its membership, Germany's largest union, IG-Metall (the Industrial Union of Metalworkers), has sought to improve conditions for on-demand workers by launching FairCrowdWork Watch, an online platform that facilitates exchange among workers performing outsourced tasks. FairCrowdWork Watch has also established a system that ranks crowd-working platforms in terms of payment, work quality, communication and the platforms' site functionality. [57]

In addition to government-related organizations and unions, many German foundations, think tanks, universities and economic research institutes are engaged in the broader debate on the future of work. [58]

IV. Mapping the Potential for U.S. – Germany Exchange: Retail & Industry 4.0/Advanced Manufacturing

Scholarly and public debate concerning the changing nature of work has evolved along different tracks and at different speeds in the United States and Germany. While press coverage has raised public awareness of the challenges posed by the future of work, rapid advances in automation may soon transform swaths of the U.S. and German economies that employ millions – or tens of millions – of workers. Drawing on our comparison of how evolution in the manufacturing and service sectors has informed debate and nascent policy responses, in this section we seek to draw policymakers' attention to the potential for disruption in retail and Industry 4.0. In doing so, we showcase how the experience of one country can inform debate in the other.

A) SERVICE SECTOR CASE STUDY: RETAIL

To date, discussion surrounding the future of work in the United States and Germany has centered on manufacturing and select service sector jobs in, for example, transportation and trucking. However, this focus is somewhat misplaced, as retail directly employs more than three times as many American workers as the transportation sector.[59] Although the U.S. Department of Labor predicts retail employment will grow at a healthy clip of 7 percent from 2014 to 2024, the sector is also vulnerable to automation and technological disruption.[60] As the pioneer adopter of automated retail technologies, the United States will likely serve as a bellwether for the mass disruption of low-wage service sector, and particularly retail, jobs. Barely on the radar of German policymakers, the highly competitive sector is ripe for widespread disruption.

As of January 2017, more than 16 million Americans – 10 percent of the total workforce – were employed in retail as cashiers, salespeople, stock clerks and customer service representatives.[61] In addition, retail supports an additional 5 million jobs in logistics, 4 million jobs in management and administration, 2 million jobs in health care, 2 million jobs in finance, insurance and real estate, and, finally, 800,000 jobs in technology. Therefore, 25 percent of all American jobs are directly or indirectly supported by retail.[62] In Germany, retail directly employs 3 million workers and supports an additional 1.4 million positions.[63-64] As in the United States, demand in recent years for retail workers in Germany has been robust, with 31,000 new positions created in 2016 alone.[65]

However, as of May 2017, signs of retail disruption are starting to appear in what has been dubbed the "retail meltdown" by the U.S. press. In 2017, overall retail employment in the United States has fallen each month, with roughly 30,000 layoffs in March alone.[66] Since October 2016, department stores such as Macy's have trimmed their payroll by nearly 100,000, more workers than "the total number of coal miners or steel workers currently employed in the U.S." [67] Many of these displaced retail workers have found employment in fulfillment and logistics in the booming e-commerce sector, which has spawned more than 350,000 jobs since 2008. [68] Amazon alone plans to add 100,000 positions in the United States in 2016 and 2017.

In Germany, disruption in retail has thus far been limited, with transformation coming in the form of massive logistics centers set up by e-commerce startups such as Zalando. [69-70] Although the construction of fulfillment centers has created jobs – 1,000 alone in Zalando's new distribution center near Freiburg – workers are not bound by collective bargaining agreements and starting wages are pegged at $13.91 to align with the prevailing wage in the logistics sector.

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This has focused domestic debate on whether or not this new form of retail is creating "quality" jobs instead of whether the retail industry will eventually succumb to automation.

Despite large-scale job creation in e-commerce in the United States and Germany, retail workers face significant headwinds. First, while it might seem unlikely that warehouse workers selecting and preparing products for shipment could be replaced by machines, refinements in autonomous vehicles and robotics – and their deployment in highly controllable warehouse environments – are likely to presage the automation of warehousing and logistics functions. [71] Amazon's $775 million acquisition of Kiva Systems and deployment of 30,000 Kiva robots provides a glimpse of how it plans to optimize its operations through the symbiotic integration of automation and technology.[72] Second, automation will soon affect labor-intensive retail sectors that have to-date been impervious to the changes wrought by e-commerce.

In the United States, the threat posed by the automation of retail is typified by developments in the grocery subsector, which employed 856,850 Americans in 2015. Just 1 percent of the $1.5 trillion sector's sales have moved online, sparing grocery stores from large-scale disruption.[73] However, the deployment of Amazon Go stores, which eliminate cashiers and checkout lines in favor of real-time inventory management, smart shelves and smartphones, threatens to transform not only how consumers shop, but also how millions of low-wage, low-skill service sector workers make a living. Compared to an average U.S. grocery store employing 72 full-time staff, Amazon Go stores are operated, on average, by just six workers.[74] Although the Amazon Go concept is still being refined, the company plans eventually to open 2,000 or more locations across America, potentially catapulting it to become one of America's top grocery retailers. [75]

In Germany too, the long-term impact on retail generated by the automation of physical stores and warehousing presents a key challenge for policymakers. In 2016, "retail salesperson," was the most popular vocation within Germany's vaunted vocational training system, with 30,474 trainees. However, with the rapid innovation cycles demonstrated by retail concepts such as Amazon Go, Germany's vocational education system risks continuing to churn out workers whose skills could quickly become outmoded. Hanushek et al. (2017) have argued that the vocational training model is limited in its ability to provide the type of generalized education that helps transition displaced workers to other industries and job categories.[76] Although retail trainees learn effective interpersonal interaction aimed at generating sales, a task that remains difficult to automate, there is reason to believe that interpersonal sales will face mounting pressure not only from e-commerce, but also from AI.[77] For example, German e-commerce retailer Otto is already using AI and machine learning to forecast consumers' purchasing decisions with up to 90 percent accuracy. [78]

Since retail employment is diffuse and present in nearly every town in the United States and Germany, mass job loss across the sector could have social and political consequences that dwarf those caused by displaced workers in manufacturing. Furthermore, the disappearance of retail jobs could deprive displaced or part-time workers of low-wage, low-skill jobs that have traditionally served as havens during previous labor market downturns such as that experienced during the 2007 – 2008 financial crisis. As retail jobs disappear, minor disruption in other service and manufacturing subsectors may be amplified when displaced workers are unable to turn to employment in retail.

Automated retail technologies are more likely to take root in the United States, due to the scale of the market and early technical advances. If present trends hold, the United States will be one of the first countries to encounter massive disruption in retail employment. While transformation in the retail sector remains limited in Germany, policymakers should use developments in the U.S. retail sector as a barometer for future disruption at home. Germany could also prepare by updating its vocational model to make retail workers more resilient to potential disruption (see the example of Switzerland in Section IV).

B) MANUFACTURING CASE STUDY: INDUSTRY 4.0'S JOBS CONUNDRUM

In recent years, policymakers in the United States and Germany have searched for ways to encourage competitiveness and increase employment in manufacturing. The great fear – that automation of repetitive tasks in highly controlled factory environments will lead to a decline in manufacturing employment – has been met with increasing optimism in the potential of Industry 4.0 (often referred to as "advanced manufacturing" in the United States) to jumpstart production, exports and, eventually, job creation. Boosting employment in manufacturing, however, remains an uphill task. In the United States, employment in the sector declined from 26.4 percent of the workforce in 1969, to just 8.6 percent in 2016.[79-80] Manufacturing employment has seen a similar decline in Germany, from 48.5 percent of the workforce in 1969 to 18.6 percent in 2016. [81]

Industry 4.0 technologies have come to be viewed as a means to stem the loss of manufacturing jobs while boosting international competitiveness through the use of efficient production methods. Broadly defined, Industry 4.0 is the digitization of manufacturing following the previous three "revolutions" of "lean" manufacturing in the 1970s, outsourcing in the 1990s and automation in the 2000s.[82] Industry 4.0 leverages big data, the internet of things (IoT), business analytics, augmented reality, advanced robotics, machine learning and new manufacturing techniques such as 3-D printing to optimize production. Using Industry 4.0, computers and automation are fused in new ways, with robotics connected remotely to computer systems equipped with algorithms that can learn and control robotics with little input from human operators. [83]

Yet despite Industry 4.0's potential to create value through more efficient and networked production methods, it is unclear if the concept can develop into the jobs creator that policymakers on both sides of the Atlantic had hoped it would. Despite vast investment and the launch of numerous government-funded programs and initiatives to "restore manufacturing competitiveness" through Industry 4.0, there is scant evidence in the United States to support assertions that Industry 4.0 can "reshore" up to 3 million manufacturing jobs in the coming years. [84-85] Since policymakers in the United States have drawn a great deal of inspiration from Germany's export-oriented model, how can Germany, which is farther along than the United States in crafting policy and funding Industry 4.0 initiatives, inform the Industry 4.0 (advanced manufacturing) debate occurring in the United States?

In Germany, transformation of the traditional manufacturing sector to the Industry 4.0 model is considered vital not only to maintaining the country's position as a world leader in the export of manufactured goods, but also to securing overall economic prosperity. Speaking at the 2015 World Economic Forum in Davos, Merkel herself referred to Industry 4.0 as

a way to "deal quickly with the fusion of the online world and the world of industrial production." In March 2015, the Federal Ministry of Economic Affairs proudly announced that its Industry 4.0 strategy was projected to lead to a $166 billion increase in economic growth by 2020.[86] Implementation of the Industry 4.0 concept has been supported by $110 million in government programs to explore intelligent production technologies (Autonomik Industrie 4.0)[87] and smart services, created through vast amounts of device-generated data (Smart Service Welt). The federal ministries of economic affairs and energy, interior, and transport and digital infrastructure are jointly tasked with implementing Industry 4.0 initiatives across the economy. [88]

Other policy solutions focus on empowering German SMEs, often referred to as "Mittelstand," to adopt Industry 4.0 production methods. While the Mittelstand are crucial to enhancing output and employment in the manufacturing sector, their scale makes them reluctant to adopt and scale Industry 4.0 methods such as cloud services and IoT. For this reason, 11 regional competence centers have been built to provide technical assistance to SMEs exploring the potential of Industry 4.0 technologies. Behind the concept lies the hope that the evolution of the manufacturing sector will incorporate new production processes, business models and products that will in turn safeguard the roughly 15 million jobs directly and indirectly supported by the manufacturing sector. [89]

In the United States, trailblazing efforts on Industry 4.0 were instituted by the Obama administration, which in 2011 unveiled the Advanced Manufacturing Partnership to bring together industry, universities and the federal government to invest in the technologies and methods necessary to secure manufacturing jobs and, as in Germany, global competitiveness.[90] In 2012, Obama launched the National Network for Manufacturing Innovation, aimed at creating clusters in the emerging technologies and manufacturing capabilities required for a successful transition to advanced manufacturing. Since then, U.S. researchers have found that in addition to automation via robots, Industry 4.0 tools such as computer software – perhaps misleadingly classified by the Bureau of Labor Statistics as "machinery" – may come to abet automation's substitution of labor. [91]

However, given leaps in advanced robotics, cyber-physical systems, and highly self-regulating production processes that define Industry 4.0, it is difficult to envision scenarios in which Industry 4.0 maintains or increases employment in manufacturing. Despite government-led initiatives in Germany (and to a lesser degree the United States) to stimulate the piloting of Industry 4.0 processes, its impact on employment remains hard to predict and the issue of job creation is at most peripheral in the future of work policy discussion. [92]

Wolter et al. (2015) project a decline in manufacturing's share of employment, especially in jobs focused on controlling and maintaining machinery. [93] They expect 490,000 manufacturing and agriculture jobs in Germany to vanish by 2025, even as 430,000 jobs are created in other economic sectors such as services. [94] In the same vein, Hüther (2016) points out that Industry 4.0 processes may lead to decreased opportunities for less-qualified workers. [95] One bright spot, however, is that while the digitization of industry is predicted to reduce overall unskilled labor by 10 percent, it will spur demand for engineers and IT professionals. [96]

This duality – of job-destruction and job-creation in parallel – is characteristic for the Industry 4.0 as

well as for the Work 4.0 debate. Researchers broadly agree that jobs will be displaced rather than become fully automated and that increased digitization of production and work processes will ultimately lead to higher qualification requirements for workers. [97]

The construction of some of the first Industry 4.0 factories in Germany and the United States provides some evidence of the technology's ability to generate employment. In Germany, Adidas has "reshored" production of some shoes through its robot-staffed "Speedfactory" in Ansbach, which meshes robotics with 3-D printing and data from a system dubbed AMARIS that maps an individual's skin and muscle.[98] In Nevada, employees at Tesla's gigafactory work in unison with sensors, augmented reality and robots supplied by Germany's Kuka.[99] In both factories, workers do less repetitive work and heavy lifting, instead concentrating on tasks that are less akin to traditional manufacturing and more like service sector jobs using critical thinking and troubleshooting.

In other words, Industry 4.0 may raise the profile of jobs that demand higher levels of qualification and training, including technicians, scientific occupations, and advising and teaching professions. Industry 4.0 is also likely to have knock-on effects in the research, marketing and media-related occupations, where employment will be created in, for example, the design of new products. Therefore, Industry 4.0's true promise may not be in its ability to create employment in manufacturing, but rather as a tool for the transition of manufacturing workers to the service sector. Therefore, in seeking to transition its manufacturing sector and workforce to Industry 4.0, Germany may very well accelerate the economy's structural transformation to a service-based model. [100]
It is clear that the Industry 4.0 concept may have the positive effect of creating jobs by spurring innovation and creating new businesses, not necessarily in manufacturing but in service sectors directly connected to it. In addition to producing manufactured goods, interconnected machinery and, perhaps far more importantly, the data generated using Industry 4.0 production processes will lead to the creation of a new class of industrial services. These industrial services will in turn become an integral part of the Industry 4.0 ecosystem. Thus, Germany has the opportunity to export not only high-quality industrial goods – but also services – by selling production concepts based on the Industry 4.0 blueprint.

This method has already been proven with the construction of a highly digitized Siemens factory in Chengdu, China, that is based on its sister factory in Amberg, Germany. Just like the prototype in Amberg, 75 percent of all production processes in the Chengdu factory are fully automated and 60 percent of the factory's output is meant to serve the Chinese market.[101] Siemens Chengdu is the textbook example of the strategy behind Germany's Industry 4.0 concept – leveraging the output of the manufacturing sector using frontier digital technologies and thereby maintaining its preeminence in the production and export of manufactured goods. If at the same time employment can be secured in the manufacturing sector or created elsewhere in the service sector, better to embrace the technological change than to prevent it. This may be the true rationale driving political efforts to facilitate the transformation of traditional manufacturing to Industry 4.0.

V. Trans-Atlantic Labor Markets in Flux: Pathways Forward

Labor market disruption generated by the changing nature of work is increasingly acknowledged as a first-order policy challenge. While researchers, policymakers and the public struggle to grasp the implications of this disruption, the need for mobilized public policy and concrete solutions is rapidly becoming apparent. Although this discussion paper has sought to assess the potential for future exchange, debate and lesson-learning between Germany and the United States on the future of work, we wish to draw attention to 10 "pathways forward" raised in the course of our work. Thus far, proposed solutions have focused on relatively easy wins in domains ranging from tax reform to skills forecasting to the perennial favorite, universal basic income. Although any of these approaches may become viable in the future, many of the "pathways forward" outlined below spotlight the crucial role of exchange and lesson-learning in the generation of sound policy.

1. **Develop a Framework for International Exchange on the Future of Work:** More attention is being paid to the future of work in the United States, Germany and many other countries. However, debate, exchange and the creation of policy solutions often occur within the vacuum of single countries. As the tempo of labor market disruption quickens, there will be increased demand for policy solutions and, therefore, cross-country collaboration. We believe the potential for international exchange and collaboration on the future of work to be immense. Policymakers, civil society, government and citizens should lay the foundation for this exchange now as a hedge against future labor market disruption.

2. **Raise Awareness among Policymakers and the Public:** The full – and sometimes dystopian – impact of technology and automation on how we work remains difficult for policymakers and citizens to grasp. For example, a widely cited 2016 poll by the Pew Research Center found that, while 65 percent of American workers believe that robots and technology will "definitely" or "probably" replace much of their work within the next 50 years, 80 percent believe that their individual jobs would "probably" or "definitely" still exist.[102] This glaring gap between how workers perceive the impact of the future of work on the collective workforce and their individual position within the labor market is telling, and could impede the demand for policy solutions. Therefore, awareness-raising will play a vital role in catalyzing solutions to address the challenges associated with the future of work.

3. **Focus Research on Service Sector Disruption:** Popular debate and policy responses to the future of work have focused disproportionately on manufacturing. As detailed in this paper, manufacturing employment has been in long-term decline, with just 8.6 percent of the U.S. workforce and 18.6 percent of German workers employed in the sector. With the continued transition to a service-dominated economy, advances in automation and technology will increasingly be applied to the service sector, causing widespread disruption in, for example, retail and finance. As a precursor to designing policy, policymakers in the United States and Germany should stimulate research into precisely which segments of the service sector face the greatest disruption.

4. **Pilot Projects Targeting Dislocated Populations:** The disconnect between manufacturing and services highlighted in Pathway 3 has meant that relatively few programs have been created to transition displaced service sector workers to other employment. Pilot projects, which could be informed and focused by the research agenda outlined in Pathway 3, would allow

policymakers to incubate solutions for those whose jobs will come under increasing pressure in the future. They would also provide policymakers with a policy toolbox that could be rapidly deployed and scaled to regions or worker populations impacted by labor market disruption.

5. Catalogue, Support and Share 'Bottom-Up' Initiatives: As outlined in Section II, debate and policy responses to the future of work have thus far been an elite-driven affair. Since workforce development remains the competency of local or regional authorities in the United States and to a certain extent in Germany, greater credence should be given to finding and cataloguing "bottom-up" initiatives incubated by citizens and local workforce development boards. Although the potential for such "place-based solutions" was mentioned in the Obama administration's 2016 report on "Artificial Intelligence, Automation, and the Economy," policymakers could do far more to facilitate the germination and "uploading" of successful local initiatives.[103]

6. Update Vocational Training Models: As the United States and Germany transition to the future of work, government-sponsored vocational training may continue to churn out workers with skills that do not match employers' needs. Switzerland, which boasts 200 vocational education programs (compared with Germany's 340), has introduced a model whereby trainees receive two years of general education before specializing only in their third year.[104] This change "future proofs" trainees' education by making it easier for them to transition to another discipline if they are displaced.[105] As policymakers in the United States consider reinforcing vocational training, they should ensure that it is malleable enough to adapt to changing labor market dynamics.

7. Update Adult Education Models: Skills shortages soon will be aggravated by demographic change. Denmark has designed a sophisticated adult education system able to counter skills shortages. In specific vocational training programs, skilled and unskilled workers and job seekers can choose from almost 3,000 sector-specific training courses. The certified courses are offered by state bodies and private education providers but are geared to the needs of local companies. In continuous dialogue with local companies across Denmark, 200 new training courses are developed annually and outdated courses are discontinued.

8. Introduce and Communicate Skills Forecasting and Strategic Human Resources Planning: The United States could learn much from Germany's success in developing a skills forecasting system, which helps firms judge the future demand for skills and qualifications.[106] Furthermore, the results of skills forecasting exercises should be visualized and communicated so the public understands which skills are in demand. Federal and local workforce development agencies should invest in methods of analyzing – for example, data scraping and text mining – and sharing their vast data on changing job profiles. That information should then be used to create tailor-made (on-the-job) training programs and counseling.

9. Pilot Reallocation Vouchers: A general trend observed in the United States and German literature concerning the future of work is that automation and technology will birth new employment opportunities across economic sectors and regions. But jobs lost through automation and technology may not necessarily be recreated within the same local labor markets (as the loss of employment in the Detroit area or

the German "Ruhrgebiet" in North Rhine-Westphalia have demonstrated in the past 30 years). Academic Carl Benedikt Frey has advocated the distribution of "relocation vouchers" to low-skilled or displaced workers as a way of restoring workers' physical – and social – mobility.[107] The vouchers would assist workers in relocating to employment in different sectors in more prosperous cities or regions. This idea could help to overcome structural unemployment within regions affected by high levels of automation. However, a potential downside could be the further development of relatively prosperous super-clusters at the expense of economically depressed regions.

10. Introduce Government Programs to Spur the Creation of SMEs: Germany can learn from two U.S. government programs directed at enhancing innovation in SMEs. The Small Business Innovation Research (SBIR) program requires all federal agencies to set aside a portion of their R&D budget to fund SMEs, either through the provision of grants or in the form of government contracts (often used by the Defense Advanced Research Projects Agency).[108] Since its inception, SBIR has led to large-scale technology transfer, early-stage funding for startups and the connecting of mature SMEs to venture capital. The Small Business Technology Transfer program requires participating agencies to direct a specific share of their R&D budgets to small business and their nonprofit research institution partners.[109] Through this link, small businesses gain access to otherwise unaffordable research laboratories, facilitating the commercialization and development of products. Both programs have contributed to increased technological innovation among small businesses [110] and increased employment, and have in part helped generate clusters in Silicon Valley, Boston and New York.

VI. Conclusion: The Imperative of Trans-Atlantic Exchange

This discussion paper has sought to identify and frame trans-Atlantic views and policy responses concerning the future of work. In comparing the United States and Germany, we identify several trends that will shape debate and cooperation in the years to come. In the United States, despite forward-looking policy papers and research on AI, automation and Industry 4.0 undertaken by the Obama administration, debate and policy responses have been geared toward displaced manufacturing workers. Although manufacturing now employs a small minority of the American workforce, the election of Donald Trump has heaped more attention on this vulnerable segment of the workforce. In Germany, the future of work has been viewed almost exclusively through the lens of manufacturing and ways that Industry 4.0 processes can be leveraged to maintain Germany's preeminence in the manufacture and export of goods. However, the job creation potential of the Industry 4.0 concept is not yet a major component of the future of work debate.

In both cases, we believe the potential for labor market disruption in the service sector, which accounts for an outsize proportion of employment, is greatly underappreciated. As physical retail undergoes painful transformation in the years ahead, displaced workers may secure similar employment in the labyrinth of warehouses and logistics facilities set up by e-commerce retailers. However, the recent automation of grocery stores and the potential for the automation of warehousing and logistics highlight the disruptive future that the retail workforce is likely to encounter.

In the case of Industry 4.0, we find that although Germany is much farther along in the implementation of an Industry 4.0 strategy, it may increase output without generating employment in manufacturing. While the technology's ability to create jobs in the manufacturing sector remains unproven, its real value may be as a tool to (slowly) transition workers to more knowledge-intensive positions in the service sector. Therefore, by implementing the Industry 4.0 concept, Germany may create a win-win-win situation in which it ramps up production of manufactured goods and transitions workers to service sector jobs while creating fresh demand for the export of its innovative industrial services.

Finally, we point to the importance of pathways for the exchange of best practices concerning the future of work, ranging from the creation of an international framework for exchange, to supporting research into which service sector jobs will face disruption. We also outline the need for pilot projects targeting displaced service sector workers or providing unemployed workers with so-called "relocation assistance." Serious consideration of these projects and means of exchange will be critical to safeguarding trans-Atlantic leadership and may come to act as an important buffer against the instability that will inevitably be generated by the changing nature of work.

Works Cited

[1] See Autor 2015; Bessen 2015; Mokyr et al 2015.

[2] Carl Benedikt Frey and Michael A. Osborne, "The Future of Employment: How Susceptible are Jobs to Computerisation?" Oxford Martin School, University of Oxford, September 17, 2013, http://www.oxfordmartin.ox.ac.uk/downloads/academic/The_Future_of_Employment.pdf.

[3] German Missions in the United States, "Dual Training in the USA." http://www.germany.info/Vertretung/usa/en/07-Econ-Energy-Innovation/02__Bus__w__Germany/Skills-Initiative/Skills-USA.html.

James Bessen, Learning by Doing: The Real Connection between Innovation, Wages, and Wealth (New Haven: Yale University Press, 2015).

David H. Autor, "Why are there still so many jobs? The history and future of workplace automation," Journal of Economic Perspectives, Vol. 29/3, Summer 2015, pp. 7-30.

[4] See James Bessen, Learning by Doing: The Real Connection between Innovation, Wages, and Wealth (New Haven: Yale University Press, 2015).

[5] Bessen, p. 121.

[6] Heather Long, "U.S. has lost 5 million manufacturing jobs since 2000," CNN Money, March 29, 2016,http://money.cnn.com/2016/03/29/news/economy/us-manufacturing-jobs/.

[7] Derek Thompson, "A World without Work," The Atlantic, July/August 2015, https://www.theatlantic.com/magazine/archive/2015/07/world-without-work/395294/.

[8] Drew DeSilver, "10 Facts About American Workers," Pew Research Center, September 1, 2016, http://www.pewresearch.org/fact-tank/2016/09/01/8-facts-about-american-workers/.

Andrew McAfee and Erik Brynjolfsson, The Second Machine Age: Work, Progress and Prosperity in a Time of Brilliant Technologies (New York: W.W. Norton & Company, 2014).

See more at: http://oecdobserver.org/news/fullstory.php/aid/5433/What_future_for_work_.html#sthash.WmZE3qar.dpuf.

[9] David H. Autor, "Why Are There Still So Many Jobs? The History and Future of Workplace Automation," Journal of Economic Perspectives, Vol 29, No. 3, pp 3-4.

[10] Jonathan Morduch and Rachel Schneider, "We Tracked Every Dollar 235 U.S. Households Spent for a Year, and Found Widespread Financial Vulnerability," Harvard Business Review, April 12, 2017, https://hbr.org/2017/04/we-tracked-every-dollar-235-u-s-households-spent-for-a-year-and-found-widespread-financial-vulnerability?utm_campaign=hbr&utm_source=facebook&utm_medium=social.

[11] David Hart, Mark Muro and Siddharth Kulkarni, "America's advanced industries: New trends," The Brookings Institution, August 4, 2016, https://www.brookings.edu/research/americas-advanced-industries-new-trends/.

[12] Ibid.

[13] See Sachs and Kotlikoff 2012; Sachs, Benzell and LaGarda 2015

[14] David H. Autor, "Why Are There Still So Many Jobs? The History and Future of Workplace Automation," Journal of Economic Perspectives, Vol 29, No. 3, pp 5-6.

[15] Executive Office of the President, "Artificial intelligence, Automation, and the Economy," https://obamawhitehouse.archives.gov/sites/whitehouse.gov/files/documents/Artificial-Intelligence-Automation-Economy.PDF.

[16] Ibid.

Works Cited

[17] Barack Obama, "Address Before a Joint Session of the Congress," http://www.presidency.ucsb.edu/ws/index.php?pid=85753.

[18] Susan Helper, "Will Trump be the one to take apprenticeships to scale?" The Brookings Institution, April 7, 2017, https://www.brookings.edu/blog/the-avenue/2017/04/07/will-trump-be-the-one-to-take-apprenticeships-to-scale/.

[19] Chris Weller, "Trump's treasury secretary says the threat of robots taking jobs is 'not even on our radar,' " Business Insider, March 24, 2017, http://www.businessinsider.com/trump-administration-robot-automation-2017-3.

[20] The Markle Foundation, "Skillful," https://www.markle.org/rework-america/skillful.

[21] The Aspen Institute, "Future of Work Initiative," https://www.aspeninstitute.org/programs/future-of-work/.

[22] "The Commission on Work, Workers, and Technology," SHIFT Commission, https://shiftcommission.work/.

[23] National League of Cities, "The Future of Work in Cities," 2016, http://www.nlc.org/sites/default/files/2016-12/The%20Future%20of%20Work%20in%20Cities%20Report.pdf.

[24] Destatis, "Foreign trade," https://www.destatis.de/EN/FactsFigures/NationalEconomyEnvironment/ForeignTrade/Tables/ImportsExports.html.

[25] Destatis, "Aussenhandel," https://www.destatis.de/DE/ZahlenFakten/Indikatoren/LangeReihen/Aussenhandel/lrahl01.html.

[26] Destatis, "Basistabelle," https://www.destatis.de/DE/ZahlenFakten/LaenderRegionen/Internationales/Thema/Tabellen/Basistabelle_IndWertschoepfung.html.

[27] Hermann Simon, "Why Germany Still Has So Many Middle-Class Manufacturing Jobs," Harvard Business Review, May 2, 2017, https://hbr.org/2017/05/why-germany-still-has-so-many-middle-class-manufacturing-jobs?utm_content=buffer4fe06&utm_medium=social&utm_source=twitter.com&utm_campaign=buffer.

[28] Destatis, "Erwerbstatige," https://www.destatis.de/DE/ZahlenFakten/GesamtwirtschaftUmwelt/Arbeitsmarkt/Erwerbstaetigkeit/TabellenErwerbstaetigenrechnung/ArbeitnehmerWirtschaftsbereiche.html#Fussnote2.

[29] Destatis, "Arbeitsmarkt," https://www.destatis.de/DE/ZahlenFakten/Indikatoren/LangeReihen/Arbeitsmarkt/lrerw013.html.

[30] Federal Ministry of Labor and Social Affairs, "Green Paper Work 4.0," http://www.bmas.de/EN/Services/Publications/arbeiten-4-0-greenpaper-work-4-0.html; http://www.bmas.de/DE/Service/Medien/Publikationen/a883-weissbuch.html; http://www.bmas.de/DE/Schwerpunkte/Arbeiten-vier-null/arbeiten-vier-null.html

[31] H. Kagermann, W.-D. Lukas and W. Wahlster, "Industrie 4.0: Mit dem Internet der Dinge auf dem Weg zur 4. Industriellen Revolution," VDI nachrichten, 13, April 1, 2011, http://www.vdi-nachrichten.com/Technik-Gesellschaft/Industrie-40-Mit-Internet-Dinge-Weg-4-industriellen-Revolution.

[32] Federal Ministry of Education and Research, "The new High Tech Strategy: Innovations for Germany," August 2014, https://www.bmbf.de/pub/HTS_Broschuere_eng.pdf.

[33] See section 4.

[34] Destatis, "Erwerbstatige," https://www.destatis.de/DE/ZahlenFakten/GesamtwirtschaftUmwelt/Arbeitsmarkt/Erwerbstaetigkeit/TabellenErwerbstaetigenrechnung/ArbeitnehmerWirtschaftsbereiche.html#Fussnote2.

[35] Statistische Amter des Bunds und der Lander, "Volkswirtschaftliche Gesamtrechnungen – Bruttowertschöpfung," http://www.statistik-portal.de/Statistik-Portal/de_jb27_jahrtab66.asp; Destatis, "Inlandsproduktsberechnung," https://www.destatis.de/DE/ZahlenFakten/GesamtwirtschaftUmwelt/VGR/Inlandsprodukt/Tabellen/

Works Cited

BWSBereichen.html.

[36] German public television devoted an entire week of broadcasting to the future of work in November 2016: http://www.ard.de/home/themenwoche/ARD_Themenwoche_2016_Zukunft_der_Arbeit/3234726/index.html.

[37] IAB, "Substituierbarkeitspotenziale von Berufen in Deutschland," November 2015, http://doku.iab.de/forschungsbericht/2015/fb1115.pdf; H. Bonin et al., "Übertragung der Studie von Frey/Osborne (2013) auf Deutschland," Series: ZEW Kurzexpertise No. 57, Zentrum für Europäische Wirtschaftsforschung (ZEW), 2015, http://hdl.handle.net/10419/123310; Wolter et al., "Industrie 4.0 und die Folgen für Arbeitsmarkt und Wirtschaft Szenario-Rechnungen im Rahmen der BIBB-IAB-Qualifikations- und Berufsfeldprojektionen," Institut für Arbeitsmarkt- und Berufsforschung der Bundesagentur für Arbeit, 2015, http://doku.iab.de/forschungsbericht/2015/fb0815.pdf; Wolter et al., "Wirtschaft 4.0 und die Folgen für Arbeitsmarkt und Ökonomie Szenario-Rechnungen im Rahmen der BIBB-IAB-Qualifikations- und Berufsfeldprojektionen," Institut für Arbeitsmarkt- und Berufsforschung der Bundesagentur für Arbeit, 2016, http://doku.iab.de/forschungsbericht/2016/fb1316.pdf; S. Pfeiffer, "Robots, Industry 4.0 and Humans, or Why Assembly Work Is More than Routine Work," Societies, 6 (2), May 3, 2016, p. 16, http://www.mdpi.com/2075-4698/6/2/16/htm; O. Stettes, "Arbeitswelt der Zukunft wie die Digitalisierung den Arbeitsmarkt verändert," Institut der deutschen Wirtschaft Medien GmbH., 2016, https://www.iwkoeln.de/_storage/asset/306403/storage/master/file/10732656/download/Analyse_2016_108_Arbeitswelt_der_Zukunft.pdf.

[38] H. Bonin et al., "Übertragung der Studie von Frey/Osborne (2013) auf Deutschland," Series: ZEW Kurzexpertise No. 57, Zentrum für Europäische Wirtschaftsforschung (ZEW), 2015, http://hdl.handle.net/10419/123310. Prepared for the Austrian government, see the similar study by W. Nagl, G. Titelbach, K. Valkova, "Digitalisierung der Arbeit: Substituierbarkeit von Berufen im Zuge der Automatisierung durch Industrie 4.0," Endbericht, 2017, https://www.ihs.ac.at/fileadmin/public/2016_Files/Documents/20170412_IHS-Bericht_2017_Digitalisierung_Endbericht.pdf.

[39] Ibid.

[40] K. Dengler and B. Matthes, "Folgen der Digitalisierung für die Arbeitswelt Substituierbarkeitspotenziale von Berufen in Deutschland," IAB, 2015, http://doku.iab.de/forschungsbericht/2015/fb1115.pdf.

[41] Ibid.

[42] Ibid.

[43] Destatis, "Arbeitsmarkt," https://www.destatis.de/DE/ZahlenFakten/Indikatoren/LangeReihen/Arbeitsmarkt/lrerw013.html.

[44] B. Hershbein and L. B. Kahn, "Do Recessions Accelerate Routine-Biased Technological Change?: Evidence from Vacancy Postings," National Bureau of Economic Research, 2016, http://www.nber.org/papers/w22762.

[45] Ibid.

[46] Ibid.

[47] D. Acemoglu and P. Restrepo, "Robots and Jobs: Evidence from US Labor Markets," National Bureau of Economic Research, 2017, http://www.nber.org/papers/w23285.

[48] Ibid.

[49] Wolter et al., "Industrie 4.0 und die Folgen für Arbeitsmarkt und Wirtschaft Szenario-Rechnungen im Rahmen der BIBB-IAB-Qualifikations- und Berufsfeldprojektionen," Institut für Arbeitsmarkt- und Berufsforschung der Bundesa-

Works Cited

gentur für Arbeit, 2015, http://doku.iab.de/forschungsbericht/2015/fb0815.pdf;

Wolter et al., "Wirtschaft 4.0 und die Folgen für Arbeitsmarkt und Ökonomie Szenario-Rechnungen im Rahmen der BIBB-IAB-Qualifikations- und Berufsfeldprojektionen," Institut für Arbeitsmarkt- und Berufsforschung der Bundesagentur für Arbeit, 2016, http://doku.iab.de/forschungsbericht/2016/fb1316.pdf.

[50] Federal Ministry of Labor and Social Affairs, "Studie: 'Wertewelten Arbeiten 4.0,' " March 2016, http://www.bmas.de/DE/Service/Medien/Publikationen/Forschungsberichte/Forschungsberichte-Arbeitsmarkt/fb-studie-wertewelten-a40.html.

[51] "Streit um Ausbau der Bundesagentur für Arbeit," RP Online, February 28, 2017, http://www.rp-online.de/wirtschaft/streit-um-ausbau-der-bundesagentur-fuer-arbeit-aid-1.6642102.

[52] Ibid.

[53] Ibid.

[54] Initiative NEW Quality of Work "The Initiative," http://www.inqa.de/EN/Take-part_The-Initiative/AIMS/content.html.

[55] Personnel management, equal opportunities and diversity, health, knowledge and competence, see: http://www.inqa.de/EN/Find-out_Issues/inqa-vier-handlungsfelder-en.html?nn=13478.

[56] FairCrowdWork Watch, http://www.faircrowdwork.org/en/watch.

[57] FairCrowdWork Watch, "test IO," http://www.faircrowdwork.org/en/node/317.

[58] For a list of the participating institutions in the Federal Ministry of Labor and Social Affairs' green paper see: http://www.arbeitenviernull.de/dialogprozess/fachdialog/stellungnahmen.html.

[59] United States Department of Labor, Bureau of Labor Statistics, "Employment by major industry sector," https://www.bls.gov/emp/ep_table_201.htm.

[60] The Aspen Institute, "The Retail Trade Workforce in the United States," http://www.aspenwsi.org/wordpress/wp-content/uploads/RetailOverview.pdf.

[61] United States Department of Labor, Bureau of Labor Statistics, "Industries at a Glance: Retail Trade: NAICS 44-45," https://www.bls.gov/iag/tgs/iag44-45.htm.

[62] National Retail Federation, "Retail's Impact," https://nrf.com/advocacy/retails-impact.

[63] HDE Handelsverband Deutschland, "Weiterhin positive Beschäftigungsentwicklung im Handel," April 19, 2017, https://www.einzelhandel.de/index.php/presse/aktuellemeldungen/item/127506-weiterhin-positive-besch%C3%A4ftigungsentwicklung-im-handel.

[64] Ibid.

[65] Ibid.

[66] Nolan Gray, "How to Survive a Retail Meltdown," CityLab, April 30, 2017, https://www.citylab.com/work/2017/04/how-to-survive-a-retail-meltdown/524868/.

[67] Derek Thompson, "The Silent Crisis of Retail Employment," The Atlantic, April 18, 2017, https://www.theatlantic.com/business/archive/2017/04/the-silent-crisis-of-retail-employment/523428/.

[68] James Covert, Linda Massarella and Bruce Golding, "Amazon introduces next major job killer to face Americans," New York Post, December 5, 2016, http://nypost.com/2016/12/05/amazon-introduces-next-major-job-killer-to-face-americans/.

Works Cited

[69] Counting 19.9 million active customers in 2016, 3,639 million euros in total revenues and an operating result of 216.3 million euros: https://corporate.zalando.de/de/pressemitteilungen?tid=2&date_filter%5Bmin%5D%5Bdate%5D=&date_filter%5Bmax%5D%5Bdate%5D=&keys=.

[70] Ronny Gert Burckholdt, "Warum Zalando in Lahr so viele neue Arbeitsplätze bringt," Badische Zeitung, October 13, 2016, http://www.badische-zeitung.de/lahr/warum-zalando-in-lahr-so-viele-neue-arbeitsplaetze-bringt--128544806.html.

[71] Will Knight, "A Robot with Its Head in the Cloud Tackles Warehouse Picking," MIT Technology Review, April 5, 2017. https://www.technologyreview.com/s/604038/a-robot-with-its-head-in-the-cloud-tackles-warehouse-picking/.

[72] Kim Bhasin and Patrick Clark, "How Amazon Triggered a Robot Arms Race," Bloomberg, June 29, 2016, https://www.bloomberg.com/news/articles/2016-06-29/how-amazon-triggered-a-robot-arms-race.

[73] Craig Giammona, "Why the Retail Crisis Could Be Coming to American Groceries," Bloomberg, May 4, 2017, https://www.bloomberg.com/news/articles/2017-05-04/why-the-retail-crisis-could-be-coming-to-american-groceries.

[74] Statista, "Average per store number of full-time equivalent employees (FTE) of supermarkets in the United States from 2011 to 2013," https://www.statista.com/statistics/240965/average-per-store-number-of-ftes-of-us-supermarkets/.

[75] Todd Bishop, "Obama: Amazon is 'killing traditional retail,' and 'relentless' automation is the real threat to jobs," Geek Wire, January 23, 2017, https://www.geekwire.com/2017/obama-amazon-killing-traditional-retail-relentless-automation-real-threat-jobs/.

[76] Hanushek et al., "General Education, Vocational Education, and Labor-Market Outcomes over the Lifecycle," Journal of Human Resources, 52, Winter 2017, 48-87. http://hanushek.stanford.edu/sites/default/files/publications/Hanushek%2BSchwerdt%2BWoessmann%2BZhang%202017%20JHR%2052%281%29_0.pdf.

[77] Derek Thompson, "The Silent Crisis of Retail Employment," The Atlantic, April 18, 2017, https://www.theatlantic.com/business/archive/2017/04/the-silent-crisis-of-retail-employment/523428/

[78] "How Germany's Otto uses artificial intelligence," The Economist, April 12, 2017, http://www.economist.com/news/business/21720675-firm-using-algorithm-designed-cern-laboratory-how-germanys-otto-uses.

[79] http://www.nam.org/Data-and-Reports/State-Manufacturing-Data/State-Manufacturing-Data/April-2017/Manufacturing-Facts---United-States/

[80] Mark Muro, "Manufacturing Jobs Aren't Coming Back," Technology Review, November 18, 2016, https://www.technologyreview.com/s/602869/manufacturing-jobs-arent-coming-back/.

[81] Destatis, "Arbeitsmarkt," https://www.destatis.de/DE/ZahlenFakten/Indikatoren/LangeReihen/Arbeitsmarkt/lrerw013.html; 18.6 percent when subtracting the construction sector, see: https://www.destatis.de/DE/ZahlenFakten/GesamtwirtschaftUmwelt/Arbeitsmarkt/Erwerbstaetigkeit/TabellenErwerbstaetigenrechnung/ArbeitnehmerWirtschaftsbereiche.html#Fussnote2.

[82] Cornelius Baur and Dominik Wee, "Manufacturing's Next Act," McKinsey, June 2015, http://www.mckinsey.com/business-functions/operations/our-insights/manufacturings-next-act.

[83] Embassy of Austria, Office of Science and Technology, "Industry 4.0: Manufacturing in the United States," De-

Works Cited

cember 2014, http://ostaustria.org/bridges-magazine/item/8310-industry-4-0.

[84] The Reshoring Initiative, "Reshoring Initiative Data Report," http://reshorenow.org/blog/reshoring-initiative-data-report-reshoring-and-fdi-boost-us-manufacturing-in-2015/

[85] D. Acemoglu and P. Restrepo, "Robots and Jobs: Evidence from U.S. Labor Markets," National Bureau of Economic Research, Working Paper No. 23285, March 2017; Bureau of Labor Statistics; Office of Productivity and Technology; Robotics Industries Association; U.S. Census.

[86] Federal Ministry of Economic Affairs and Energy, Autonomik Industrie 4.0, "Industrie 4.0," March 2015, https://vdivde-it.de/system/files/pdfs/industrie-4.0-volks-und-betriebswirtschaftliche-faktoren-fuer-den-standort-deutschland.pdf; https://www.bmwi.de/Redaktion/EN/Dossier/industrie-40.html.

[87] Federal Ministry of Economic Affairs and Energy, "Autonomics for Industrie 4.0," http://www.digitale-technologien.de/DT/Navigation/EN/Foerderprogramme/Autonomik_fuer_Industrie/autonomik_fuer_industrie.html.

[88] Federal Ministry of Economic Affairs and Energy, "Digital Agenda," https://www.bmwi.de/Redaktion/EN/Artikel/Digital-World/digital-agenda.html.

[89] Federal Ministry of Economic Affairs and Energy, "Industrie 4.0," https://www.bmwi.de/Redaktion/EN/Dossier/industrie-40.html.

[90] National Science and Technology Council, Subcommittee for Advanced Manufacturing, "Advanced Manufacturing: A Snapshot of Priority Technology Areas Across the Federal Government," April 2016, https://www.whitehouse.gov/sites/whitehouse.gov/files/images/Blog/NSTC%20SAM%20technology%20areas%20snapshot.pdf

[91] Mira Rojanasakul and Peter Coy, "More Robots, Fewer Jobs," Bloomberg, May 8, 2017, https://www.bloomberg.com/graphics/2017-more-robots-fewer-jobs/

[92] H. Hirsch-Kreinsen, "Entwicklungsperspektiven von Produktionsarbeit," in Alfons Botthof and Ernst Andreas Hartmann, eds., Zukunft der Arbeit in Industrie 4.0. (Berlin: Springer Vieweg, 2015).

[93] Wolter et al., "Industrie 4.0 und die Folgen für Arbeitsmarkt und Wirtschaft Szenario-Rechnungen im Rahmen der BIBB-IAB-Qualifikations- und Berufsfeldprojektionen," Institut für Arbeitsmarkt- und Berufsforschung der Bundesagentur für Arbeit, 2015, http://doku.iab.de/forschungsbericht/2015/fb0815.pdf.

[94] For all see: Wolter et al., "Industrie 4.0 und die Folgen für Arbeitsmarkt und Wirtschaft Szenario-Rechnungen im Rahmen der BIBB-IAB-Qualifikations- und Berufsfeldprojektionen," Institut für Arbeitsmarkt- und Berufsforschung der Bundesagentur für Arbeit, 2015, http://doku.iab.de/forschungsbericht/2015/fb0815.pdf.

[95] Michael Hüther, "Industrie 4.0 – unterschätzte Herausforderungen oder überbewertete Modeerscheinung?" Zeitschrift für Wirtschaftspolitik, 65 (1), pp. 48-58.

[96] Ibid.

[97] Wolter et al. (2015, 2016), Bonin et al. (2015), Hüther (2016), Dengler and Matthes (2015), Stettes (2016).

[98] Edgar Alvarez, "Adidas shows off the first shoe made at its robot factory," Engadget, September 21, 2016, https://www.engadget.com/2016/09/21/adidas-futurecraft-mfg-speedfactory/.

[99] Fred Lambert, "Tesla Gigafactory: a look at the robots and 'machine building the machine' at the battery factory," Electrek, July 31, 2016, https://electrek.co/2016/07/31/tesla-gigafactory-robots-machines-battery-factory/.

[100] Ibid.

[101] Christoph Giesen, "Kopie in China," Süddeutsche Zeitung, July 17, 2016, http://www.sueddeutsche.de/wirts-

Works Cited

chaft/siemens-baut-werk-in-chengdu-kopie-in-china-1.3081954.

[102] Pew Research Center, "Public Predictions for the Future of Workforce Automation," March 10, 2016, http://www.pewinternet.org/2016/03/10/public-predictions-for-the-future-of-workforce-automation/.

[103] Executive Office of the President, "Artificial Intelligence, Automation, and the Economy," December 2016, p. 43, https://obamawhitehouse.archives.gov/sites/whitehouse.gov/files/documents/Artificial-Intelligence-Automation-Economy.PDF

[104] Ludger Wössmann, "Wenn das Gleis zur Sackgasse wird," Frankfurter Allgemeine Zeitung, February 20, 2017, http://www.faz.net/aktuell/beruf-chance/campus/duale-ausbildung-wenn-das-gleis-zur-sackgasse-wird-14885656.html?GEPC=s3.

[105] Hanushek et al., "General Education, Vocational Education, and Labor-Market Outcomes over the Lifecycle," Journal of Human Resources, 52, Winter 2017, 48-87. http://hanushek.stanford.edu/sites/default/files/publications/Hanushek%2BSchwerdt%2BWoessmann%2BZhang%202017%20JHR%2052%281%29_0.pdf; Ludger Wössmann, "Wenn das Gleis zur Sackgasse wird," Frankfurter Allgemeine Zeitung, February 20, 2017, http://www.faz.net/aktuell/beruf-chance/campus/duale-ausbildung-wenn-das-gleis-zur-sackgasse-wird-14885656.html?GEPC=s3.

[106] Initiative NEW Quality of Work, "Die Initiative," http://www.inqa.de/DE/Mitmachen-Die-Initiative/Foerderprojekte/Projektdatenbank/strategische-personalplanung-kmu-dgfp.html.

[107] Carl Benedikt Frey, "The Future of Jobs and Growth: Making the Digital Revolution Work for the Many," G20 Insights, March 18, 2017, http://www.g20-insights.org/wp-content/uploads/2017/03/The-Future-of-Jobs-and-Growth.pdf.

[108] SBIR-STTR "About SBIR," https://www.sbir.gov/about/about-sbir.

[109] SBIR-STTR "About STTR," https://www.sbir.gov/about/about-sttr.

[110] A. N. Link and J. Scott, "How the Small Business Innovation Research (SBIR) Program Matters," University of North Carolina Greensboro Department of Economics Working Paper, June 2012, http://bryan.uncg.edu/assets/research/econwp/2012/12-07.pdf.