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Meanwhile, the labor-saving impact of digital technologies is substantial and likely to increase. Economist David Autor and his colleagues showed in the early 1980s that computers had displaced workers in a wide range of routine work, including many clerking and manufacturing jobs—work that is typically concentrated at the middle of the income distribution.<sup>5</sup> Other research has shown that employment continued to grow both at the top and the bottom end of the skill and income distribution.<sup>6</sup> The automation of routine work, therefore, appears to have contributed to the hollowing out of labor markets across the industrial world.

Recent technological breakthroughs and the prospect of further technological advances are quickly expanding the potential scope of job automation, making it likely that the labor market effects of technological change are also likely to become even more significant over time. Historically, computerization has largely been confined to routine tasks that involve explicit rules-based activities that can easily be specified in computer code. Recent technological advances, in contrast, have made it possible to also automate a growing range of non-routine tasks. Some tasks, such as driving a car or deciphering scrawled handwriting, were deemed non-automatable only a decade ago. Today such tasks to a large extent can be automated or are close to that stage.

### Implications for the developing world

Both the benefits and the challenges of digital technologies and automation in particular are not limited to the industrial world alone. Indeed, there is reason to believe that its effects could be more dramatic on the developing world. Job polarization, with some exceptions, is also already taking place in developing economies. The World Bank's World Development Report 2016 noted that between 1995 and 2012 the share of routine employment has fallen by almost eight percentage points while the share of non-routine jobs (both high-skilled and low-skilled) increased in most countries (the decline of routine jobs among industrial countries was even larger at roughly 12 percentage points). The “hollowing out” was visible across a large number of developing countries, including Macedonia, Turkey, Mexico, and Malaysia. The most notable exception to the trend was observed in China, where middle-income jobs have rapidly expanded, following the offshoring of manufacturing jobs in advanced economies and the mechanization of agriculture (commodity exporters also partly bucked the trend away from automation during the commodity super-cycle, but that is likely to reverse soon).

However, China may be one of the last countries to ride the wave of industrialization to prosperity. Technological breakthroughs of the 20th century—such as the container ship and the computer—significantly contributed to the rise of global supply chains, enabling companies to locate production where labor is cheap. Yet, recent developments in robotics and additive manufacturing, or “3D printing,” have made it increasingly economical for companies in advanced countries to “reshore” production to mostly automated factories. The Harvard economist Dani Rodrik has shown that



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over the 20th century peak manufacturing employment has steadily declined among emerging economies, a phenomenon sometimes called “premature deindustrialization.”<sup>7</sup> This global trend may well be related to, and likely reinforced by, increasing automation of the workforce, posing significant challenges for developing economies to create jobs, let alone “good” jobs.

The expanding scope of automation might constitute a watershed for labor markets worldwide. According to a recent study, around 47 percent of U.S. employment may be susceptible to automation as a result of ongoing technological improvements.<sup>8</sup> It is no longer only production and back office jobs that are at risk, but also areas of logistics and transportation, construction, sales, and services. Thus, the reach of potentially automatable professions is now reaching sectors previously deemed relatively safe from technological replacement.

Again, developing economies may face even greater challenges than industrial economies. This is in part because the share of manufacturing and agriculture—still among the easiest to be mechanized and automatized—in many developing countries is substantially larger than in the average industrial country. According to World Bank data, employment in agriculture and industry still accounts for around 55 percent of total employment in low- and middle-income countries, while it is only around 26 percent in high-income countries.

Indeed, applying the Frey-Osborne methodology, the World Bank recently estimated that the share of jobs at risk of automation is even higher in developing countries—77 percent and 69 percent of all jobs in China or India, respectively—and perhaps 85 percent in Ethiopia, against an average 57 percent of jobs in member countries of the Organization for Economic Co-operation and Development (OECD). Since this methodology only reflects the technological capabilities and does not take into account differential labor costs, it should not be interpreted as implying that automation is likely to replace jobs even faster in developing countries than in industrial ones. After all, labor costs are of course lower in developing countries and automation is currently happening at a faster pace in industrial economies. But developing economies are by no means insulated from these trends (indeed, China is already one of the largest markets for robots in the world) and, importantly, automation may hinder the ability of developing economies to use their labor-cost advantage to build prosperous economies and societies over time.<sup>9</sup>

Given the potentially transformative impact of automation and related technological trends on labor markets, decisive policy responses are likely to be needed to ensure that the gains will be shared and the losers looked after, including measures to improve the quality of education and training, fiscal incentives for employment, and some measure of protection and subsidies for the vulnerable. That is likely to be a tall order for most countries, but developing countries may find it even more difficult because of lower government effectiveness and less resilient economic and political systems. For instance, according to World Bank data, low- and middle-income countries



significantly underperform high-income countries across all six categories of measured governance indicators (voice and accountability, political stability and absence of violence/terrorism, government effectiveness, regulatory quality, rule of law, and control of corruption) and show high levels of inequality.

In addition, developing countries are likely to be less capable of taking advantage of many of the opportunities that the new technologies offer. This is because, outside of concentrated areas like China and India's technology hotspots, much of the populations lack the skills that would be most complementary to new technologies and the physical and soft infrastructure (including extensive and fast broadband networks).

### How realistic is the prospect of technological unemployment?

If technology is becoming less job-creating and more labor-saving, should we resign ourselves to a fate of technological unemployment, and, in the case of developing countries, bid any hopes of prosperity farewell? The answer is no, for various reasons.

First, not all jobs that are automatable are in fact automated—despite the promise of self-service technology, there are still more than 3 million cashiers in employment in the U.S. There are a variety of hurdles, including the need to adapt processes to make automation economically worthwhile and the flexibility to time and shape the introduction of technologies.

Second, job creation depends on factors other than technology. Importantly, most job creation since the computer revolution of the 1980s has come from non-technology sectors of the economy. A study by Council on Foreign Relations, for example, showed that non-tradable sectors producing goods and services that are consumed locally can account for as much as 98 percent of total U.S. employment growth between 1990 and 2008.<sup>10</sup> Around 40 percent of this growth, in turn, came from government and health care services (sectors that are not primarily driven by market forces), while retail, construction, and food and accommodation industries also contributed significantly.

Third, technology has had significant impacts on jobs beyond the technology sector. Technology-using sectors, such as professional services, have expanded rapidly as advances in information and communications technology has made many of these jobs tradable. Furthermore, technology jobs create significant spillovers on local demand for services—it is estimated that one additional technology job creates around five new jobs in the local non-tradable sector.<sup>11</sup> As increasingly automated factories mean that manufacturing is absorbing fewer workers, including in the developing world, the future of job creation will depend on making the transition toward more skilled modes of production. Importantly, skilled jobs (and in particular non-routine jobs) are typically less susceptible to automation, and such jobs have the potential to create more demand for local services. Multipliers for one additional skilled manufacturing job in developing countries are at



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least three times higher than multipliers for unskilled jobs (the multiplier for skilled manufacturing jobs ranges from 16 in South Africa to 21 in India).<sup>12</sup> It would therefore be misleading to focus merely on the job-destroying effects of technology or indeed only take into account those directly created by technology sectors.

Overall, the impact new technologies may have on labor markets and conventional development models in developing countries is likely to be very significant and pose major challenges for policymakers who may already be stretched by a combination of economic pressures and political instability. The primary concern may not be widespread, technologically-created unemployment but rather creating rewarding jobs and inclusive growth. Widening inequalities of income and wealth could in turn stretch social cohesion and further complicate the capacity of policymakers to address these challenges. Of course, the threat that disruptive technological progress poses is not unmitigated. Even though technology jobs may be few and far in between, the additional demand for job creation in loosely related or unrelated sectors is likely to be significant. It is currently difficult to predict where these jobs will be, but for now we are very far from an abundance of jobs that would cause a lack of demand for job creation. Meanwhile, the same technological advances that threaten jobs and development models also bear unprecedented possibilities to boost productivity, reduce poverty, and improve the efficiency of public services.

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