THE GROWTH DIALOGUE

NOVEMBER 2017
NUMBER 14

POLICY BRIEF

New Technologies, Jobs, Growth, and Development

*Carl Dahlman**

Introduction

The Paradox of Innovative Technologies

There is concern in many policy circles that new technologies, while productive, may be disruptive because they may significantly change the way products and services are produced, distributed, and consumed. This dynamic will exert negative effects on the operation of existing firms, employment patterns, and the competitiveness of countries. Much of the analysis on these topics has been done in the context of developed countries because that is where the new technologies are being developed and applied, and where the effects will be felt in the first instance.[1] However, these technologies may also have strong effects on developing countries.

This policy note first identifies some of the new technologies and summarizes some of the evidence of the past impact of automation on jobs in developed countries. It then surveys some of projected impact of new technologies on jobs, and identifies some of the factors that will influence outcomes in developing countries. Finally, this note considers the potentially broader impact of new technologies on developing countries in terms of development strategies and the concomitant policy implications.

New and Potentially Disruptive Technologies

These include digital technologies such as automation, additive manufacturing (3D printing), the Internet of things, (IOT), autonomous vehicles, cloud computing, big data analytics, and artificial intelligence (AI); and non-digital innovations such as genetic engineering (synthetic biology), nanotechnology (new materials), and others (OECD 2017). There is some debate on how important these advances are likely to be. At one extreme Gordon (2016) and Cowen (2011) argue that these new technologies are not as significant as innovations of the last century (such as electricity, the internal combustion engine, indoor plumbing, clean water, and proper sewage disposal).

On the other side of the debate, Kurzweil (2005) and Brynjolfsson and McAfee (2014) predict an age when machines and artificial intelligence will replace humans. The truth probably lies somewhere in between; however, the prevailing sentiment is that the new technologies are going to be both disruptive and transformational. Digital technologies in particular are considered disruptive enough to constitute a fourth industrial revolution.[2] One version of this

*This note, prepared by Carl Dahlman, Senior Policy Advisor at the Growth Dialogue, George Washington University, School of Business, draws on a Symposium on this topic at the World Bank, September 22, 2017, organized by the Growth Dialogue, George Washington University; CIIP (the Competitiveness Industry and Innovation Program funded by EU, ACP, Austria, Norway and Switzerland); and the Center on Global Economic Governance, Columbia University. The program and a recording of the symposium are available for a year at: https://www.theciip.org/search/node/Symposium.

revolution entails the integration of the entire manufacturing process from design to production and distribution by combining automation, data exchange, and cloud computing. It is often called Industry 4.0, following this designation by the German government, and aspects thereof are already being implemented in many dynamic firms across many sectors in the United States, Europe, and advanced countries in Asia.[3]

Historical Effect of Automation in Developed Countries

One of the major concerns about the impact of new technologies is their overall effect on employment. Autor and Salomons (2017) and Autor (2015) have done very detailed analyses of the historical impact of automation on employment in the United States and other developed countries. They find that while automation often reduces employment in the industry where it occurs, there is compensating job growth in other industries that receive positive spillovers. There is also increased demand in other industries as a result of higher incomes associated with technology-induced productivity increases. The authors also find that automation favors increased employment (and wages) of workers with complementary skills to the tasks that were automated, while decreasing the employment (and wages) of workers whose skills are made redundant by the automation.

Most importantly, Autor contends that the process of new technology adoption tends to increase employment polarization as well as wage inequality. Autor and Salomons also note that in the last decade there has been a slowdown in overall job and wage growth for higher-skilled jobs in the United States. They attribute that slowdown to the impact of the 2008–09 "great recession," and to the possibility that advances in machine learning and artificial intelligence may be substituting for higher-level skills that had been complementary before. In sum, many analysts fear that current rapid advances in technology will depart from historically manageable trends in automation, and instead generate widespread dislocations in labor markets.

Safety Net Measures in the Event of Wholesale Automation of Jobs

In the extreme case of widespread labor dislocations, the problem becomes distribution of the fruits of productivity increases rather than of scarcity. Even if there is no full substitution of workers by machines, governments will need to focus on redistributive policies to address the growing inequality that is likely to result.

Moreover, workers who are completely left behind in the transition will need help (Bourguignon 2017; Lustig 2017). This leads to discussions of unemployment insurance, retraining, and minimum income guarantees, or a universal minimum income. In practice, there are various challenges to these safety-net notions. There is political and ideological opposition to programs such as a guaranteed minimum income, as it appears to reward people for doing nothing. Moreover, such programs are expensive and very difficult to implement, particularly during periods of restructuring before the expected longer-term benefits of new technologies kick in (Lustig 2017).

Potential Impact of Automation in Developing Countries

The labor implications of new technologies are less studied in developing countries than in developed countries. Frey and Osborn (2013), based on the analysis of 702 occupations, estimated that about 47 percent of U.S. occupations were at risk of automation over the next 10 to 20 years. Frey, Osborne, and Holmes (2016) extended this analysis to more than 50 countries and regions. They estimated that in OECD countries, on average 47 percent of jobs were susceptible to automation, but the risk rises to 57 percent in India and 77 percent in China. Artnz, Gregory and Zierahn (2016) using a more conservative methodology, estimated that

only 9 percent of jobs across 21 OECD countries are subject to automation.

A high risk of automation was again cited in a January 2017 McKinsey Global Institute report. Based on detailed analysis of 2,000 tasks in more than 800 occupations, the report estimated that 49 percent of the activities done by workers in the global economy could be "automated by adapting currently demonstrated technology."(McKinsey 2017) For China and India, the report estimated that potentially half the total labor force could be displaced by automation. However, these findings can be regarded as upper-range estimates in light of a new McKinsey report released in November 2017 that estimates that only 37 percent of the labor force in China and 17 percent in India is subject to automation in the most rapid dissemination scenario.[4] Thus, there is still major uncertainty on the potential impact of automation on jobs in developing countries.

Limited Effects of Automation in Developing Countries

Conditions in developing countries may limit the impact of automation on jobs. For example, much of the population still lives in rural areas that lack access to electricity or are otherwise disconnected from the modern economy. That said, advances in digital connectivity, including cell phones, are making rural isolation less relevant to future problems related to new technologies. Even in highly connected cities, urbanization patterns are making joblessness a growing and serious concern. In urban or rural areas, technological change may cause the already poor job outlook in most developing countries to deteriorate. Higher skill levels could be required for even basic employment, and job training may not keep pace.

Moreover, the main impact on jobs in developing countries may not be on existing jobs, but rather on new jobs. These new jobs may never be created because of re-shoring of what would have been off-shored production (Hallward-Driemeier and Nayyar 2017).

Challenges and Opportunities for Development Strategies

New technologies pose many challenges, including the following:

- Automation and the new production technologies make it harder for developing countries to compete based on low-cost labor, as labor costs become a smaller share of total costs. Developing countries may remain competitive only in sectors where low-cost labor is still important, or produce just in domestic and regional markets that are not exposed to international competition.
- At the same time, the ecosystem required to use new technologies, such as the Internet of things (IOT) and Industry 4.0, is becoming more demanding. Required elements of future technological ecosystems may include advanced logistics, high-speed Internet connectivity, sophisticated infrastructure, and specialized skills and standards that are beyond developing-country capabilities.
- Services, many of which are facilitated by the digital economy, are becoming a more important part of production and consumption. Thus, developing countries need to improve the breadth and competitiveness of their service sector. However, most important service sectors are dependent on high-level skills and sophisticated infrastructure that developing countries often lack.
- Human capital remains weak in developing countries. Overall attainment and quality of education is lacking, as are the specialized skills needed to adopt, adapt, or develop new technologies.
- Even technologies that have been common in developed countries for many years are uncommon in developing countries. More generally, developing countries have weak innovation systems.
- Developing countries lack sufficient resources to support workers who are displaced by the new technologies. Many developing economies are also making

a labor transition from agriculture to manufacturing and services. In addition, many have large labor force growth, for which it will be very difficult to find productive employment.

- Finally, the traditional growth paradigm in developing countries of labor-intensive manufactured exports has reached its limits (Hallward-Driemeier and Nayyar 2017). This is exacerbated by globalization and the very strong performance of China in manufacturing and exports.[5] The shares of manufacturing value added (in GDP) and of manufacturing employment (in total employment) are now peaking at lower levels of per capita income (Rodrik 2015). Furthermore, the commodity super-cycle that spurred the growth of natural resource–exporting developing countries is over. Therefore, new drivers of growth and development need to be found.

Some new technologies offer many opportunities for developing countries to improve competitiveness and to address critical social needs. It may be difficult for developing countries to adopt full-fledged industry 4.0 factory automation because they lack many of the necessary supporting elements of the broader industrial ecosystem. However, they can adopt many discrete elements of the new technologies and adapt them for their critical needs. This can be done across different sectors of the economy:

- *Examples in manufacturing* include: using 3D printing to overcome the constraints of scale as well as the lack of well-developed component supplier industries and logistics. Developing countries also can use robots for part of their production even if they do not adopt fully automated "industry 4.0" factories. In addition, AI systems can be used to overcome some knowledge constraints in manufacturing, agriculture, and services.
- *Examples in agriculture* include: using genetically improved seeds. These can produce crops with higher yields, drought and pest resistance, and more nutrients and vitamins than conventional crops. Electronic sensors and trackers can be used to improve drip irrigation, harvesting, and distribution of agricultural products, among other applications.[6]
- *Examples in services include:* using the Internet to develop mobile money systems such as M-Pesa in Kenya and Tanzania to reach people who do not have access to the formal banking system because of their location or small transactions; using Internet-enabled systems to expand lending to under-banked populations in Bangladesh; extending electricity to off-grid communities through solar energy hubs in India and various African countries; extending Internet access to African countries through equipment in helium balloons in stratospheric orbits;[7] using the Internet and electronic devices to extend education and training to millions of users in India, Indonesia, and other low-income countries; using new, simple, low-cost diagnostic techniques and medical AI systems to extend health services to underserved rural communities in Sub-Saharan Africa and South Asia; and using Internet-enabled platforms and the sharing economy to increase the utilization of scarce capital or mismatched labor.[8]

In addition, there are many opportunities to access existing knowledge. Labor productivity in developing countries is generally less than 10 percent of that in developed countries. With few exceptions (most notably China), the productivity gap has been increasing over the last decades (Hallward-Driemeier and Nayyar 2017; OECD 2014). Thus, developing countries have tremendous potential to increase productivity. There are many ways to access global knowledge on productivity, including: attracting foreign investment that can bring more advanced technologies, management, and business organizations; importing capital goods and services that embody

the new technologies; purchasing foreign technology and management assistance; accessing the knowledge, management skills, and finance, of Diaspora populations in more advanced countries; foreign study and work experience; copying and reverse engineering; and using electronic and other means to access existing technical and management knowledge (OECD 2014).

- China has accessed existing knowledge very successfully and has achieved very impressive results. However, China's path is not easily replicable, given the special type of government and the advantage of its large market size.
- Other countries have developed very effective strategies for accessing global knowledge and to address local needs. These include the Republic of Korea and Singapore in Asia, Chile in Latin America, and Ethiopia and Rwanda in Africa. In addition, there are many new technologies to address local needs in many countries around the world, including many low-income countries in Africa and elsewhere in the developing world.

The Challenges for Public Policy

Public policy challenges include how to take advantage of both existing technologies and the new disruptive technologies to increase innovation. There is little innovation in developing countries. In addition to the usual market failures associated with innovation (such as externalities and lack of appropriability), developing countries face a number of other challenges, such as low physical and human capital. Poor policy and institutional environments are also prevalent, including restrictions on trade, foreign direct investment, and competition, and poor institutional support for education, finance, and technology. Finally, developing countries exhibit low firm operational and management capabilities, and low government capability to design, monitor, and implement innovation policies (Cirera and Maloney 2017). Therefore, policies have to be designed that take into account country-specific human and institutional capabilities.

Developing countries should aim to build a broadly defined innovation system that includes not just R&D but complementary factors including firm management skills and an overall economic regime supporting accumulation of human and physical capital and knowledge. (Cirera and Maloney (2017) propose a three-stage approach that builds capacity in the private sector and the public sector (including policy makers and institutions).

- Stage 1 consists of supporting the production and management capabilities of firms to strengthen technology absorption and production.
- Stage 2 consists of building technological capabilities in firms and accelerating technology transfer from abroad as well as from universities to firms
- Stage 3 consists of extending support for the invention and technology generation capabilities of firms and making the economic regime more supportive of innovation.

Countries should also take advantage of specific opportunities already offered by some of the new technologies, as outlined above. Private firms often are foremost in identifying concrete opportunities. But some technological opportunities, particularly those aimed at extending services to low-income populations, may require the government to play an active role. The market by itself may not seize the opportunity to develop new technologies because private returns are not sufficiently attractive, despite large social returns.[9]

In addition, countries need to build capacity to take advantage of new technologies. This includes developing the specialized skills and expertise to understand the potential of new technologies and to harness them for domestic needs; tapping into global knowledge research networks to have access to the latest advances; and

investing in some critical new technologies in agriculture, manufacturing, and services. More specifically, being prepared to adapt or develop some of the new technologies requires the following.

- ***Improve economic efficiency and flexibility.*** Efficiency and flexibility will allow developing country economies to meet the new demands of the competitive international environment, and to take advantage of the opportunities opened by new technologies.. Besides improving flexibility in capital and labor markets and the entry and exit of new firms the regulatory system needs to be updated to deal with the rise of sectors with increasing returns to scale, such as e-commerce, information service providers, and collaborative Internet-based platforms.
- ***Invest in education and skills.*** Countries need to develop broad education and training systems that include both formal education and programs for life-long learning. This goal includes fostering multiple providers and alternative pathways to learning. Special focus should be given to building new skills required by the digital economy.
- ***Strengthen and upgrade infrastructure.*** Governments should consider whether access to the Internet should be treated as a basic right and how to extend access to the whole population. The new technologies also put additional demands on other aspects of infrastructure that will therefore need upgrading, including advanced logistics, the adequacy and reliability of electricity, and physical transportation systems.
- ***Develop the knowledge-intensive service sector.*** Services in advanced economies are much more knowledge intensive and Internet-enabled. In addition, the service component of manufacturing is now as much as half the value added of manufacturing, and most of these services are knowledge and information intensive. Therefore, developing countries need to develop these services to be able to compete and to take advantage of many of the Internet-enabled new technologies. This requires reducing restrictions to trade in services; and increasing access to financing for knowledge services (the assets of such companies are intellectual capital that cannot be collateralized).
- ***Examples of some country responses:*** China's 13th Five Year Plan 2016–2020 has targeted innovation as the first of its five key focus areas. The country aims to move into all new high-technology areas and is investing massively in R&D and high-level human resources to accomplish that. Other countries like Chile has a more immediately pragmatic approach. Chile is focusing on accessing new technology through a "smart specialization strategy." The strategy focuses on sectors that Chile is already strong in and identifies how new technologies may affect them. The strategy uses a four-helix approach that consists of coordinating government, industry, academia, and civil society to forge consensus and develop technological roadmaps for Chile's key sectors. (Bitran 2017).

Conclusions

New technologies are coming and will have strong implications for developing countries. There is much uncertainty about how significant some of the new technologies will be, how fast they will disseminate, and how disruptive or helpful they will be from the perspective of developing countries. Developing countries need to be prepared for the challenges and take advantage of the opportunities. Pasteur's dictum that "fortune favors the prepared mind" also applies to countries and country strategies. The impact of new technologies on a developing country will vary significantly depending on their endowments, their capabilities, and the policies they undertake. There is

scope for action in many areas: innovation policy, education and skills, improving the overall economic environment, strengthening infrastructure, and developing the knowledge-intensive service sector. Countries will need to decide which are the most important policy areas as well as which are the most feasible to develop. At the same time, countries will need to develop greater preparedness and resilience regarding the changes that are bound to come. Preparedness will depend a lot on the natural, human, and institutional endowments of the country and the capability and vision of its government.

But a broader issue is the need develop viable new strategies to help countries grow and improve welfare, now that export strategies based on labor-intensive manufactures seem to be reaching their limits. Many developing countries face the challenge of finding productive employment for their rapidly growing labor forces. Key questions related to this challenge include:

- What is the potential of specialized agriculture?
- What is the potential of specific manufacturing areas where developing countries can still maintain or develop comparative advantage?
- What is the potential of tradable and non-tradable services? These include many labor-intensive sectors such as physical infrastructure, housing, education, health, and government services.
- What is the role of technology?
- What can developing countries export to be able to import some of the foreign knowledge, components, and services that can greatly contribute to development (Haussmann 2017)?

These critical issues and others need to be addressed in order for developing countries to take advantage of the opportunities of new technologies, and to mitigate their challenges.

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Endnotes

1. However, there are examples of new technologies being first developed and applied in developing countries, such as mobile banking in Sub-Saharan Africa.

2. See Klaus Schwab, who argues that the Fourth Industrial Revolution is a fusion of the physical, digital and biological spheres (WEF 2016).

3. See Germany Trade and Invest (GTAI), https://industry4.0.gtai.de/INDUSTRIE40/Navigation/EN/industrie-4-0 (Accessed March 30, 2017).

4. Lund (2017), slide 12.

5. In 2015 China accounted for more than 50 percent of world manufacturing employment, 25 percent of world manufacturing, and 13 percent of all world merchandise exports. In addition, China is rapidly adopting robotics and is expected to have the largest number of robots installed in any country by 2020 (Hallward-Driemeier and Nayyar 2017).

6. See many examples of using new technologies to innovate in developing countries in Cornell University, INSEAD, and WIPO (2017).

7. See https://www.technologyreview.com/s/544861/how-facebook-and-googles-plans-to-boost-internet-accessadvance.

8. Some examples are Uber for transportation, RB&B for accommodations, and Taskrabbit to match freelance labor with local demand in the gig economy.

9. For some examples for Africa see World Bank (2017a).