Tanzania Case Study: Rapid Technological Change - Challenges and Opportunities

Final Report

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Executive Summary

This report presents a theoretical framework and empirical methods for developing countries to assess the challenges and opportunities posed by rapid and disruptive technological change. It applies the framework and methods to a case study of Tanzania based on the following: extensive research into the Tanzanian innovation system; a policy stocktake; and the insights that surfaced through a workshop, a series of focus-group discussions, and key informant interviews with Tanzanian stakeholders conducted in Dar Es Salaam and Dodoma between 29 July and 3 August 2018. The report is intended to complement and feed into other research activities of the *Pathways for Prosperity Commission*, specifically, the project to design a diagnostic toolkit.

The report begins with a summary of the key challenges and opportunities presented by new technologies, and a critical assessment of the ways in which the literature addresses them. These accounts tend to be both **technologically deterministic**, reflecting what is technologically rather than economically or politically feasible. They tend to be **Western-centric** in their representation of employment and of the mechanisms through which technology may generate disruptive effects. Moreover, they often **neglect policy**. These shortcomings motivate our approach, which focuses on identifying the **specific mix of country factors and policy choices that determine outcomes in developing countries.**

The current debate over the impact of technologies stems from a set of interrelated claims: the unprecedented pace and scope of change; the relationship between change and inequality; and the potential for new technologies to dramatically reduce the costs of and barriers to the transfer of information and knowledge. We argue that the debate over technologically-driven unemployment is methodologically flawed. This distracts from more significant questions regarding potential effects of new technologies, and the potential pathways through which these technologies might generate job creation, productivity gains and learning. In domestic economies, the capacity for new technologies to reduce communication costs and transfer information could, for example, solve information problems, strengthen linkages between sectors, engage the informal sector, and improve transparency and accountability in the delivery of public services. At the same time, evidence suggests that technological solutions in these areas do not always succeed. Thus, ensuring that such solutions are 'demand-led' and 'problem-driven' is crucial. Finally, the global effects of new technologies (for example, through reshoring or altering global value chains) could have serious implications for industrial strategies, especially those oriented towards export-led manufacturing. Nevertheless, new technologies may present opportunities for globalised learning, tradable services and new forms of industrial policy. All possibilities should be considered.

The crucial question of how to think of technological change underlies these debates. Our review underscores that technological diffusion, adoption, adaptation, and innovation are embedded in political, institutional and social structures. The concept of 'capabilities' – at individual, firm and national levels – provides a useful device for assessing the capacity of a country to respond positively to new technologies and to think through what might constrain or enable the acquisition of capabilities. We single out firm-level capabilities as key. With this focus, our 'desk-based' research applies qualitative and quantitative analysis of firm enterprise surveys to build a picture of a country's innovation system. The policy stocktake and workshops address more general aspects of structures that foster or impede innovative capacity.

The case study of Tanzania shows that considerable structural change and dynamism have taken place since 2000. Economic reforms started in the 1990s seem to have given space for some formal-sector growth, and for a huge movement of workers from traditional agriculture to much more productive, non-agricultural employment. Even though workers moved predominantly into informal work (83 percent), this shift drove sustained rapid growth and average productivity gains. Productivity gains in Tanzania overwhelmingly stem from between-sector labour movements rather than from within-sector gains. At the same time, labour productivity has been falling in almost all non-agricultural sectors, which means these sectors have been taking on workers faster than they have been growing. We emphasise that much of this is a very efficient reallocation of resources.

The 'innovation system' raises cause for concern. Neither innovations nor within-industry productivity gains have driven growth. Large firms are most productive; they dominate non-agricultural output, and they have the fastest productivity growth. However, they have been unable to lead the formal sector to expand its share of output. We do not find conclusive evidence of a lack of competition; most industries do not exhibit high levels of concentration. And yet, we cannot reject the idea, widely put forward in the literature, that larger firms enjoy privileges and insulation from competition that renders them less innovative than they otherwise would be. We also find substantial supporting evidence for the commonly held view that the environment for small, innovative start-ups is difficult because of costs, risks, access to finance, and regulatory frustrations, formal and informal. This presents a problem; an ability to innovate will almost certainly be necessary to withstand challenges of and to exploit opportunities created by the shock of disruptive technologies.

The impact of disruptive technologies is likely to vary from industry to industry, the country case study shows. Disruptive technologies could have positive direct impacts in some industries. Such technologies would likely have little impact, direct or indirect, in other industries. The case study, which serves as a preliminary diagnostic tool, cannot claim to provide a comprehensive industry-by-industry analysis on par with a more definitive diagnostic exercise. However, we found potential for positive impacts of technology in large-scale agriculture, which could improve if market conditions were made right. Also, technologies may offer potential for improved efficiency and viability in diverse mining activities, including exploration. Blockchain technologies that allow shared databases across computer networks might help marketise social benefits from environmental and social responsibility in agriculture and mining. The garment industry in Tanzania has experienced slower growth than its counterparts in Ethiopia and Kenya in response to incentives provided by the United States under its African Growth and Opportunity Act (AGOA). Nevertheless, we conclude that the sector still has growth potential, largely because disruptive technologies are unlikely to impact Tanzania's garment production, which is based on low-cost labour and focused on simple, rather than complex, production.

Digital platforms hold high potential to coordinate informal microenterprises, and to bring the benefits of formalisation and reduced transaction costs to a large part of the economy. UBER provides a case in point, but opportunities extend to many other sorts of businesses. Examples include: platforms for allocating freight space, sharing assets, and sharing information and advice. Almost boundless opportunities exist for using digital coordination to reduce waste, and to improve efficiency in highly decentralised supply networks. Moreover, with only 10 per cent of Tanzania's workforce employed by large, private-sector firms, the 'gig' economy could potentially bring workers into rather more formalised employment, a contrast to the situation playing out in high-income countries. While economic reforms might reduce the prevalence of under-the-radar microenterprises, digital solutions might allow for much quicker progress. A major issue is that the developers of platforms are themselves small, innovative start-ups. Thus, reforms or shortcuts, such as incubators, are needed to allow them to thrive.

The policy stocktake reveals strengths and weaknesses. Tanzania's 2016 Five Year Development Plan is the latest in a long line of development strategies, including the excellent Vision 2025, formulated in the late 1990s before the country's recent structural transformation started. Both these documents bemoan 'under-implementation' of development policies. In fact, the country has made considerable progress towards the key aims of Vision 2025, including in economic well-being and in education. The 2016 plan is much longer than Vision 2025, but shares its aims and focus. Over-comprehensiveness is blamed for under-implementation in both documents. More specifically, the development strategies contain good statements of intent but seemingly insufficient action to improve conditions for dynamic young companies. For larger and foreign investors, the issue of electricity, once important, has been eclipsed in priority by access and availability of land. Firms also widely acknowledge the fundamental importance of education and skills in the workforce. Progress in providing firms with needed access to finance remains slow. Mobile money services may supersede the formal financial sector in providing financial services to microenterprises and the poor. Whether the latest policies will deliver on these issues remains to be seen.

Education, the enabling environment, and communication and coordination emerged as key themes in the main stakeholder workshop. The paramount issue for participants is the ability of the education system to equip young people with the mindset to become innovators and entrepreneurs; firm surveys underscore this view. Similarly, several break-out sessions underline the significance of the enabling environment to technological uptake. Participants view information 'mismatches', resulting from a lack of communication and coordination across sectors, as key inhibitors to success. Participants see technology's potential to overcome these issues as a key opportunity across sectors.

The workshop, focus-group discussions and key informant interviews form a critical part of this study. These sessions provided expert local knowledge on sectoral and policy issues. Discussions explored practical ways in which Tanzania might prepare itself for rapid and disruptive technological change. As such, this fieldwork not produced research findings, but also helped OPM to develop and refine research methods, both for this study and, it is hoped, for future work in this area.

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List of Abbreviations

ADB	Asian Development Bank
AI	Artificial Intelligence
CGD	Centre for Global Development
DFID	Department for International Development
DUI	Doing, Using and Interacting
EDI	Economic Development and Institutions
EU	European Union
ES	Enterprise Surveys
FDI	Foreign Direct Investment
FGD	Focus Group Discussion
GDP	Gross Domestic Product
GVC	Global Value Chains
ICT	Information and Communications Technology
IGC	International Growth Centre
IMF	International Monetary Fund
IoT	Internet of Things
IT	Information Technology
KII	Key Informant Interview
LDC	Less Developed Country
LIC	Lower Income Country
MIC	Middle Income Country
NSE	Non-Standard Employment
NSI	National Systems of Innovation
OECD	Organisation for Economic Co-operation and Development
OPM	Oxford Policy Management
R&D	Research and Development
RISE	Research for Improving Systems Education
STI	Science, Technology and Innovation
TFP	Total Factor Productivity
UK	United Kingdom
UNCTAD	United Nations Conference on Trade and Development
UNIDO	United Nations Industrial Development Organization
URT	United Republic of Tanzania
US	United States
WDR	World Development Report

1. Introduction

Rapid technological change presents policymakers in developing countries with significant challenges but also major opportunities. New technologies, in such fields as automation, Artificial Intelligence (AI), digital, energy and biotechnology have the potential to revolutionise not only individual lives and workplace routines but also firms, sectors and even developmental models themselves.[1] On the one hand, technological change can drive increases in productivity and create demand for goods and services. On the other, it may lead to labour displacement, joblessness and the reshoring of value chains. For some countries, it may facilitate 'leapfrogging', while for others it may impede development strategies, especially those oriented around export-led manufacturing. Technology raises prospects for entrepreneurism and innovation but, at the same time, requires regulation and the careful nurturing of a favourable investment climate. It offers new ways of solving traditional developmental problems and delivering services while also necessitating new modes of governance. Harnessing human capital through education and re-skilling is essential to maximise the benefits, yet social protection measures are also needed to mitigate these negative distributional effects.

Many large economies, including the US, UK, EU, France, India and China, have already conducted research into the economic implications of automation and other forms of technological change – or are in the process of doing so.[2] One common theme in the reports of wealthier countries is that they anticipate being able to leverage their existing 'technological comparative advantage' to capitalise on technological dividends – making it all the more urgent for developing countries to move fast and prevent the deepening of a 'digital divide'. These concerns are reflected in a recent report by the Asian Development Bank (ADB) which observes that, of 12 previous major studies into the impact of technologies on work, while there is considerable divergence on predictions for wealthy countries, all four of those that examine developing countries expect a downward pressure on both wages and employment (ADB 2018 p.62-63). Benchmarking this Pathways for Prosperity study against international comparators is important, as a preliminary analysis of the findings already suggests that we should anticipate significant differences between the strategies of wealthy countries and those of low-income countries (LICs) and middle-income countries (MICs), as well as a consensus that this is an area of the highest strategic priority for all countries.

Major multilateral organisations, including the World Bank, ADB, Organisation for Economic Co-operation and Development (OECD), United Nations Industrial Development Organisation (UNIDO), United Nations Conference on Trade and Development (UNCTAD) and the International

1 See, for example, Yusuf (2017), Norton (2017), (Hallward-Driemeier and Nayyar 2018) or (Kozul-Wright et al. 2017)

2 The US government published *Artificial Intelligence, Automation, and the Economy* in 2016. In the UK, the House of Lords Select Committee on Artificial Intelligence produced its report *AI in the UK: ready, willing and able?* in April 2018, followed later in the same month by the European Commission's *Artificial Intelligence* in Europe. In July 2017, the Chinese State Council stated its goal of becoming a global innovation centre for AI by 2030, anticipating that the total output of AI industries should surpass 1tn Yuan ($147bn) by that point. The Indian government established a policy group in September 2017 to study new technologies and recommend a framework for their adoption. Both Indian and Chinese initiatives also connect with other policy programmes such as *Made in China* or *Make in India*.

Labour Organization (ILO) have also recently commissioned reports into the impact of rapid technological change on the world of work.[3] The more recent studies are cautiously optimistic about the future. The World Development Report (WDR) 2019 (Concept Note) asserts that "the balance of evidence does not suggest… that the world is on the cusp of an era of widespread, technology-induced unemployment" (World Bank 2018 p.1) while the ADB (2018) emphasises the potential for technology to create new jobs and industries. UNIDO describes various "radical innovations" which it claims could generate significant economic effects for developing countries.[4] These conclusions contrast with earlier studies, such as those of Citigroup (2016), ILO (2016), McKinsey (2013, 2017), the WDR (2016) or the World Economic Forum (2015) which are less enthusiastic about the opportunities, and more pessimistic as to the scale of the challenges, especially technologically-driven unemployment. The World Technology Summit (2015), attended by Joseph Stiglitz and Larry Summers, declared technologically-driven unemployment to be "one of the most challenging societal issues in the 21st century".[5]

Despite the wealth of data and analysis contained in these studies, there are shortcomings in the approaches taken. Firstly, the methodological basis on which many of the above studies are based is largely concerned with estimating what is technologically possible[6] (for example, what proportion of jobs might be automated). Such an approach neglects the other factors – economic, social, geographical, institutional and political – which constrain or enable the adoption, diffusion and impact of technology. It also neglects the extent to which outcomes are affected by policy choices, including those not directly linked to technology, such as macroeconomic, trade and social protection policies (Kozul-Wright et al. 2017). Aggregate studies tend to blur the country-specific factors, which means that technological impacts are experienced very differently in one country compared to another. In focusing on overall effects, there is a danger of missing the distributional consequences or the ways in which technology transforms jobs, as opposed to simply creating or destroying them. Finally, the methodological approaches in question originate from research into industrialised economies and so tend to be western-centric. Many of the key terms regarding (un)employment, technology and innovation, may apply in quite different ways in developing countries. Appreciating such things as the degree and nature of informality in the labour market, or the non-frontier aspects of technology and innovation are important to evaluating the impact of technology.

This paper takes a country-specific approach to understanding the challenges and opportunities of new technologies. The starting point is to consider the particular pathways through which new technologies may generate positive or negative effects. In Section 2, we explore the possible pathways through which technology might transform the world of work. We reflect critically on the current obsession with predicting the total number of job losses, and instead focus on the nature or work itself, and what determines whether technology enhances or diminishes its economic and

[3] See the forthcoming WDR 2019, also WDR 2016, OECD (2016), UNCTAD Trade and Development Report 2017 and 2016, UNIDO (2016), and ILO (2016).

[4] For example, the economic effects due to mobile technologies alone are forecast to be worth $1.85tn to $5.4tn by 2025. Automation and knowledge work is estimated at £1tn to $1.3tn (UNIDO 2016 p.55). See also (Manyika et al. 2013)

[5] See www.wtn.net/technological-unemployment-summit

[6] There are two main methodologies – the 'occupation-based' approach of Frey and Osborne, and the 'task-based' approach of Arntz, Gregory, and Zierahn (2016) to be discussed further in Section 2

social value. Lastly, we consider the global pathways, such as the impact on global value chains, through which technology may affect industrial policies and development strategies themselves. Throughout all this discussion, the paramount question concerns the process of technological change itself, and in particular the ways in which the adoption and diffusion of technology are embedded in institutional and political systems. In Section 3, we address this question at a theoretical level, paying particular attention to the acquisition of capabilities, especially at the firm-level, noting John Sutton's remark that "the scarce resource most important to the process of industrial development lies in the capabilities of firms" (Sutton 2005 p.2); although other forms of capability, at the individual level in terms of education and skills, and the national level, in terms of innovation and policy, are also crucial for technological change. Then, in section 4 we explore these issues in the Indonesian country case study. We want to understand the barriers that countries face in developing capabilities. We first address this issue in the specific context of the firm, through an original qualitative and quantitative analysis of the patterns of growth and firm dynamics, as captured in Enterprise Surveys and other data. Next we review some of the key policy areas and correlate this and the firm analysis with the findings of our workshops, focus group discussions and key informant interviews. In so doing, we frame an approach for investigating the challenges and opportunities that new technologies present for developing countries.

Country studies, national dialogues - towards a diagnostic toolkit: It is hoped that the country case study can establish evidence and initiate dialogue at national level to help identify the country-specific determinants of technological change. In this way they are preliminary to a more complete *diagnostic toolkit* whose development is beyond the scope of this project. A future toolkit needs, on the one hand, to be general enough to be applied to other developing countries, but on the other to be flexible enough to reflect those country-specific features that the case studies are intended to uncover.

In general, a diagnostic consists of three main elements: a fundamental problem; a specific method for obtaining empirical data regarding that problem; and a theoretical framework in which those empirical data may be analysed to obtain a differential diagnosis of the fundamental problem. The 'method' needs to be programmatic – in the Growth Diagnostics approach of Hausmann, Rodrik and Velasco, it consists of using the 'decision tree' and the calculation of shadow prices to identify the binding constraint to growth; in the Research on Improving Systems Education (RISE) systems diagnostic, it involves establishing the effectiveness of various relationships of accountability between agents in an education system. But a diagnostic approach differs from a theory: "in the former, the subject is a particular country. In the latter, it is a general economic phenomenon in which individual countries are examples." (Hausmann, Klinger, and Wagner 2008 p.4)

Therefore, in undertaking the country case studies, we are not seeking to set out a general theory of technological change, nor to establish a definitive method of collecting data. But we are trying to take tentative first steps towards a practical set of procedures that are informed by theoretical discussion. Our motivation, from a conceptual point of view, is to ask what the effects of technological change are, and also what factors determine how those effects manifest themselves. Our strategy, from an empirical point of view, is to try to 'zero-in' on the key policy issues and findings that help to refine the theoretical approach and research methods.

In the two case studies (the other parallel study is Indonesia), we have contrasting examples: one is an emerging economy that has to deal with potential loss of jobs with automation, while the other is a late-aspiring industrialiser which may lose the opportunity to develop through traditional export-led manufacturing strategies. The two countries also differ in their strategies: Indonesia is trying to keep its place in the global value chains while pursuing new service-oriented strategies; Tanzania is now selectively upgrading its industrial portfolio and banking on linkages to create jobs. Thinking about how such different strategies play out in such different contexts provides an illuminating contrast.

The country studies should connect with global dialogues. While the work undertaken in these studies is necessarily focused at the country level, there are important aspects regarding the impact of rapid technological change that operates globally. Globalisation and the nature of global value chains means that decisions, such as reshoring, that are taken elsewhere, for instance in China, the US or Europe, can have significant impacts on production in developing countries. At the same time, the lowering of costs in terms of trade barriers, transportation and the flow of knowledge also creates new opportunities for developing countries. International policy and global governance issues – for example, concerning trade, intellectual property and the regulation of technology, especially digital technologies – can therefore play a significant role in determining the outcomes of technological change at the country level. Although such areas lie beyond the remit of this study, the importance of connecting with these global dialogues and with other work of the Commission is implicit in this report.

2. Pathways for Prosperity: Challenges and Opportunities

There is a consensus, supported by almost all major development organisations, governments and leading commentators, that we are living in an era of rapid, even unprecedented, technological change.[7] Not only are technologies themselves changing, but so too are the ways in which these changes disrupt the world of work, the nature of production and indeed the fabric of society. Yet disruptive technological change has always been with us, as have anxieties about it.[8] So what is it about the current wave of change that generates such concern? Why should we think: 'this time it's different'? There appear to be three main (inter-related) claims on which to base such a belief:

- Technological change today is proceeding at a faster pace and across a wider scope than ever before, both in terms of the range of technological areas that are changing and in terms of the diversity of their applications and the locations in which they are applied. The rate at which technologies reach maturity, and are diffused, adopted and adapted into modes of production has increased.

- New technologies create new inequalities and heighten existing ones. They contribute to patterns of polarisation and appropriation which combine to generate adverse distributive effects. Moreover, the pace at which technologies are changing makes it difficult to regulate, or to design and implement policy that might mitigate against these effects.

- New technologies not only embody the accumulation and utilisation of productive knowledge, but also accelerate the ways in which this happens – most obviously through lowering communication costs and facilitating the transfer of information. Moreover, these mechanisms also facilitate the fusion of different areas of technology, building connections and allowing advances in one field to catalyse further advances in others.

There is already an enormous body of literature on these claims, which is far too vast to summarise here let alone critique. Suffice it to say that good arguments can be made in favour of all three claims, but that none of them holds without qualification. The unfortunate tendency in the technology literature to take extreme positions – either of unbridled optimism or of apocalyptic gloom-mongering – has tended to over-simplify these very complex areas and obscure the debate of some neglected issues. It is this latter point that we wish to take up in this section. For example,

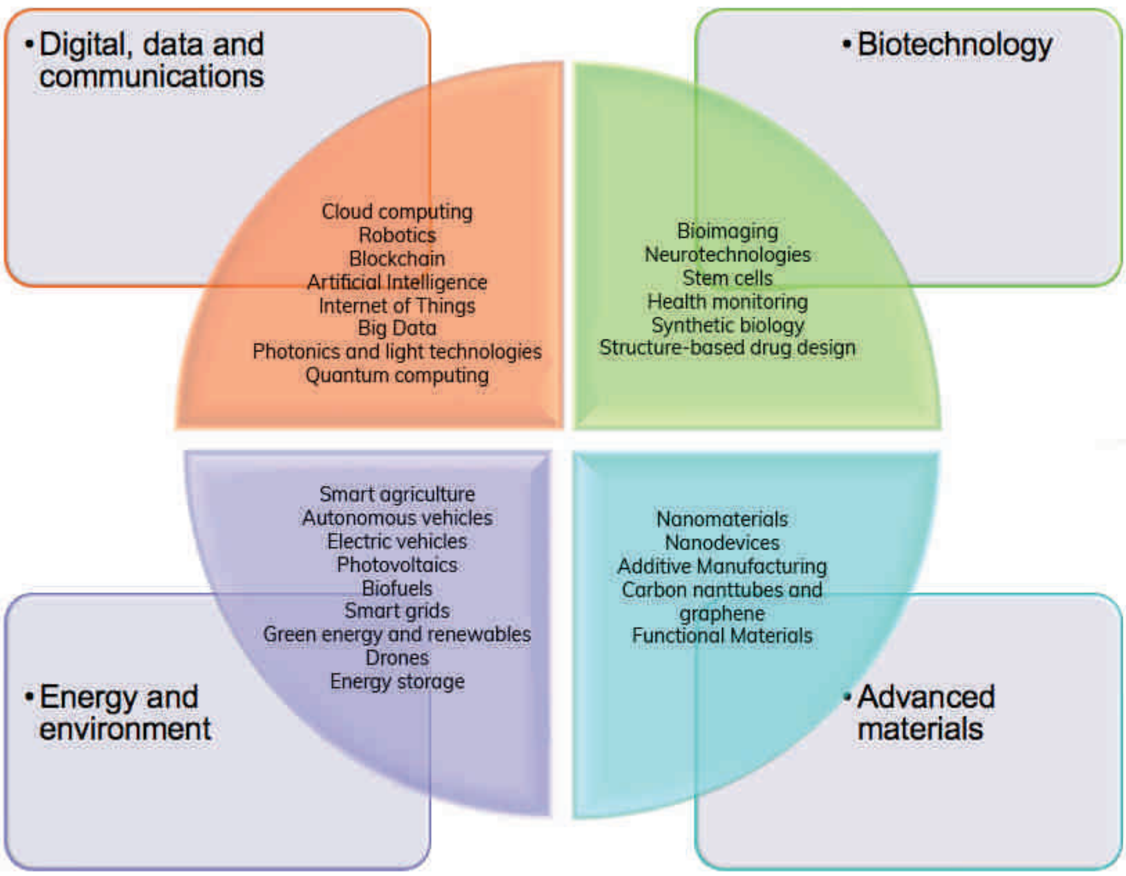
[7] See, for example, (World Bank 2018b), (ADB 2018), (Schwab 2017a)

[8] A comprehensive historical account of technological anxieties is given by Mokyr, Vickers, and Ziebarth (2015) who distinguish between three particular forms of anxiety. The first is that technological change will surpass the ability of humankind to keep up, and that the Schumpeterian 'destruction' will not be compensated by 'creation', for example, fears of widespread technologically-driven unemployment due to automation. The second anxiety is with the moral implications, broadly defined, of rapid technological change, for example: fears over the dehumanising effects of modern technology, 'digital isolation', the influence of social media, etc. The third form of anxiety is that technological progress is insufficient, that it has little to contribute economically or socially, for example the 'Solow paradox' - "You can see the computer age everywhere but in the productivity statistics" (Solow 1987); and also the inadequacy of modern technologies to respond to global issues, such as climate change.

Klaus Schwab, in his preface to the World Economic Forum report writes that "technological innovation will lead to a supply-side miracle".[9] We are not so sure. One of the key reasons for the failure of so many technology-driven 'solutions' in developing countries is a failure to appreciate the demand side and to make the technology fit the problem, rather than the other way around. We would advocate a **problem-led approach to technology.**

Also, one of the most over-discussed aspects of the debate has been the fascination with numerical predictions of technologically-driven unemployment due to automation. As we shall argue, this obsession has had the unfortunate consequence of distracting attention away from the very real benefits that developing countries could gain from new technologies and also certain key dangers that are far more pressing and plausible than unemployment. Our goal in this section is to reflect on each of the three claims and identify some of the key challenges and opportunities that follow from them.

Figure 1: New Technologies for the 21st Century



Based on OECD: Science and Technology Outlook 2017; particularly disruptive technologies are shown in bold.

9 See www.weforum.org/agenda/2016/01/the-fourth-industrial-revolution-what-it-means-and-how-to-respond/

2.1 Technological change: pace and scope

The first claim concerns specific features of new technologies, namely the *pace* and *scope* of technological change (Brynjolfsson and McAfee 2014; Frey, Osborne, and Holmes 2016). The claim holds that the pace of technological change is accelerating, if not exponentially, then at least demonstrably faster than in previous eras. It evokes Moore's Law[10] combined with a set of propositions regarding the inter-connectedness of new technologies – the idea that advances in one field rapidly unlock those in others (Schwab 2017a). So, while previous waves of technological advancement may have moved quickly, they did not display the sustained and accelerating rate of change that we appear to be seeing in some technological areas today. Perhaps more importantly, technology now seems to reach maturity faster than ever before – diffusion times are decreasing (Comin and Hobijn 2008). Then there is the (related) claim that the scope of technological change is unprecedented, in terms of the ways in which automation, robotics, machine learning and digital technologies have the potential to supplant human activity in hitherto inconceivable ways and thus fundamentally re-order almost every sector of the economy in a short space of time (Mitchell and Brynjolfsson 2017).

The pessimistic interpretation of taking these two claims together is that the disruptive effects of new technologies may proceed at such a pace and scope that individuals and policymakers will simply be unable to keep up.[11] As a result, we will see a collapse in labour demand, and the technologically-driven unemployment that will ensue will be not only inevitable but long-term (Brynjolfsson and McAfee 2014; Frey and Osborne 2013; Frey, Osborne, and Holmes 2016). It is predictions of this kind that have most dominated the headlines, conjuring images of a 'jobs apocalypse' and other gloomy scenarios. Others are optimistic, dismissive of such anxieties and seeing more opportunities than challenges. The forthcoming World Development Report (WDR) 2019 critically recalls unfulfilled predictions of Marx and Keynes, before referencing Aristotle's *Politics* "when looms weave by themselves, man's slavery will end" and declaring fears of widespread unemployment "overblown". This optimistic position expects disruption to be a Schumpeterian wave of creative destruction, largely short-term and ultimately compensated for by new forms of entrepreneurship, adjustments in the labour market and job creation.

We are highly critical of these predictions. Regarding the negative predictions of extreme job losses, there are reasons to be sceptical about the methodology itself (see Section 2.1.1). When applying this methodology to developing countries, there seems to be a problem with focusing exclusively on the potential losses to the formal sector, when so much of employment is informal, or formal but non-standard – perhaps the effects on those sectors are just as important. Similarly, there is a problem with the focus on frontier technologies, such as automation, AI and additive technologies, when non-frontier technologies are also highly important to many developing countries. But, most fundamentally, the predictions and the debates they have spawned, take a deterministic view of

[10] The 1965 claim by Gordon Moore that the computing power, purchasable by a dollar, would approximately double every year.

[11] In an interview, Brynjolfsson and McAfee put it as follows: "Digital technologies are doing for human brainpower what the steam engine and related technologies did for human muscle power during the Industrial Revolution. They're allowing us to overcome many limitations rapidly and to open up new frontiers with unprecedented speed."

technology in which effects are inevitable consequences of intrinsic features of technology and an abstract characterisation of jobs. Such a view fails to reflect that **the adoption (or not) of technology is not only constrained by technological feasibility, but by a range of other structures - political, institutional and social - in which it is embedded.** We take this latter point to be of fundamental importance and make it the centre of the discussion in Section 3.

Unfortunately, a similar line of criticism can be aimed at the blithe optimism of those who assume that the creative potential of technology will necessarily outweigh the destructive possibilities. Although, it is certainly the case that there is huge potential for technological gains in developing countries, those same factors that might prevent the worst excesses of disruption, also constrain or derail the positive possibilities. Understanding the barriers to technological adoption and diffusion is therefore one of the main goals of the empirical work in Section 4.

2.1.1 Employment and automation

One of the key issues is the extent to which recent advances in robotics and AI will lead to the displacement of labour and technologically-driven unemployment.[12] The seminal study of this kind is that of Frey and Osborne (2013) which applies an 'occupation-based' methodology to estimate the proportion of jobs that could be lost to automation and other technological change in the US. Their methodology uses expert assessments of 70 particular jobs and their susceptibility to automation according to certain characteristics, described by Frey and Osborne as 'engineering bottlenecks', which reflect different types of dexterity, or cognitive or social skills that are thought to be difficult to automate. The data set from which this classification derives is O*NET, an online data source provided by the US Department of Labor. It gives a range of occupational characteristics for more than 700 job categories (including the original 70). Frey and Osborne then use statistical methods to extrapolate from these data to make predictions for wider categories of jobs and thus to estimate the effects on the economy as a whole. Further studies, such as that of the WDR 2016 or ILO (2016), apply similar methodologies to Frey and Osborne. These studies produced alarming figures for the number of jobs at risk in developing countries, which have since been frequently cited.[13]

However, extending the Frey and Osborne methodology to developing countries is problematic. The original data set used (Frey and Osborne 2013) is very specific to the US. The categories into which occupations are sorted reflect the US economy (a farmer in Ethiopia is not engaged in the same activity as one in the US) and the degree of heterogeneity within categories will also vary from one country to another – so one might expect the relationship between the bottlenecks and the job

[12] The debate regarding technology and unemployment is not new: "We are being afflicted with a new disease of which some readers may not have heard the name, but of which they will hear a great deal in the years to come—namely, technological unemployment" (Keynes, 1930).

[13] Frey and Osborne (2013) predict that 47% of jobs in the US are vulnerable to automation within ten to 20 years. The WDR 2016 concluded that even larger numbers could be at risk in other countries: 57% across the OECD, 69% in India, 72% in Thailand, 77% in China and 85% in Ethiopia. (World Bank 2016).

categories to display different statistical relationships to those in the original Bayesian analysis of the US data. From our interviews, however, it has become evident that the discussion around this is active in Indonesia. There is concern that, with increasing technological advancement, there will be labour displacement in both the formal and informal sectors.

Subsequent authors, notably Arntz, Gregory, and Zierahn (2016) in a report for the OECD, have also been critical of Frey and Osborne's focus on occupations and advocated instead a 'task-based approach', based on earlier research of Autor (2003).[14] Their main criticism is that it is not occupations that are automated but tasks. According to Autor, occupations consist of a range of tasks and the susceptibility of an occupation to automation then depends on the balance of tasks that it entails. The OECD report's estimates of job losses were dramatically lower than those of Frey and Osborne.[15] More recent work using the task-based approach, including that of the World Bank (2018) and ADB (2018), has echoed these criticisms. They argue that Frey and Osborne's approach overestimates the susceptibility of jobs which involve a range of tasks, some of which are more difficult to automate than others, and under-estimates the potential of new technologies to generate new jobs.

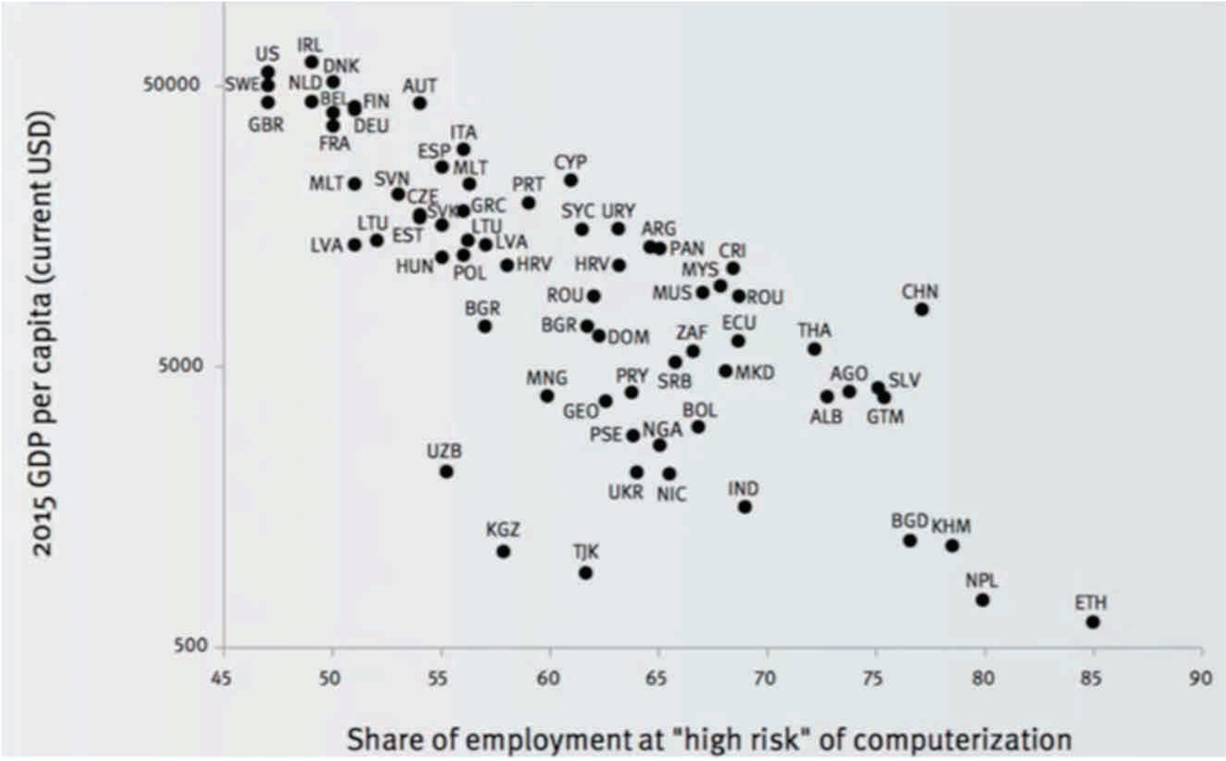
Conversely, however, Frey and Osborne are themselves critical of the task-based methodology. This is because the original paper (Autor, Levy, and Murnane 2003) on which it is based is, in their view, too simplistic in its classification of tasks within jobs. They argue convincingly that merely distinguishing between cognitive and non-cognitive (or manual), and routine and non-routine tasks are not sufficiently differentiated categories. The distinctions that define them do not adequately demarcate which tasks will become automable, given the pace at which machine-learning, AI and data analytics are progressing. Many non-routine and/or cognitive tasks are now within the grasp of AI technologies. Frey and Osborne cite Levy and Murnane's (2004) own reference to the impossibility of autonomous vehicles negotiating a left-hand turn against oncoming traffic, before observing that a mere six years later, Google's driverless cars were doing just that.

Overall, the two methodologies produce startlingly different predictions and imply contradictory functional relationships. The 'occupation-based' methodology indicates a fairly robust negative relationship between GDP per capita and automation risk (see Figure 2).

[14] See also (Acemoglu and Restrepo 2017; Autor 2015; Autor, Dorn, and Hanson 2015) for further discussion of the task-based approach.

[15] The OECD (2016) figure for US jobs that are vulnerable to automation is only 9%. The analysis is applied across the OECD member states and also refined according to other characteristics such as education.

Figure 2: GDP Per Capita versus Share of Employment at “high risk” of computerisation



Source: (Frey, Osborne, and Holmes 2016)

Whereas, the task-based methodology, if anything, suggests the opposite (Figure 3).

Figure 3: Share of Jobs at high risk of automation, by country

Source: (Hallward-Driemeier and Nayyar 2018)

2.1.2 Job creation and productivity: calculating the aggregate effects

What do we make of the methodological controversies above and the wildly conflicting predictions regarding technologically-driven unemployment? We argue that this particular focus – on estimating the total numbers of jobs lost to automation – is not only difficult to resolve, but actually misleading in that it distracts from other, more important questions. Part of the difficulty in only considering the susceptibility of jobs is that to do so is to ignore the new jobs that may be created by new technologies, or the existing jobs that unemployed workers may be able to move into, following automation, or the ways in which their existing jobs might be improved by complementary use of technology. Yet, these creative aspects have always been understood as going hand-in-hand with the destructive side of technology, even if it is difficult to predict the relative pace at which these effects proceed. Equally, if the only negative effect that we consider is job *losses* then we distract ourselves from the perfectly plausible scenario in which technological change damages not the numbers but the nature of employment. Indeed, there is evidence that this latter possibility has already happened, at least in wealthy countries (Brynjolfsson and McAfee 2014).

Let us first deal with the positive side of the story and consider how **rapid technological change generates a range of positive effects.** Firstly, technology is a key driver of within-sector **productivity growth** at both a firm and individual level. Adopting new technologies has been essential in transforming sectors to higher productivity models: whether it be the use of fertilisers, irrigation or machinery in agriculture; in machinery or machine tools in manufacturing; or in information technologies in offices and businesses. In addition, rising productivity lowers production costs and stimulates demand, in some cases leading to job creation; alternatively the technology itself may create new job categories to manage its utilisation. Technology also has the potential to generate **cross-industry effects**, such as spillovers across sectors, either: by generating cheaper/better inputs; by diffusing technological capability; or through workers with new skills and knowledge moving between industries. There may be income effects – for example, when technology is complementary as opposed to purely displacing, then increased incomes for workers in that sector drive demand from other sectors. Finally, there is a category of **aggregate effects** that technology may have on jobs, due to such factors as: the relative cost of labour to automation; the elasticity of labour supply; or the nature of the demand response to income elasticity. All three of these factors may have positive effects on employment and wages for those workers whose skills are complementary to new technologies (ADB 2018 Section 2).

However, modelling these effects – positive and negative – to assess the aggregate effects of technology, (or even just automation) is extremely difficult. Acemoglu and Retrepo (2017) construct a labour market model based on commuting zones (proxies for local labour markets) that tries to gauge the equilibrium impact of automation. The model makes certain simplifying assumptions regarding trade between the zones and then estimates how exposure to automation creates displacement and adjustment effects. They find large and robust negative aggregate effects of automation on jobs and wages across the US in the period 1990–2007.[16] However, Dauth et al. (2017), in an empirical study, found no aggregate job losses for the period 1994–2014 in Germany,

[16] Acemoglu and Retrepo

although they did find significant adjustment effects and negative effects on wages.[17] Earlier work, such as Hornstein et al. (2005), points to similar divergences in the past between the US and EU and suggests mechanisms through which divergences of these kinds might arise, stressing the importance of institutional factors such as labour representation, unions, etc. This tends to confirm the hypothesis that the outcomes of technological change depend upon the political economy and institutional context in which they occur.

2.2 Distribution effects: polarisation, appropriation and inequality

The second argument is a claim, or set of claims, that new technologies, especially digital technologies, give rise to new forms of inequality or enhance existing inequalities, either by permitting new forms of ownership and appropriation – for example through the patenting of intellectual property – or by polarising society, disproportionately rewarding the most skilled and disadvantaging the least, while at the same time 'hollowing out' the middle, or by undermining democratic or redistributive political structures. Forms of employment that derive from new technologies, such as digital platforms and the 'gig economy' may be inherently more insecure and precarious than other jobs (Norton 2017). Thus, the benefits of innovation may not be shared in the same way as with previous episodes of technological change (Frey, Osborne, and Holmes 2016; Norton 2017).

Yet, while the prevailing views may be pessimistic, at least in principle the non-rivalrous and only partially excludable characteristics of knowledge could also be a force for inclusivity.[18] New technologies greatly facilitate knowledge sharing and the transfer of other technologies (Cummings 2003; United Nations 2014). If the benefits of knowledge sharing could be harnessed by developing countries, then the greatest inequality of all – the knowledge gap between rich and poor – might be narrowed. Moreover, digital and mobile technologies are already transforming the structure of work and society, connecting people with more formal employment, and providing greater transparency and accountability, and potentially enhancing the delivery of public services (see Section 2.3).

Regarding the possibility that new technologies may have a negative impact on the world of work, Schlogl and Sumner (2018) have recently proposed a model, in a paper produced for the Center for Global Development (CGD) where the primary effect is not on unemployment but rather on wages.

[17] "Every robot destroys two manufacturing jobs... But this loss was fully offset by additional jobs in the service sector. Moreover, robots have not raised the displacement risk for incumbent manufacturing workers. Quite in contrast, more robot exposed workers are even more likely to remain employed in their original workplace, though not necessarily performing the same tasks, and the aggregate manufacturing decline is solely driven by fewer new jobs for young labour market entrants. This enhanced job stability for insiders comes at the cost of lower wages" (Dauth et al. 2017)

[18] a rivalrous good is one in which the consumption of that good by an individual prevents the simultaneous consumption by another. Knowledge may be said to be non-rivalrous in the sense that knowledge of a particular piece of information or of a skill does not preclude others from also having knowledge of that information or skill. Excludability is the possibility of being able to prevent others from consuming or having access to a particular good. Knowledge is, in general, only partially excludable – it may be possible to limit the access of others to knowledge, for instance through intellectual property legislation, but seldom the case that excludability is absolute.

Schogl and Sumner's report emphasises the importance of economic, social, legal and economic factors,[19] argues that **rather than causing mass unemployment, AI and robots are more likely to lead to stagnant wages and deindustrialisation.** The authors anticipate that increasing automation in agriculture and manufacturing will drive workers into services, pushing down wages.

Schogl and Sumner's model provides a theoretical justification of why new technologies may have a polarising effect. In high-income countries there is a fairly robust set of evidence to support this. At a national level, various authors – for instance Autor and Dorn (2013) – argue that, since the 1980s, the IT revolution has led to a polarisation of the labour market, in which middle-skill, middle-wage ('routine') jobs are substituted by new technologies, while high-skill, high-wage ('abstract') jobs are complemented – the 'routinisation' hypothesis. Siegel and Barany (2015) claim that this polarisation actually started much earlier, in the 1950s, but the conclusions are similar – that digital technologies have accelerated this trend and are likely to do so in the future through increased automation. The result is a 'hollowing-out' of the middle class, in which human labour is divided into low-skill and high-skill occupations, which machines find harder to replicate ('Moravec's paradox').

However, in developing countries the evidence is less clear-cut. In a recent study on the adoption of complex software in Chile,[20] adopting firms significantly expand their employment of administrative and unskilled production workers. This led to an increase in firms' use of routine and manual tasks, and to a reduction in firms' use of abstract tasks, which are now arguably being performed by technology. In fact, at least in the short term, growth seems to have been inclusive and not at the expense of less skilled workers. Maloney and Molina (2016) set out several reasons why the polarising tendencies that occur in industrialised countries might not do so in the same way in the developing world. These include: differing initial occupational distributions; the net impact of offshored jobs; removal of trade barriers; improved access to ICT; and productivity gains due to new technologies. Following another study (Autor 2015; Autor and Dorn 2013) , they tracked job categories over time in various less developed countries (LDCs), using data from the US and France to provide comparator patterns of what polarisation would look like. In the crucial category of 'plant and machine operators', Maloney and Molina did not find evidence of polarisation in general in LDCs. However, this is a cautious conclusion, as in some countries (Indonesia being one of them) there is such evidence. It is also of concern how much robotisation in China could affect manufacturing in other developing countries. This is because the assumption that routine manufacturing tasks would be transferred to other countries as China moved up technologically may no longer hold. Thus it may be that the inequalities are compounded by effects that we *don't* see as much as by those that we do. As the authors say: "it may be the non-appearance of the Vietnam pattern of expanding assembly and operators in Africa, for example, that will be the important story" (Maloney and Molina 2016 p.17)

[19] Schlogl and Sumner give an interesting example from Indonesia, in which automation of the part of road toll operator PT Jasa Marga could potentially have led to 20,000 job losses. Yet, in fact, there have been virtually none. It is hard to make sense of this in purely economic terms and Schlogl and Sumner consider what institutional and political factors might have been relevant.

[20] http://blogs.worldbank.org/latinamerica/future-jobs-and-skills-gloomy-or-glowing-scenario-less-skilled-workers

Closely related to the polarisation effect is the **appropriation effect:** the claim that the gains due to information technology and automation are especially easily to appropriate. Thus the benefits will be unevenly shared with the returns to capital vastly outstripping those to labour, but with a smaller capitalist class than in previous technology booms, and without an entrepreneurial middle class to generate innovation. Such arguments are compatible with other accounts of wage-stagnation and rising inequality, such as that of Thomas Piketty (2014). They align digital technology with other factors, such as financialisation and globalisation, as drivers of inequality. This is also in line with the arguments of Robert Gordon which unfavourably contrasts the productivity gains due to IT with those of earlier technological revolutions of the 19th and 20th centuries (Gordon 2004) or the 'digital storm' of Galbraith (2014). Finally there are other forms of **inequality effects** that come from isolation, insecurity and the erosion of organised labour as a political force (Norton 2017).

Labour market displacement and non-standard employment create new challenges for social protection policy. In addition to technologically driven unemployment, many of the forms of employment created by new technologies are found in non-standard employment. This includes a range of contractual arrangements that deviate from a standard open-ended, full-time, dependent employment relationship, which constitutes the key reference point for most labour and social security legal and policy frameworks (Behrendt and Nguyen 2018). While such employment provides flexibility and opportunities for many workers to participate in the economy, it also heightens social risk and the potential for exploitation. Lower job and income security, poorer working conditions and lower social protection coverage are more likely for those in non-standard employment (both in traditional and new sectors) than for those in standard employment; women, young people and migrants are disproportionately affected (ILO 2017). The lack of protection drives many workers into the informal economy. Meeting these new challenges places extra strain on government's financial and organisational resources. Many of the issues that arise are part of a broader discussion on social protection and/or non-standard employment, but a number of specific concerns can be made for workers in employment created by new technologies, such as digital platforms (Behrendt and Nguyen 2018). These include: adapting legislative frameworks and ensuring compliance (for example, ensuring that legislative frameworks are adapted to cover crowd workers); clearly establishing rights and responsibilities (in the platform economy, the division of tasks into micro-gigs delegated to a large pool of workers can obstruct employee protection or benefits); and using digital technologies themselves to simplify administrative and financial arrangements. But it is also possible that new technologies themselves could provide greater formalisation and protection for workers in the informal economy, or in non-standard formal employment. Simple record-keeping and data-management could be an effective means of preventing exploitation in many cases.

Distributive effects and social protection issues, such as those mentioned above, illustrate the two-way relationship between social and political institutions and the pathways through which technological change occurs. We have discussed how non-technological factors determine the extent to which technology is adopted and diffused, but there is a reciprocal nature to this. If it is the case that political factors, such as those described in Mushtaq Khan's work on the political economy of rent-seeking (Khan 2013, 2015a, 2015b), do determine new modes of production, then what are the new political forces that follow from them? New technologies have the potential to profoundly reshape society and the institutions that govern it, and by doing so pose a set of questions that essentially ask whether or not technologically-driven development is *inclusive*. We have discussed the polarisation effect already, but there may well be effects within the general category of polarisation. For example, if it were the case that automation/reshoring led to unemployment within the garment sector, then what would be the gender implications when so much of the workforce is female in many developing countries? And where does policy feature in any of this – reskilling, redistribution or representation? These are all factors in considering what a new societal deal would look like.

2.3 Technology, information and knowledge

There is an argument that all technology is the accumulation and expression of knowledge. But when it comes to the current generation of technologies, especially ICT, these technologies not only embody accumulated knowledge, but also directly increase the rate at which knowledge is itself created or disseminated. Most obviously, they facilitate the cheap and fast transfer of information. Under certain circumstances, they may lead to other forms of learning, or the transfer of tacit knowledge. Evidently, technological change in these areas has the potential to drive change in others. This is the substance of the third of our claims.

2.3.1 The domestic economy

There are numerous mechanisms through which information or knowledge transfer might create opportunities for developing countries. Quite generally, reduced communication and transaction costs deliver benefits by helping to better co-ordinate the domestic economy, strengthening linkages between sectors, matching inputs with outputs, solving any number of information problems, improving market efficiencies and creating jobs.

A good example is agriculture. External agricultural conditions, such as soil and weather, are better monitored and controlled today, thanks to the improved precision technologies, The Internet of Things (IoT) and the availability of big data. The use of this technology in agriculture production systems is referred to as ‘smart farming/agriculture’ (Pivoto et al 2018)[21] or alternatively ‘precision farming/agriculture’ (MGI 2013), both of which derived from the idea of the farm management information system.[22]

Digital communication technologies, which often come in the form of mobile telephony, are another type of technology that have the potential to make a huge impact on the farm and farm employment. There are numerous examples of how digital communication technologies have been used (co-ordinating distribution of seeds and fertilisers; delivery of timely, relevant and actionable information

[21] Pivoto et al (2018), Scientific Development of Smart Farming Technologies and Their Application in Brazil, *Information Processing in Agriculture* 5, pp. 21-32.

[22] The literature on this topic is quite recent, and hence the concepts and terms associated with it have not been agreed in the scientific literature yet.

and advice to farmers; provision of agrometeorological services for early warning of weather climate risks; provision of digital financial services among others) benefited farmers (see 2016 WDR Digital Dividends). Some of these examples include an increase in agriculture productivity and/or income gains due to improved information flows and lowered monitoring costs. Deichmann, Goyal, and Mishra (2016) give a useful survey of the impact of digital technologies on agriculture.

Another example is the provision of financial services ('mobile money'). Jack and Suri (2011) describe the emergence in Kenya of M-PESA, perhaps the best-known mobile-money provider. They explain how the system delivers benefits of various kinds to users, including facilitating trade, safe storage, risk management and efficient use of human capital. When technologies of this kind are effective, (as M-PESA appears to be), they can deliver much-needed and highly valued financial architecture to sectors of society that had not had such access before. Castro and Gidvani (2014) provide an analogous review for mobile money in Tanzania, explaining how the technology has been extended to provide a wide range of services.

Platform economies too, such as Uber, or GO-JEK in Indonesia are based around ways of collecting and manipulating data, enabled by new technologies. The extraordinary penetration of mobile technologies in particular, have revolutionised transportation in some areas. In rich countries, such companies are viewed with suspicion on account of poor security and status for their drivers. However, there is evidence that workers in developing countries such as Mexico have seen improved working conditions.

In terms of public services, more and better information can provide mechanisms for monitoring and accountability, reducing corruption, strengthening trust in government and improving service delivery. An example is the Citizen Feedback Monitoring Programme in the province of Punjab in Pakistan, which has a population of 110 million people.[23] In Punjab the initiative has been at scale for a number of years – with a mix of success and some challenges.

There is potential too for industry regulation, since very often the difficulties that regulators face are information problems. An example from Indonesia is that of Global Fishing Watch, an innovative use of Google-designed technology to combat illegal, unreported and unregulated fishing. The Indonesia government took a pioneering role, by becoming the first country to adopt the vessel monitoring technology, and use it to aggressively curtail illegal fishing. Thus far, the initiative has been a success, showing substantial reductions in illegal fishing and helping pave the way for recovery policies (Cabral, Mayorga, and Clemence 2018). In a bold new paper in *Nature*, Brynjolfsson and Mitchell call for governments to collect and analyse public and private sector data sources to make data-driven policy decisions (Mitchell and Brynjolfsson 2017).

However, fashionable as they are, there are reasons to be cautious about such applications of technology. Development is littered with failed technology schemes of one kind or other. Very often the reasons for these failures lie in an excessive enthusiasm for a technologically-driven solution combined with an inadequate understanding of the problem. In Indonesia, the citizen-feedback scheme LAPOR was deemed to have failed as it generated very few actionable complaints

[23] https://pitb.gov.pk/cfmp; see also: www.youtube.com/watch?v=CN0aKpK4tYc

(World Bank 2016), whilst in Tanzania, the Maji Matone initiative that collected data on rural water supply was also unsuccessful. Molony (2008) considers the effects of mobile phones on traders of perishable foodstuffs operating between Tanzania's Southern Highlands and Dar-es-Salaam's wholesale market, with a particular focus on the importance of credit in the relationship between potato and tomato farmers and their wholesale buyers. He argues that the ability to communicate using these new information and communication technologies (ICTs) does not significantly alter the trust relationship between the two groups. This also suggests that farmers, in effect, often have to accept the price they are told their crops are sold for – irrespective of the method of communication used to convey this message – because their buyers are also their creditors. In this situation, many farmers are unable to exploit new mobile phone-based services to seek information on market prices, and potential buyers in other markets. Finally, in their studies of small and medium-sized enterprises (SMEs) in Indonesia and Tanzania, Voeten et al reveal a range of institutional factors that need to be overcome for technologies to be successfully applied (Voeten, Achjar, and Utari 2016; Voeten, Kirama, and Macha 2016).

We would argue that we can learn as much from the failures of technology initiatives as from the successes. We agree with the general principle that improved communication and data management can deliver significant gains; it can connect the domestic economy, provide valuable institutional support, generate mechanisms of trust and accountability, improve public services and hold industries to account. But success in these ambitions depends on: understanding the political and institutional factors that constrain technological change; ensuring that the application of technology meets a specific demand and is 'problem-driven' (OPM and Haldrup 2018).

2.3.2 Globalisation, global value chains and industrial policy

The preceding arguments have focused on the national level, but new technologies have also profoundly affected (and been affected by) globalisation. Richard Baldwin (2016) also makes the claim that improvements in information and communications technologies (ICT) have led to dramatically cheaper forms of communication, information management and the co-ordination of complex activities. He argues that the fall in transaction costs will drive a reorganisation of production processes and global value chains.

This claim has considerable implications for industrial strategy. It may be that the telescoping of global value chains has very serious negative implications for the future of manufacturing, and in particular export-oriented manufacturing strategies (Hallward-Driemeier and Nayyar 2018; Yusuf 2017). Globalisation of this form may go hand-in-hand with the 'premature deindustrialisation' (McMillan, Rodrik, and Verduzco-Gallo 2014). There could also be significant opportunities as well. Predictions of the demise of manufacturing may be greatly exaggerated, even if some servicification is likely (UNIDO 2016). If Baldwin (2016) is correct that the 'knowledge offshoring' that began in 1990 did drive the 'great convergence', then there may be strategies that developing countries can employ whereby they continue to benefit from global value chains (GVCs).

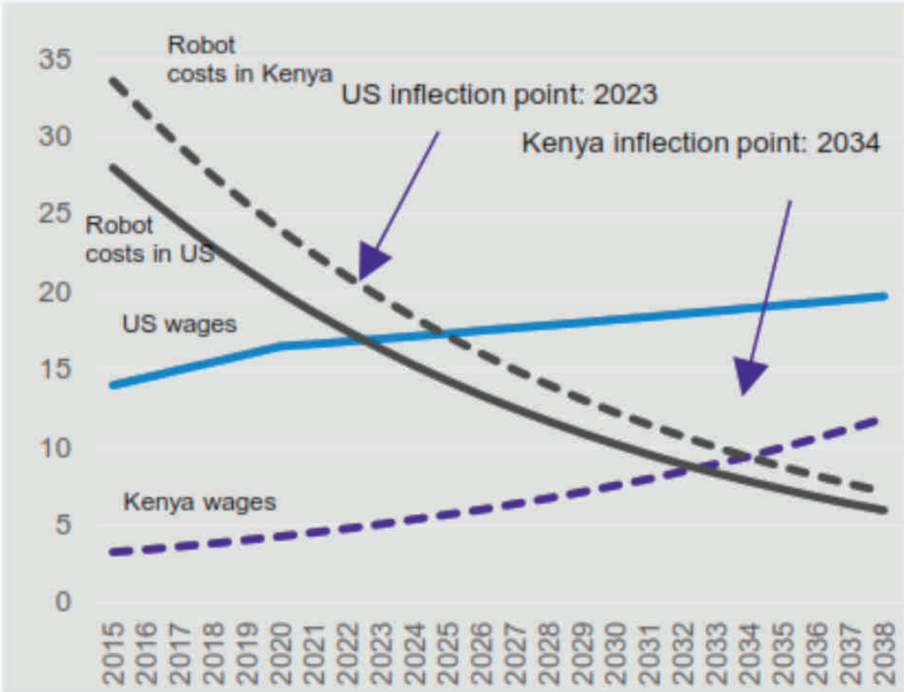
In his book *The Great Convergence*, Baldwin's argument is that there are three main costs to trade over distance: the costs of moving, goods, ideas and people (Baldwin 2016). 'Old' globalisation – the globalisation of the 19th century – is driven by the low cost of moving goods (shipping) but the high cost of moving ideas (the difference between the industrialised West and the rest of the World). The result was the 'Great Divergence' in incomes that only in the 'New Globalisation' (in which the crucial cost reduction was in communications) has there been a reversal. The greater diffusion of existing ICT reduced trade and co-ordination costs[24] and strengthened globally fragmented production, leading to global value chains, and the offshoring of production and knowledge. Successful industrial policies, especially in Asia, have been built around the capture of that knowledge (H.-J. Chang and Andreoni 2016). As a result there has been, at least until recently and at least in certain Asian economies, a 'Great Convergence'. The question is now whether or not new technologies have the potential to reverse these trends, shortening value chains, reshoring production, limiting industrial development and shutting down the acquisition of productive knowledge.

The impact of globalisation may be particularly felt in **manufacturing**. The World Bank's recent report on the future of manufacturing *Trouble in the Making* takes a negative view (Hallward-Driemeier and Nayyar 2018). This has consequences not only for those countries seeking to emulate successful manufacturing-oriented strategies of the past, but for other countries too, due to the role that manufacturing plays in driving productivity changes, generating learning and stimulating demand in other sectors. Yet, as UNCTAD's 2017 *Trade and Development Report* argued, there are also policy measures – for example, linkages between and within sectors – that can mitigate some of these factors. The ADB's 2018 report also discusses how policy can generate cross-industry effects, such as knowledge spill-overs. The ADB report also argues that reshoring may have less of an effect in Asian economies; their argument being based on the characteristics of firms that are more likely to reshore – capital-intensive, high-tech and (obviously) foreign-owned. UNIDO (2016) too is bullish about the future of manufacturing, emphasising its continued importance in terms of value-added, productivity and structural transformation. Norton (2017) argues for a strategy of 'get there while you can' and investing heavily in digital infrastructure in the meantime – capitalising on comparative advantages in labour and market access, while automated production catches up in cost terms. Certain sectors, such as textiles and apparel may remain viable manufacturing routes for some time. Banga and te Velde (2018) reinforce this point, with a discussion on digitalisation which emphasises the 'windows of opportunity' which developing countries may have to make good on their cost advantages. In the figure below, the inflection points indicate the points in time at which it is predicted to become cost-effective to introduce automation into furniture manufacturing in the US and Kenya, respectively. The predictions[25] imply that Kenya has a window of about ten years in which to develop less-automated sectors.

[24] There is evidence that more widespread use of scale-neutral digital technologies, such as ICT, have allowed firms in some low- and middle-income economies to access wider markets through reducing the costs of matching buyers and sellers all over the world. These technologies include smartphones, video and virtual-reality conferencing, and computer translation. More generally, Osnago and Tan (2016) and World Bank (2016a) find that a 10% increase in an exporter's rate of internet adoption led to a 1.9% increase in bilateral exports.

[25] Although these predictions themselves do not take reshoring into account.

Figure 4: Windows of opportunity – the case of Kenyan furniture manufacturing



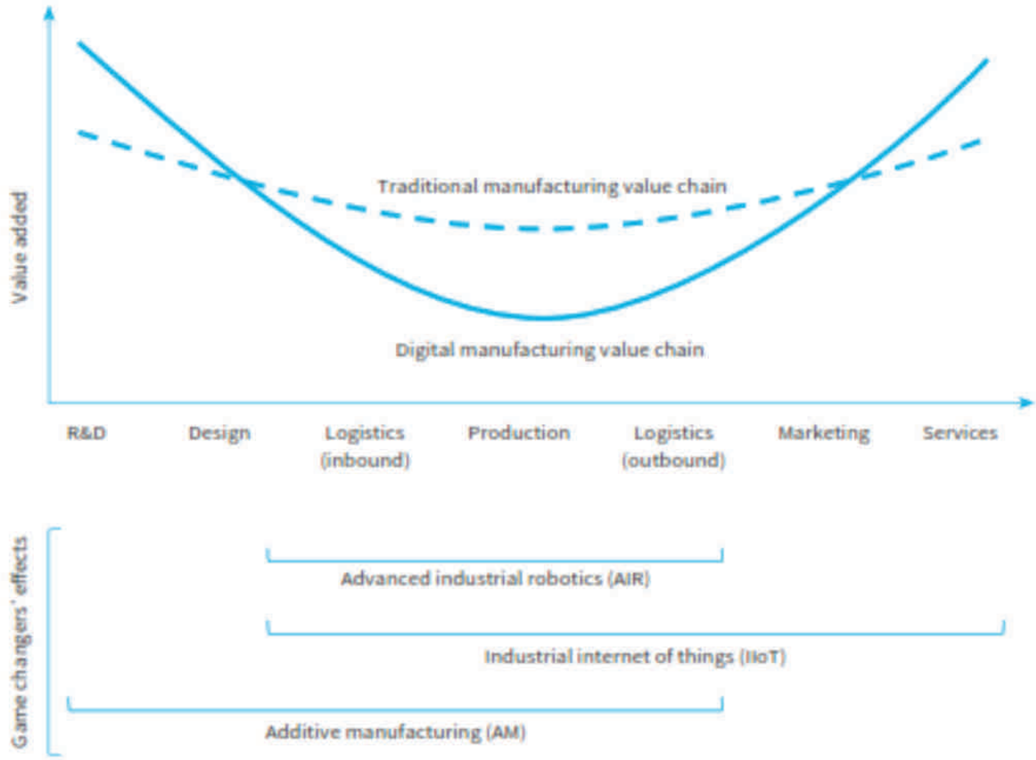
Source: (Banga and te Velde 2018)

Another possibility is that while globalisation may make it harder to emulate earlier manufacturing-oriented developing strategies, it may also open new opportunities for tradable services. The ADB (2018) argues that while Business Processing Services (BPOS), which have long been a significant industry in such countries as the Philippines, may be vulnerable to automation due to the routine nature of the interactions, there may be a new generation of Knowledge Processing Services, dependant on interactions that are far harder to automate, and capable of adding significant value-added. More generally, the crucial question for tradable services as a potential positive pathway to sit alongside (or even replace) manufacturing, is whether it offers those same virtuous features of manufacturing – knowledge spill-overs, technological and firm learning, and robust, good-quality employment.

Premature De-industrialisation and New Industrial Policy

If the relationship between global value chains and new technologies is as important as claimed, then we face a very uncertain future (Backer and Flaig 2017). It is not clear what the implications are for industrial strategies, and developing countries may have to make decisions based on extremely imperfect information. On the one hand, Diao, McMillan, and Rodrik (2017) have described the phenomenon of 'premature de-industrialisation' as growth without structural change, or even with structural change 'in reverse'. It seems that recent growth accelerations were based on either rapid within-sector labour productivity growth (Latin America) or growth-increasing structural change (Africa), but rarely both at the same time. The East Asian model of export-oriented manufacturing-led development, in which growth-increasing structural change was accompanied by rapid within-sector labour productivity growth seems not to be happening elsewhere. For some this offers empirical confirmation of the futility of pursuing manufacturing-oriented industrial strategies, but Mario Cimoli (2018) offers instead a 'New Industrial Policy' based on the promotion of 'technology ecosystems'; a cross-sectoral approach to policy aimed at promoting those technology ecosystems; a major focus on: advanced manufacturing; IoT, development of platforms and enabling technologies; an increased awareness that geographically concentrated manufacturing systems (all along the 'smile' curve) can be a competitive advantage in the technological revolution; and a focus on skills and infrastructure development. For Cimoli, the future of industrial policy is a transition from traditional manufacturing-oriented policies to long-run policies for technology-ecosystem development.

Figure 5: Value chain smile curve (top panel) and the steps of the value chain where new technologies can have an effect (bottom panel)



Source: Eurofound (2018)

3. Technological Change: Theoretical Approaches

In the previous section, we outlined the main pathways through which new technologies may generate challenges and opportunities. In each case, unlocking the potential for new technologies to generate positive effects is a question of enabling the adaptation and diffusion of technology in a manner appropriate to context, and then managing the effects of that technological change in an inclusive way. Seen in this way, the issue is not with the 'newness' of those technologies, but with the context in which they are applied. As argued previously, much of the literature has been overly exercised with the specific features of new technologies and insufficiently concerned with the realities of technological change. Therefore, a primary goal in pursuing our analysis, should be to set out a theoretical framework in which to think of technological change and an empirical method by which to assess it.

In setting out this goal, we are mindful of the need to take a heuristic, flexible approach and not to be constrained by a rigid theoretical model. Applying theory in a considered and pragmatic way may allow us to address the issue of rapid technological change in a 'deeper way', not only considering the 'symptoms', but also the underlying 'causes', and so ultimately be more useful to policymakers. However, we need to stay focused on understanding the impact of disruptive technology in LICs and LMICs, and regard technology and innovation in a broad sense. This means that we should be aware that non-frontier technologies may be extremely important, and so it is technological diffusion, adoption and adaption that matters most. Also, changes in organisational or managerial capabilities may well be as important, or even more important than 'technology' understood in a narrow, engineering sense.

With these points in mind, we review various theoretical perspectives on technological change and set out some preliminary elements in a (loosely defined) analytic framework that will inform our empirical approach to the case studies, policy stocktakes and workshops. Our approach can be summarised in the following key points:

- Technological change is the driver of economic development
- Technological change and innovation depend on a hierarchy of *capabilities*, at the individual, firm and national levels.
- The acquisition of capabilities is itself constrained by a range of institutional and political economy factors. Thus the processes of technological diffusion, adoption and adaptation are embedded in these structures.

3.1 Neoclassical approaches

From the perspective of traditional neoclassical economics, technological change is conceived of as a movement of the production function, changing the space of possible production possibilities in which capital and labour combine to generate output. In the Solow model, the basis of neoclassical growth theory, technology is exogenous and technological change is the key driver of growth – but technology itself is a black box. There is no unemployment (except temporarily in transitions, which are not explained). When technology improves, exogenously, it increases the efficiency with which capital and labour generate output (Total Factor Productivity or TFP), high returns draw in investment so that available labour is employed using the new technology: the economy grows. TFP is highly abstract and a controversial proxy for technology itself (Lipsey and Carlaw 2000). Everything is aggregate, so effectively there is only one good and only one technology.

For LICs and LMICs, this simple model seems to make technology absorption very important because: a) there is supporting evidence for the basic predictions of the model; and b) it suggests that, if technology can be absorbed, the differences between LICs and rich countries should melt away – there should be 'convergence'. In fact, there is strong empirical evidence for conditional convergence – countries do converge except for differences explained by other key factors (Barro 2012). However, the other 'key factors' clearly allow for some very big differences in levels of output per capita. One way to think about this is that the key factors are impeding the absorption of technology. LICs and LMICs simply are not using the same technology as rich countries, their aggregate production function is clearly not the same. Even if some industries do use the same technologies, many do not.

Growth theory is quiet on the processes generating technological change (Lall 1992), and the theory does not attempt to explain *how* technological change occurs, by what mechanisms it affects growth, or why agents would invest in one form of technology over another. Various endogenous growth theory models make technological change part of the model, although they retain most of the highly reductive characteristics of Solow and offer very little practical detail on the technology absorption process. They create the possibility of low-income traps – *a country is poor because it has not absorbed technology because it is poor.* Key contributions include the seminal work of Romer (1986, 1987, 1990) and Romer's classic paper (1990) which explicitly sets out three basic premises for an endogenous growth model: (i) economic growth is driven by technological progress as well as capital accumulation; (ii) technological progress results from deliberate actions taken by private agents who respond to market incentives; (iii) technological knowledge is a non-rivalrous input.

Box 1 Technology and Unemployment

Growth theory isn't primarily concerned with unemployment so most of it assumes it away. Most macroeconomics assumes that "full employment", where the labour market clears, does tend to come with a certain level of unemployment – enough to give workers and employers time to find each other, enough to prevent steep inflation. Financial crises or other triggers may cause employment to fall significantly below "full" in the business cycle – incremental upgrading is likely to occur on the way out of recessions rather than be a cause of them. But these business cycles occur at a higher frequency than disruptive technological shifts.

Theoretical models can be used to look at the impact of technological change on the level of unemployment at *full employment*. One example, influential in the debates over technological unemployment is that of Aghion and Howitt (1994). In this model, growth and unemployment are related to one another, through a 'capitalisation effect', whereby an increase in growth raises the capitalised returns from creating jobs and, consequently, reduces the equilibrium level of unemployment, and a 'creative destruction' effect, whereby increases in growth raise the job turnover rate and consequently the equilibrium rate of unemployment, according to search theories of Lucas and Prescott. In the destructive phase, technology substitutes for labour so forcing workers to reallocate their supply, while in the creative phase, firms enter industries where productivity is relatively high and so drive up employment in those industries.

It is worth considering that the nature of unemployment might differ according to place, times, economic and labour market conditions and also with different technologies. In 19th-century Britain, the Industrial Revolution replaced skilled workers with machines, making skills redundant and depressing wages, even as national income increased (Allen 2016). In South Africa, the legacy of apartheid constrains labour demand and creates persistent high unemployment (Hausmann 2008). In modern Nigeria, the unemployed are mostly educated middle-class youth who can afford to wait for job opportunities – the unemployed poor are 'underemployed' in international nomenclature, relying on traditional agriculture but unable to find enough work there (Kale, Yemi; Doguwa 2015).

In the near future, the impact of disruptive technology on employment in any one LIC will arise partly from the direct impact of technology use in the country, but also indirectly from the impact of technology on the global pattern of production.

3.2 Firm-learning, innovation and capabilities

Neoclassical growth theory tells us to be interested in convergence and what might be impeding it but to understand more about what is impeding the full employment of labour in ways that use new technologies, then we need theory which probes microeconomic processes more. Growth theory tends to assume away the problems of assimilating or adapting to technologies, of firm learning and of the fact that different firms operate with different levels of efficiency, and different technologies (Lall 1992). Technology is assumed to be freely available to, and immediately usable by, all firms and it is only factor price ratios and capital labour intensities that determine where firms lie along the production function. These assumptions tend to diminish the role of technology in developing countries. It is assumed that innovation happens elsewhere and all developing countries need to do is import and then apply foreign technologies. Endogenous growth models are far more complex and demonstrate that the sort of axiomatic assumptions and employment effects identified by Romer, Aghion and Howitt can be framed within the neoclassical paradigm. As such, they allow us to think about technology at the macro-level in ways that connect with mainstream economics. Yet, as the same time, to investigate the micro-concerns that Lall raises requires something else: how do firms assimilate and adapt to technologies; what conditions or activities need to occur for firm learning and innovation to take place? In trying to gauge the challenges and opportunities presented by rapid technological change, these issues seem especially relevant.

For most economists, the concepts of innovation (and also 'creative destruction') are immediately associated with Joseph Schumpeter who viewed capitalist economic development as driven by continuous waves of technological innovation and entrepreneurism. Each such wave would inevitably lead to disruption to the prevailing economic order – jobs, firms, methods of production and forms of organisation – according to how these structures were able to exploit the new technologies, innovations and enterprises. But out of this 'destruction' there would also be 'creation' in which new jobs and firms would emerge, and new modes of production and industrial organisation would be established. Uncertainty is a key concept in Schumpeter's work, and his observation that innovation arises from deliberate effort and the incentives to make that effort are important insights into the nature of innovation. However, as Nelson observes, Schumpeter has something of a 'blind spot' (Nelson 2008 p.11), namely his failure to appreciate the institutional complexities of modern market economies.

More practical literature on which to base a conceptual approach to technological change and innovation[26] is that of *capabilities*. Capabilities may be understood as "personal and collective skills, productive knowledge and experience that are embedded in physical agents and organisations" (Andreoni 2013 p.73). We can think of capabilities as operating at a hierarchy of levels, principally the *individual, firm* and *national*.

[26] From here onwards, we shall follow the Oslo Manual's definition of innovation: "Creation or adoption of new product or process, or new organisational and marketing practices (where "new" means new to the world or new to the country or the firm), but, also new business models and new sources of supply. (Oslo Manual, 2005)

At an individual level, the category of capabilities embodies a richer notion than human capital, or skills, as it specifically includes those skills and forms of tacit knowledge that are acquired through experience, 'on-the-job' training, and interactions with others. This broader notion is better suited than just 'educational level' to thinking about 'complementarity' – whether the skills an individual has will complement new technologies or can be substituted by them and, moreover, whether an individual will be able to acquire new skills which are complementary to new technologies. Obviously, the education system is a key institution for acquiring individual capabilities but it is not the only route.

Important though individual capabilities are, it is at the firm-level that capabilities take on a critical role, since so much of innovation takes place within the firm – thanks to the efficiencies of industrial organisation, we are no longer in the age of the inventor. And the crucial question of firm-learning seems to be closely related to various dynamic forms of firm-level activity and organisation: learning-by-doing, learning-in-production that are directed towards the acquisition of capabilities. As John Sutton says "the scarce resource most important to the process of industrial development lies in the capabilities of firms" (Sutton 2005 p.2). In Section 4 much of the analysis is at the level of the firm.

At a national level, capabilities roughly correspond to the capacity a country has to transform its production activities and converge. This will depend on the capabilities of firms, and on how they are organised, as well as the nature of institutions that mediate their interactions. National level capabilities may be enhanced through a range of innovation and industrial policies: Research and development (R&D), finance, risk-management and training.

When it comes to useful taxonomies for classifying capabilities in detail, an important contribution is to be found in Sanjaya Lall's work (1992, 1998, 2000) which sets out a theory of "technological capabilities" at the firm level. Lall classifies various forms of capabilities according to the different functional areas (for example, investment versus production, process-engineering versus product engineering) in which they take place and the degree of complexity that the corresponding activities entail (simple/routine, adaptive or innovative). Lall's work is closely aligned with the NSI approach, pioneered by Nelson and Winter, and subsequently developed by Freeman, Dosi, Soete, Lundvall and others, and which is grounded in evolutionary economics, which in turn is inspired by Schumpeter. Like the NSI authors, he emphasises the crucial nature of learning and the non-equilibrium characteristics of innovation. Later authors, within the NSI tradition, develop Lall's approach further to consider learning in developing countries (Lundvall 2007). Lundvall distinguishes between Science, Technology and Innovation (STI), and Doing, Using and Interacting (DUI) modes of learning and innovation. This distinction feeds into the Tilburg studies of innovation, (Voeten, Achjar, and Utari 2016; Voeten, Kirama, and Macha 2016), as well as other scholars on technology (Zanello et al. 2016). Another important taxonomy, which distinguishes between the 'static' and 'dynamic' forms of capabilities is that of Bell and Pavitt (1992).

When it comes to empirically determining capabilities, John Sutton's work is invaluable. Sutton's view of firm capabilities gives rise to two measurements – a measure of the maximum quality a firm can achieve, and a measure of its cost of production (productivity) – for each line of production. Sutton's Enterprise Maps, which survey firms in a number of African countries, together with other resources such as the World Bank Enterprise surveys, are a key source of empirical data. Further resources are set out in the International Growth Centre (IGC) Firm Capabilities Evidence Paper (IGC 2014). Sutton's work also establishes other aspects of capability acquisition, such as the important role of agglomeration effects and clustering.

3.3 Determinants of capabilities

What determines the acquisition of capabilities, the cultivation of learning, and the process of innovation? There are many factors and many perspectives on them. Technological capabilities, understood in a narrow sense, are not sufficient to lead to firm learning on their own, just as 'knowledge production' does not take place exclusively in labs and R&D departments (Andreoni 2014). Rather, learning is cultivated through organisational and managerial structures, and through what Abramovitz refers to as 'social capabilities' (Abramovitz 1986).

Institutions are of fundamental importance to innovation, acquisition of capabilities and technology absorption – Lundvall refers to NSI as an institutions approach *par excellence* – as they determine the relationships between different agents in the innovation system. Policy decisions directly affect or even create formal institutions – by creating laws, drafting and enforcing regulation, and determining investment decisions. But the impact of policy is also governed by informal institutions – patterns of learning and work – that are only affected indirectly, if at all, by policy. So an institutional approach that describes interactions between institutions is very helpful – the Economic Development and Institutions (EDI) programme,[27] funded by the Department for International Development (DFID), exemplifies such an approach.

If institutions are fundamental, so are the issues of power and politics. Technological interventions, such as digital land ownership, mobile money, smart contracts or block chain, are disruptive and likely opposed by those who benefit from the *status quo*; organisational capacity is crucial for implementation, as has been seen recently in research into citizen feedback initiatives. Data protection and privacy issues illustrate the importance of legal and policy frameworks (OPM and Haldrup 2018). From a theoretical point of view, Mushtaq Khan (Khan 2013, 2015a, 2015b) outlines a theoretical approach to the political economy of capability acquisition, that focuses on the ability of the state to manage various forms of contracting problems. The key strategic consideration is whether it is possible to effectively manage rents so that firms can acquire capabilities for various technologies. The success of the state in addressing this problem is, for Khan, more or less the definition of good industrial policy design. Without it, firms may monopolise government subsidies or policies, and then use their political influence to capture the corresponding rents. In this way, inefficiencies become endemic as these firms can only survive through the exploitation of the subsidies and policies. Technological change and innovation are stifled. On the other hand, there are also examples in which firms obtained rents through political influence, thus contradicting the norms of good governance, but then used those rents to acquire productive capabilities and become competitive, in so doing establishing a framework for innovation.[28] In both cases, it is the political economy of the management of those rents which is the key determinant of technological change.

[27] See https://edi.opml.co.uk/

[28] See, for example, the current research programme ACE https://ace.soas.ac.uk/business-groups-tanzania/

3.4 Path dependence and international effects

So far this review of theory starts with technology as a driver of macroeconomic growth, and issues of technological difference and convergence for LICs. It then probes deeper into the processes that produce firm capabilities, innovation, technological absorption and convergence in LICs. This is because we believe that locating a country in terms of these parameters is vital for understanding the country-specific impact of disruptive technology. But, as we know, disruptive technology is new for technologically advanced countries too and will cause a reallocation of resources on a global scale. So theory points to two main impacts from disruptive technology – the direct impact on the local path of capability accumulation, specialisation and competitiveness, and an indirect effect via technology's impact on the global structure of production and prices.

We have tended to step over endogenous growth theories in favour of more detailed descriptions of the processes relating to firm capabilities, and perceive the latter as being of greater relevance in explaining the faster or slower rates of convergence of LICs. This means we are ignoring Romer-esque path dependence and low-income traps. However, we reach something like path dependence by a different route because the determinants of firm capabilities and the character of the innovation system are so tied to politics and institutions which themselves produce a deep path dependence (Robinson and Acemoglu 2012). In addition, there is a learning-driven incremental nature to amassing capabilities which also produces path dependence – what you learn determines what you learn next. Factor endowments also clearly help set the path of industrial specialisation and therefore influence the path of capability and technological acquisition. Wood (2017) charts the factor-endowment-related patterns of sectoral specialisation that have been a feature of the past 30 years of globalisation.

Technological change and structural transformation are interrelated. Innovation and capabilities are linked to productive sectors, even if this link is not rigid. If innovation and capabilities are accumulated incrementally, then the path of accumulation links to a path of industrial specialisation – this is reflected in Sutton's enterprise maps which record the path of capability specialisation and industrial specialisation in firms.

Disruptive technologies alter the technology used in production in advanced countries and alter the pattern of costs globally, producing an indirect impact on the competitiveness of industries using existing technology in LICs. As we believe innovation and firm capabilities are accumulated in a path-dependent way, these international effects might have a highly disruptive effect – not just on short-run competitiveness of certain industries, but on the process of innovation and convergence. For example, if a country has been exploiting its relatively labour-intensive factor endowment to specialise in labour-intensive manufacturing on the basis of low wages, it is possible that disruptive technology removes that immediate competitive advantage (for example, 3D-printing causes reshoring of textiles, apparel and footwear manufacturing) – but that this also removes a stepping stone in that country's path of capability and technology acquisition. The path becomes a dead end. Effectively the economy must retrace its steps and find a new path.

3.5 Summary

The purpose of exploring these issues theoretically is to guide the conduct of the research and the framing of the project as a whole. The primary goal is to understand the challenges and opportunities posed by rapid technological change in LICs. Disruptive technology will directly alter the economics of technology choices in each country. It will also impact on LICs by altering conditions in the international economy: international prices and the structure of production.

We show that growth theory puts technology at the centre of things and yet remains something of a 'black box' as to how technological change happens, and therefore, in how to think of the challenges and opportunities of the current rapid technological changes that are anticipated. LICs and LMICs need to be in the business of rapid technological change, even if there are no new and disruptive technologies. We focus on the crucial questions of firm capabilities, learning and innovation to explain how quickly LICs are catching up with rich countries. The discussion above suggests further directions towards understanding the determinants of these effects. Note that it is not necessarily intrinsic features of the technologies themselves that constrain or enable technological change. Instead, the literature review points to a range of other important factors: skills, education, experience and tacit knowledge at the individual level; technological capabilities, and organisational, management and structural features at the firm level; institutional aspects of the innovation system; factor endowments, historical industrial specialisation and political economy. All these determinants of firm capability, learning and innovation mean that a particular country will be a distance away from the technological frontier and also be on a particular path towards it, moving at a particular speed.

The challenge in conducting empirical research into these areas is that data sources that directly capture these determinants are hard to come by, and so we are forced to think creatively about what comparable data might serve as a useful proxy and how to go about collecting it. We shall discuss this in detail below, but from a theoretical point of view, the consensus in the literature – that the key locus of innovation is at the firm-level – directs us to various forms of firm data as our primary data source for this study.

We are particularly interested in the correlations between firm age, size, productivity, value-added and innovation statistics of various kinds – at both the aggregate and sector-specific levels. But we will aim to match the statistical analyses of these data with qualitative research into how particular industries (those for which we anticipate new technologies to have the greatest impact) are performing, and also the policy stocktakes and findings of our key informant interviews, focus-group discussions and workshops.

Disruptive technology impacts on countries where these processes are already at play – it may alter the available paths to convergence, and create opportunities for accelerated progress and/or setbacks for a particular country. This is important because much of the recent literature *has* emphasised intrinsic features of the new technologies but has failed to locate these features in a country-specific technology, capability, international competitiveness and cost context. The aim of the country studies is to do so.

4. Tanzania Case Study

4.1 Approach to country case studies

The first sections run through the effects we expect to see, in greater or lesser amount, as a result of disruptive technology in any particular setting. The Tanzania Case Study characterises the country's pattern of growth, and examines its innovation system and then examines Tanzania's key exposures to disruptive technology in terms of opportunities and threats.

We approach this as a 'preliminary diagnostic' exercise. That is, we describe the conditions that prevail in the case-study setting by using existing data, secondary sources and a limited amount of fieldwork. We test hypotheses about the country's exposure to challenges and opportunities arising from disruptive technology. We take into consideration global features of the technology in question and specific features thought to prevail in the setting. We assess the detail and macroeconomic magnitude of the country's exposure to these technologies, and we examine the country's ability to adapt to challenges, and to take advantage of opportunities. We review relevant policy stances, and look at how these might aid or impede desirable adaptations.

Pattern of Growth and Structural Transformation: As we have argued in sections 2 and 3, the uptake of new technologies is merely a part of long-standing, broader patterns of technological changes that encompass both frontier and non-frontier technologies. In lower-income countries, therefore, disruptive technologies will impact economies that are already dynamic. Jobs are already being replaced, and the structure of production is already shifting. The starting point of this case study is a quantitative analysis of national accounts and labour force survey-based data. These allow us to describe the pattern of growth and structural transformation taking place, and to better understand the evolution of productivity that we see over the past two decades.

Calculating the distribution of the workforce across industrial sectors and the average productivity in those sectors allows us to comment on the country's convergence path and the speed at which it is advancing along that path. This helps to identify each country's position on a pathway to industrial specialisation, and to assess the extent to which technological advances may disrupt or otherwise impact this trajectory. It also allows us to start to identify the industries that are important to the economy, and those that are susceptible to impact from disruptive technology, according to global evidence.

We examine recent trends, identify shifts in average productivity, and describe whether productivity gains occur within sectors or largely result from workers shifting between sectors (Diao, McMillan, and Rodrik 2017). This description allows a first assessment of whether and how disruptive technologies are likely to impact industrial sectors with a high level of employment and/or a high level of growth potential. The impact of technology may not be evenly felt across the economy; while technology may be highly disruptive to some sectors, it may affect others very little.

Innovation System: Essentially, the 'innovation system' is the system of institutions and incentives (including tax and regulatory measures, but also other formal and informal features) that reward (or penalise) innovation and the absorption of technological change in the economy. These institutional features play a crucial role in determining whether a country can take on new opportunities and can therefore adapt to technological advances.

Here, 'innovation' does not just mean adopting the very latest technology. It also refers to the capacity to use any technology that is not necessarily cutting edge, but is new to the country or to the firm - including the 'technology' of management practices and commercial practices, as well as in the narrower engineering sense.

To characterise innovation in the setting, we use macroeconomic data and enterprise survey data to examine production and labour productivity dynamics in the recent period. This allows distinctions to be made about performance within different industries and across different types of firms – for example, according to size or age. We are careful to examine hypotheses (e.g., 'Big firms are innovative;' 'Small, innovative firms are absent.') by interrogating the data. However, it is important, given the nature of our case study, to collect supporting evidence in the wider literature and about specific industries. Thus, we derive key hypotheses from wider evidence before examining them in the data.

Sector-specific findings: Because our 'preliminary diagnostic' study cannot comprehensively explore each and every productive sector, we must be selective. We choose representative industries that are: (i) important in terms of level of production; (ii) fast growing and/or characterised by fast productivity growth; and/or (iii) likely to be highly susceptible to the impacts of disruptive technology based on global evidence. The assessment of productivity and growth macroeconomic and enterprise survey data gives us very useful pointers towards a relevant selection of industries for deeper study. The country case study is preliminary and rapid, and, as such, it cannot be comprehensive and definitive. Nevertheless, a combination of desk-based evidence assessment, and fieldwork interviews and workshops is designed to capture the major issues, and to extend the accuracy of the findings well beyond conclusions based solely on analysis of survey data.

Policy Stocktake: We reviewed development strategies, policy statements, *de jure* and *de facto* taxes, regulations and incentives that impact on investment, innovation, and the likely ability to adapt to the opportunities and challenges identified. We consulted secondary sources to construct a picture of the policy environment and other aspects of the innovation system. We reviewed major recent reports and consulted policy documents.

Interviews and workshops: We supplemented our desk-based research with findings from in-country consultations. The in-country consultations were designed to serve three purposes: to (i) gather the insights needed to underpin our findings and analysis; (ii) identify gaps and priorities, drawing on local knowledge; (iii) build momentum and initiate discussion amongst different groups of stakeholders.

To meet these objectives, we structured the in-country consultations as follows:

- Focus group discussions and/or key informant interviews with key stakeholders;
- A workshop with youth representatives; and
- A multi-stakeholder workshop, with break-out focus group discussions on selected themes.

We targeted a range of stakeholders for these discussions, including: (i) the public sector, including government, regulators and unions; (ii) international organisations, non-governmental organisations and civil society; (iii) private-sector organisations, including manufacturers' associations, tech-start-ups, law firms and telecommunications companies; (iv) academia and research; and (v) youth organisations.

The key informant interviews and focus group discussions relied on a semi-structured interview format, using the following overarching questions: (i) What are the new technologies (investments) that may be relevant? (ii) What are the barriers to acquiring and using those technologies? (iii) What effects would utilising these new technologies have, and what impact does this have on current or future industries?

4.1.1 Reflections on the case-study method

The case-study exercise reveals some lessons for a fuller diagnostic examination. These include:

- Describing the patterns of growth and augmenting these with specific industry knowledge gives some good insights into where opportunities and challenges may lie. A useful but time-consuming analysis would provide a more detailed and comprehensive review of industries and possible future industries that are exposed to impact from disruptive technologies.
- We test hypotheses relating to the capacity to innovate and adapt by: describing the pattern of growth, using surveys of 'innovation measures', and analysing the evolution of labour productivity and the structure and dynamics in the population of enterprises. Examining these data alone, however, stops well short of providing proof about the pattern of innovation. Using these sources alone would could lead to 'fishing' - that is, fitting stories to patterns seen in the data. Any diagnostic exercise needs to address this potential pitfall. Thus, our reviews of secondary sources, and our own supporting research played important roles in forming our conclusions. The case study, for example, revealed that even industry disaggregation can mask a far more heterogeneous situation in terms of innovation. Very different types of firms with different markets and different capacities can exist within the same industry. Again, to be more definitive, primary work on an industry/firm level would be necessary.
- This case study aims to provide more useful insights than the familiar modelling exercise that assesses the vulnerability of jobs to automation based on opinions about job roles in the United States. This case study provides a fuller picture. It gives: an impression of the pattern of development and change; the country-specific challenges and opportunities that might therefore arise; the probable adaptability of the private sector to those challenges and opportunities; and a commentary on the way government is now supporting that adaptability, and the steps the government might take to offer better support.

4.2 Pattern of growth

Tanzania has seen remarkably consistent real GDP growth of over 6 per cent per year since 2001 (World Bank 2018b). This has meant GDP per capita increases of over 4 per cent on average per year, even with population growth. This very healthy-looking performance seems to be built on 1990s-era economic reforms, involving a greater role for the private sector in production and in financial markets, more open trade, and a relatively conservative fiscal stance enabling fast growth in credit for the private sector. (This has been the case, at least, for many years leading up to and following debt reductions provided to Tanzania through the Heavily Indebted Poor Countries Initiative of the International Monetary Fund and the World Bank.) (IMF 2011)

Figure 6 shows Tanzania's longer-term employment and output trends in the shares of different productive sectors. The figure is based on the Groningen University Africa Sector Database, a highly accessible and standardised data set allowing the inspection of the structure of production in the long term for (Groningen 2018). These data cover 39 countries. We used data from Bank of Tanzania to extend the series to 2016. Though definitions used by these data sources differ to a degree, overall trends are broadly consistent.

Figure 6: Structural transformation in employment and output shares

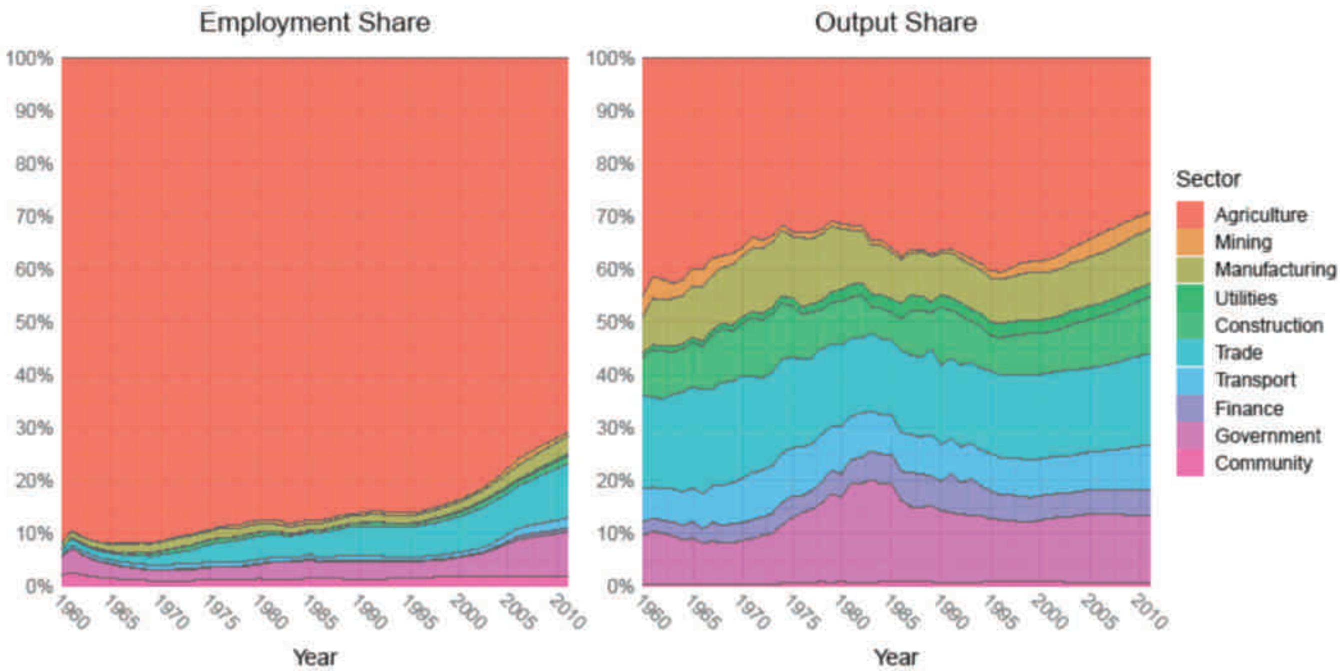
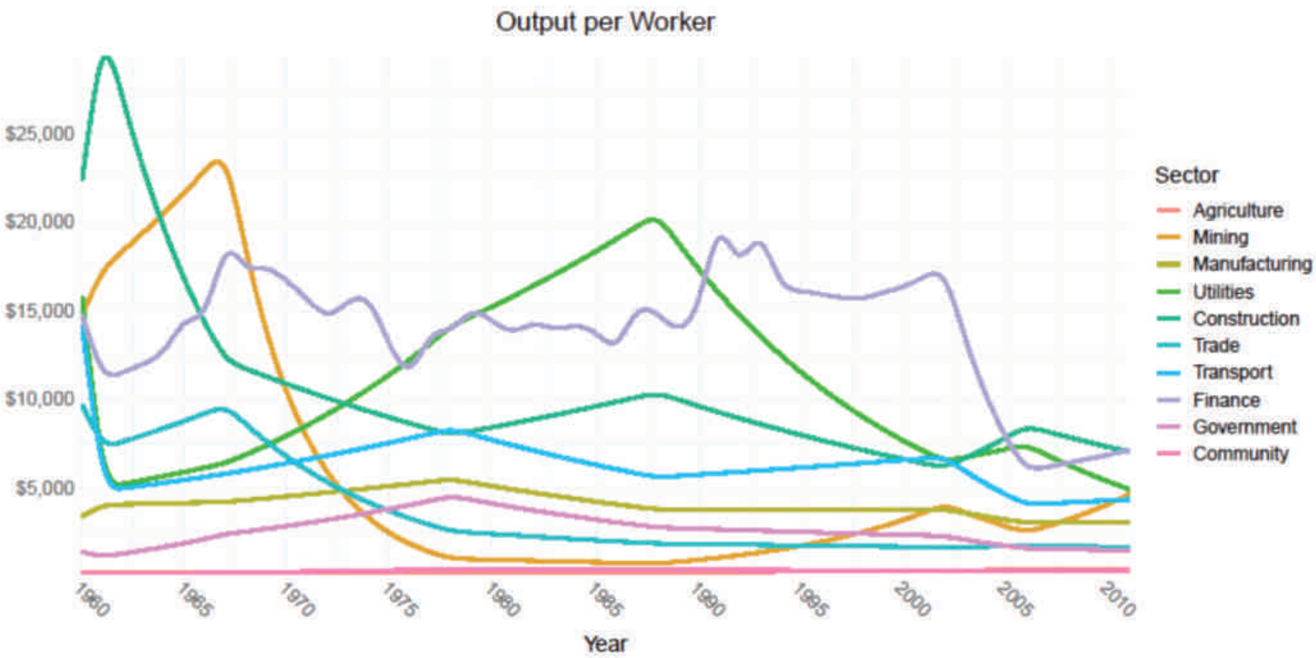


Figure 7: Labour productivity



These figures reveal considerable information about structural transformation taking place in Tanzania. The overwhelming feature, post-2000, is a shift of workers out of traditional agriculture. Though we focus on the post-2000 pattern, we note that a similar pattern exists for the period from 1960 to 1980, when reversals then occurred. That is, agriculture's share of total output steadily fell, giving way to other sectors, mainly services. After 2000, this pattern repeated itself, with agriculture's share of output decreasing from 40 per cent in 1997 to below 29 per cent in 2010, and rising again to 31.5 per cent in 2016, according to the African Development Bank. A substantial reduction in the share of the workforce engaged in agriculture also took place in that period, falling from 85 per cent in 1997, to 71 per cent in 2010, and to 67 per cent in 2017, according to data from the International Labour Organization (ILO). This represents a doubling of the share of the workforce in non-agricultural employment from 1997 to 2010, with further shifts having taken place since. **This massive release of workers from traditional agriculture into diverse non-agricultural livelihoods is the central characteristic of Tanzania's post-2000 transformation.**

This shift of workers between sectors drove productivity gains in the period since 2000. In most non-agricultural sectors, output per worker has fallen. In agriculture, average output per worker remained extremely low, US$300,[29] and until 1996, productivity was very far below the level in every other type of employment except for 'community'. As people shifted out of agriculture after 2000, labour productivity in agriculture did start to increase. It is worth underscoring that workers who shifted from traditional agriculture to almost any other activity, even to work in informal-sector trading, increased their productivity.

[29] 2005 prices, Groningen

In fact, only agriculture and mining achieved within-sector labour productivity gains from 2000 to 2010. Moreover, between-sector shifts of workers led to all gains in average productivity in the economy. This is not necessarily a bad state of affairs; it can imply major efficiencies in resource allocation. As Figure 6 illustrates, some sectors such as construction, mining and finance had extremely high average labour productivity, especially after Tanzania gained independence in 1961, but also later. This might indicate the presence of necessarily capital-intensive technologies. It could also indicate restricted labour demand - perhaps due to regulation or union power - or a very tight supply of labour with the right skills. Efficient labour markets equalise marginal, not average, labour productivity; nevertheless, a reduced range in average productivity of labour could indicate a more efficient allocation.

Another explanation for falling output per worker in non-agricultural sectors is the rapid increase in informal employment outside agriculture in the post-2000 period (Diao, Xinshen; Kweka, Joseph; McMillan, Margaret; Qureshi 2016). Of all jobs created outside agriculture, 83 per cent were in the informal sector, mainly in micro-enterprises/self-employment. This could have dragged down the average labour productivity even if productivity had increased in the formal sector and in the economy overall. However, Tanzania's enterprise survey data suggest that even in the formal sector, firm-level labour productivity fell in almost all non-agricultural industries.

There are very few individual industries in which innovation and technology absorption seem to be working to raise productivity. A possible exception to the general rule of labour productivity decline is publishing and printing. Raw data for these sectors show very minor increases (rather than decreases) in labour productivity (Annex 1). Reduction in market concentration suggests the start or growth of some smaller firms. This industry also has amongst the highest innovation scores – for taking steps such as offering a training programme, or producing a process innovation, for example. Even in printing, however, labour productivity is, at best, flat.

We sound a note of caution about over-interpreting partial labour productivity measures when major shifts of labour, constituting a labour supply shock, are taking place in most industries. We would expect innovation to result in productivity gains, including labour productivity gains, with steady labour supply. In the special conditions of Tanzania in the 2000-2016 period, these same innovations could have been taking place, but the impacts of labour productivity could have been invisible. This would be the case if the shock of the increase in the supply of low-cost labour led to higher employment levels and to lower average labour productivity, even in the innovative industries.

Three features stand out in the transformation that has taken place in the Tanzanian economy in recent years: Tanzania, first and foremost, shows clear declines in labour productivity in non-agricultural sectors. Though this should not be considered a total lack of innovation, it does mean that growth was driven by factor reallocation much more than by innovation. Second, growth in non-agricultural sectors, especially services, outstripped overall output growth. As a result, these non-agricultural sectors' share of the economy expanded. Third, despite the reduction in informal agricultural employment, the informal sector kept its hold on the huge majority of employment because of new, informal jobs. This has strong implications for the potential impact of technology in Tanzania.

4.3 Innovation system

A second component of the Tanzania Case Study involves characterising the country's innovation system. For this, we rely largely on the World Bank Enterprise Surveys, which are both available for a wide range of countries, and are produced in a highly consistent way, making them suitable for an exercise that needs to be replicable.

Enterprise surveys cover a sample of formally registered private firms in industry and service sectors. They thus offer a window onto an important part of the economy: the non-agricultural formal sector, which generates at least 45 percent of Tanzania's GDP. In Tanzania's case, one caveat applies: a substantial amount of economic output and the vast majority of employment takes place outside of these sectors because an estimated 90 percent of the labour force is employed in the informal or public sector.

Under our hypotheses, an economy with a healthy innovation system has a distinctive 'look'. In such an economy, large firms should be more productive. This is a common feature, evidenced by thriving economies worldwide, and explained by reasonably competitive markets allowing well-run, productive/innovative firms to grow to an efficient scale. At the same time, smaller firms should innovate and grow. Any snapshot of an innovative economy would reveal a lot of young firms (many which will fail) and some medium-sized firms, which are themselves successful smaller firms that have grown.

The enterprise surveys describe the distribution of firms by size. Within the formal sector, Tanzanian firms are characterised by a large number of small firms and a small number of large firms. An estimated 77 per cent of firms have fewer than 20 employees. Large firms with more than 100 employees represent just 2.7 per cent of all firms. Nevertheless, this group accounts for 84 per cent of national output (see Figure 8). The distribution of firm size in Tanzania is, superficially, similar, for example, to the United States. However, recall that about 85 per cent of workers are employed in the agricultural or non-agricultural informal sectors. So, the exclusion of informal enterprises from the sample frame has broader implications for an analysis of the situation in Tanzania than, by contrast, for an analysis of another country, such as the United States, in which the informal sector does not dominate. In Tanzania, the 'tail' indicating the number of small and micro formal and informal firms is much longer simply because these firms are more commonplace. As a result, there are relatively few middle-sized firms. This situation is often termed the 'missing middle' (Andreoni 2017). Medium-sized firms (with 20 to 99 employees) generate 9 per cent of formal-sector non-agricultural output, or about 4 per cent of total output. It is striking that one-third of total GDP is generated by the 2.5 per cent of formal firms with more than 100 employees.

The size distribution of firms raises some concerns about the innovation system in Tanzania. A healthy system that rewards innovation should result in some smaller firms growing to be medium sized, and then large. This is what happens if creative innovators surface and then out-compete incumbent firms. The general pattern - consisting of many smaller enterprises and a small number of large, highly productive firms - is not in itself unusual. However, the distribution in Tanzania is quite extreme, and possibly becoming more so. Between 2006 and 2013, the share of medium or large firms among all firms shrank from 26 per cent to 23 per cent. Meanwhile, the dominance of large firms in output grew sharply, and labour productivity fell across the board, even though large firms retained their productivity advantage.

Figure 8: Firm characteristics by size (number of employees)

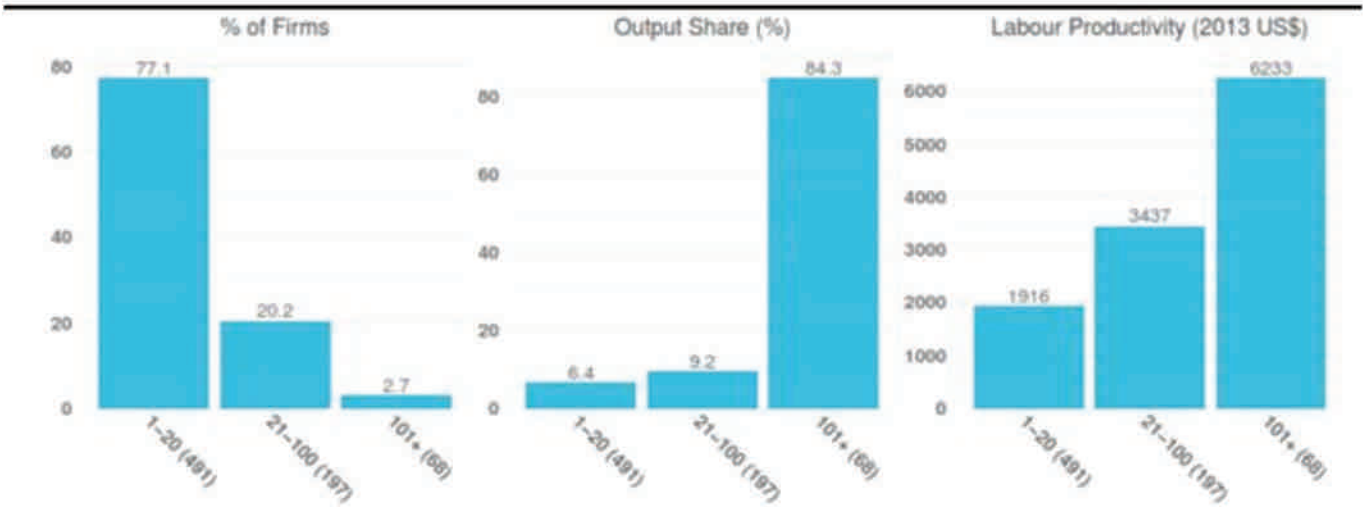
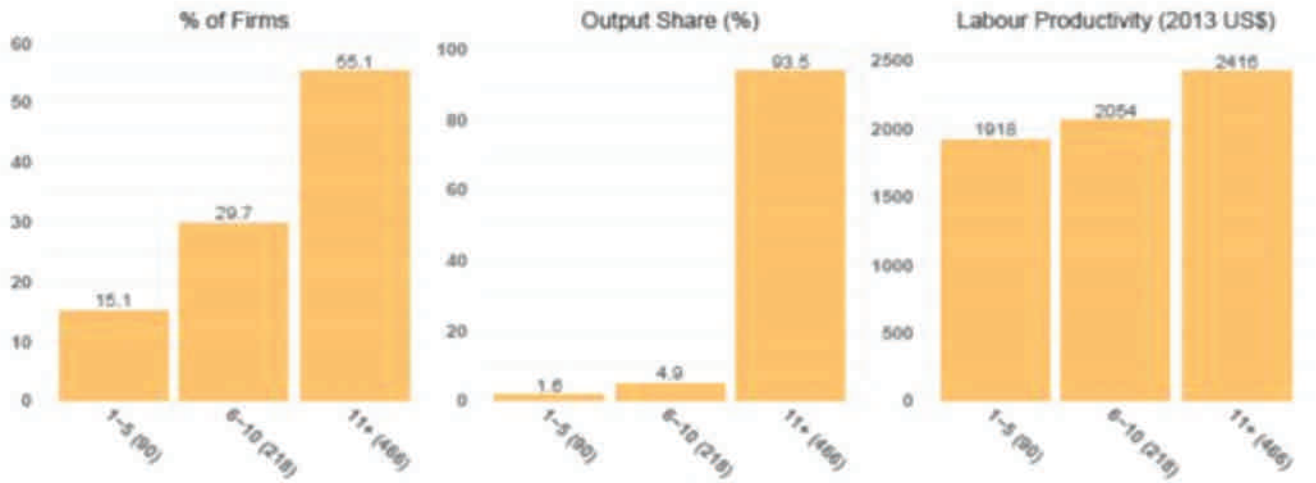


Figure 9: Firm characteristics by age (years)



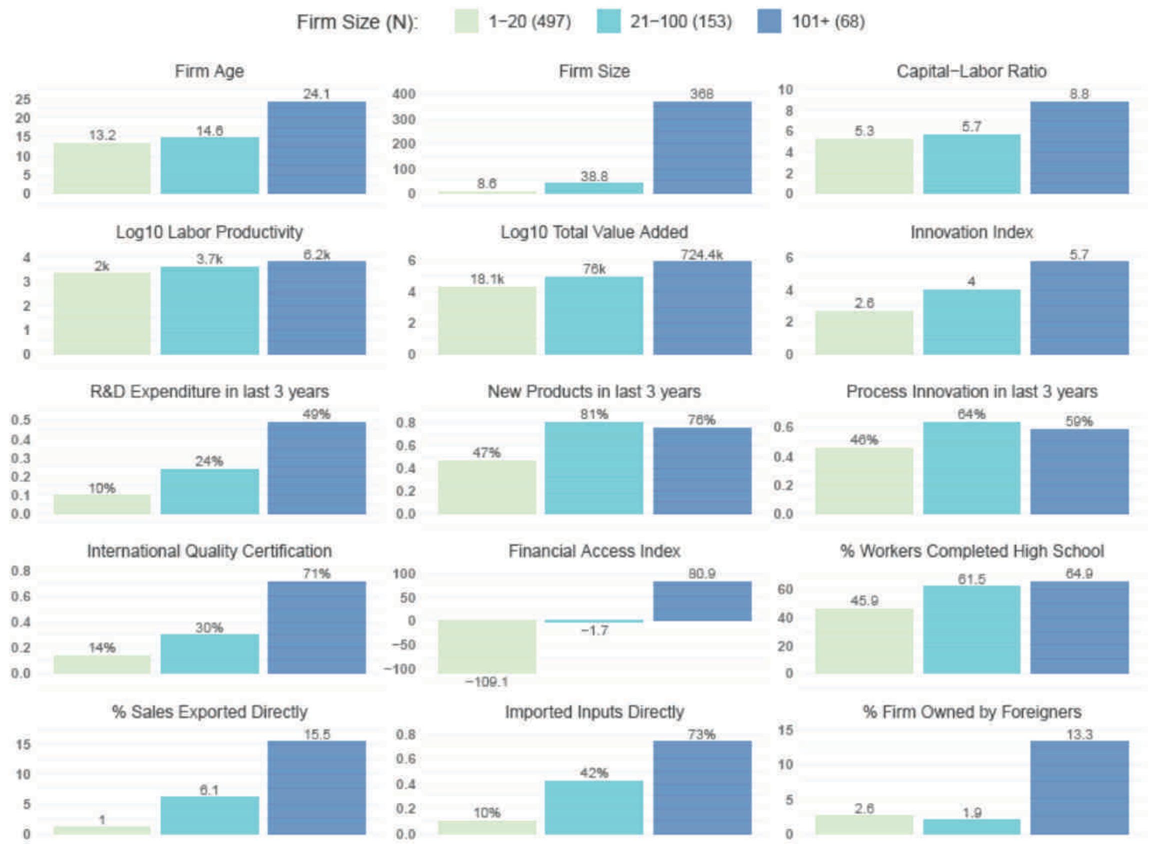
The distribution of firms by age raises additional concerns about the innovation system (see Figure 9). Few of Tanzania's formal-sector firms are young. In 2013, for example, 15 per cent of firms were five years old or younger. In the United States, by contrast, 32 per cent of firms are under five years old, and 8 per cent are less than one year old. From 2006 to 2013, the average age of firms increased significantly. If start-ups are potential innovators, then this suggests that much more innovation is taking place in the United States than in Tanzania. The obvious caveat, again, concerns the informal sector. Tanzania may have many informal sector start-ups, some of which may formalise if they show signs of success. However, the global evidence suggests that growth and formalisation of informal start-up microenterprises is very much the exception. The very large number of very small informal enterprises in Tanzania corroborates this view. Very few of these informal microenterprises have grown larger (de Mel, Suresh; McKenzie, David; Woodruff 2012).

Thus, the size and age firm profiles in Tanzania show that larger, older firms dominate production. These firms seem to face few challenges from newer firms. These 'incumbent' firms have high average labour productivity. A strong correlation emerges between size and the various innovation measures surveyed (see Annex 1). The incumbent firms are the most capitalised, and they have the highest average labour productivity. As has been previously discussed, from 2000 to 20016, average labour productivity declined in all industrial sectors, including in larger firms – perhaps due to the special labour market conditions in Tanzania at that time. Enterprise Survey statistics show that over the period from 2010 to 2013, labour productivity fell more sharply in small- and medium-sized firms; at the same time, these firms experienced annual employment growth rates of 10 per cent to 15 per cent. In large firms, annual employment growth is estimated at 7 per cent. A comparison firm size distribution and output shares from 2006 to 2013 shows that the presence of small firms (those with fewer than 20 employees) grew. Nonetheless, the output share of these firms over this period decreased, while the output share of large firms (those with more than 100 employees) increased to a dramatic degree, from about 50 per cent in 2006 to 84 per cent in 2013.

These findings raise specific questions concerning innovation. Larger firms innovate more and are more productive. In the aggregate, the following characteristics correlate positively: firm size, labour productivity, product and process innovation, research and development (R&D) spending, access to finance, and worker education levels. Firm age is unrelated to innovation indicators (product, process, management, and marketing innovations), and only weakly positively related to R&D spending. Few firms employ foreign technology licenses (11 per cent); thus, most of the innovation appears to be domestic.

In Tanzania, large and small firms report project and process innovations. Diving deeper into the relationship between firm size, productivity, innovation and finance, reveals an interesting pattern: larger firms with more than 100 employees are about three times as productive as small firms with fewer than 20 employees. (We estimate production levels of US$6,200 per worker in large firms, and US$2,000 per worker in small firms.) These larger firms also have substantially greater access to finance. Large firms are more likely to invest in research and development. Among large firms, 49 per cent spent on R&D over the last three years; by contrast, 10 per cent of small firms made such investments (see Figure 10). Yet in Tanzania the correlation between R&D and actual product innovations is quite low (r=0.15). R&D is unrelated to process innovation, but correlated much more strongly with firm size, productivity and access to finance (r=0.3). Over the past three years, new products or processes emerged from 50 per cent of small firms, 70 per cent to 80 per cent of medium-sized firms, and 60 per cent to 70 per cent of large firms.

Figure 10: Innovation profile of small, medium and large firms



Notes: The Innovation and Financial Access Indices are holistic measures of these constructs computed from survey items.

One interpretation of these findings is that innovation is occurring in Tanzania at two different levels: small firms introduce new products and processes that are of low quality, developed without formal R&D spending; large firms develop products by formal R&D and capital-intensive investments for a higher level of innovation. The capital-labour ratio in large firms is substantially greater than in small- and medium-sized firms. Qualitative evidence confirms that some of the 'innovations' reported by smaller firms may be very modest, for example, the purchase of a wire-cutting tool (Voeten, Kirama, and Macha 2016). The high prevalence of international quality certifications and the relatively higher education level of workers in large firms further support this conclusion. The international orientation of larger firms also merits attention. On average 13 per cent of large firms are owned by foreigners. Some 73 per cent of these large foreign owned firms imported production inputs directly. An estimated 16 per cent of the sales of these firms take place through direct exports. Small firms, in contrast, are fully domestic.

So, all the evidence from the Enterprise Surveys suggests a near absence of small yet dynamic firms that innovate beyond a very basic level. An important question, then, is whether smaller, innovative firms in Tanzania face strong barriers to entry. In itself, the age/size profile of firms does not provide evidence of anti-competitive entry barriers. If large firms are more capital intensive and more productive, perhaps they deserve their dominant position. A caveat to that, however, is that if large firms have anti-competitive advantages, they will *appear* to be productive on the measures we use. (Note: the applicable measure, value added per worker, implicitly includes profits; thus, high profits would lend the appearance of high value added per worker [see Annex 1].)

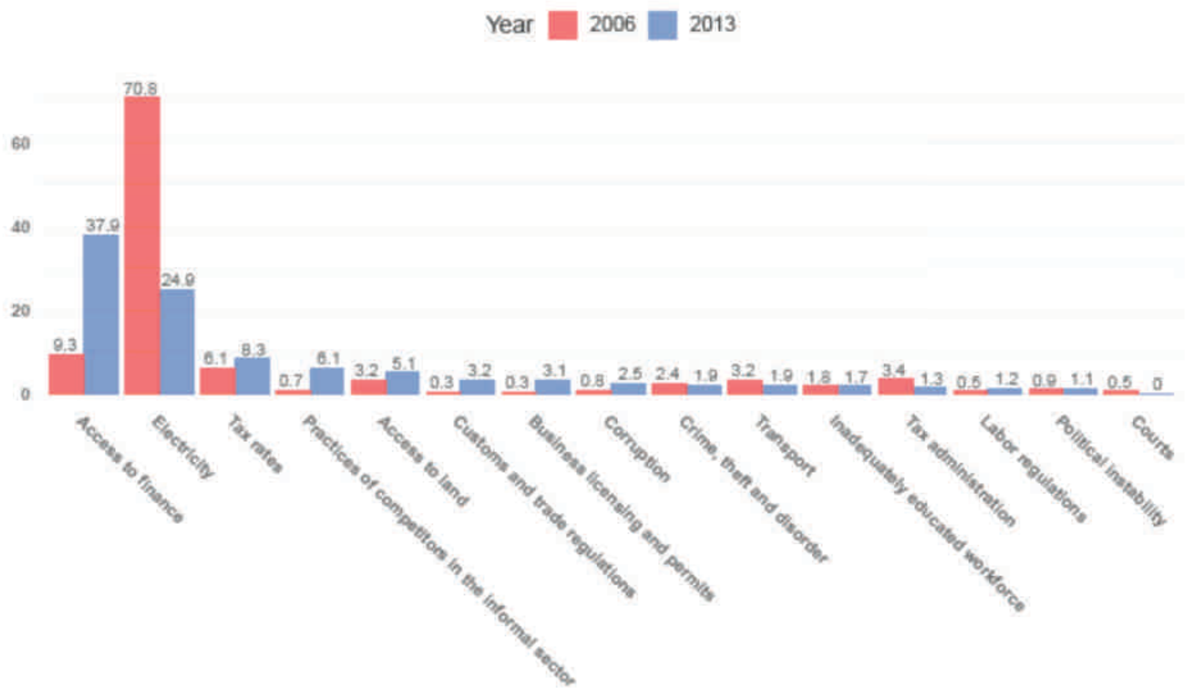
Though research has shown that output in most non-agricultural industries in Tanzania is dominated by a handful of firms (Dinh and Monga 2013), our examination of the concentration levels across a range of industries finds very little evidence of high concentration. Plastics and rubber and textiles are dominated by a relatively small number of large firms, but by international comparisons these are only 'moderately concentrated'. Retail is highly concentrated; however, this pertains only to formal-sector retail, and ignores the vast informal retail sector. Other industries are 'unconcentrated'.

Low industrial concentration, however, does not mean that competition is working perfectly. For example, fieldwork (Annex 2) examined Tanzania's internal freight transport network, which is dominated by two or three firms. These large firms carry about half of all road freight, with a much larger number of small firms carrying the other half. On the surface, this would appear to describe a sector that is not very concentrated, and, is, therefore, competitive. However, we also know that transport costs are very high, and that larger firms, at least, do not seem to be very cost conscious, as evidenced by decisions to send empty trucks on routes almost 50 per cent of the time. It is possible that this represents a more sophisticated kind of anti-competitive/ protection tactic that concentration measures do not capture. If so, other industries may be using similar strategies. This could help to explain the so-called 'missing' middle which may be more accurately characterised as a stunted and slow-growing middle.

Another way to gain qualitative information about potential obstacles to innovation and the growth of firms is by asking firms directly about their greatest business obstacles. For a number of years, the Enterprise Surveys have taken a systematic look at this issue. Respondents to the survey are given a list of 15 common issues, and they are asked to choose which one they consider to be the biggest obstacle faced by the firm for its day-to-day operations.

As Figure 11 shows, the three most commonly chosen top obstacles in Tanzania remain the same in 2013 as in 2006, although the order has changed.

Figure 11: Biggest business obstacles in 2006 and 2013 (% of firms choosing)



In 2013, most firms reported access to finance as the biggest obstacle (38 per cent in 2013 vs. 9 per cent in 2006). At the same time, however, more firms in Tanzania used banks to finance investments (18 per cent in 2013 vs. 7 per cent in 2006) (World Bank 2013). Access to finance is a much bigger obstacle for small firms than for larger firms. Moreover, this is likely a real barrier to entry for many potential firms. The proportion of firms that use banks to finance investment is higher in Tanzania than in other low-income countries but lower compared to the global average of 25 per cent.

Furthermore, in 2012, around 17 per cent of firms in Tanzania had a loan or a line of credit from a bank. This compares to the averages of 20 per cent for low-income economies, and 34 per cent for all countries for which Enterprise Survey data are available. (Section 4.5 provides a more qualitative analysis of the Tanzanian financial environment.)

In 2006, electricity presented by far the biggest obstacle for firms, and it remains firms' second most-cited obstacle (71 per cent in 2006 vs. 25 per cent in 2013). Power supply has improved since, as suggested by these data and corroborated by our fieldwork. This is good news in terms of taking up opportunities offered by disruptive technology. The average number of hours without power in a month declined from 71 hours in 2006 to 58 hours in 2013. However, Tanzania still lags other countries: globally, power outages last 29 hours per month on average, nearly half of the time spent without power in Tanzania, even with its improvements. In 2013, firms in Tanzania lost on average 5.5 per cent of annual sales due to electrical outages, down from 7 per cent in 2006, but still above the global average of 2.6 per cent. Furthermore, within Tanzania, losses due to power outages vary widely by region, with the higher percentage of losses in Mwanza and Dar Es Salaam.

In a time of technology-driven change, innovation will almost certainly depend on a country's 'digital readiness'. Research from Supporting Economic Transformation (Banga and te Velde 2018) shows that digital readiness, measured, for example, by Internet penetration rates, is strongly correlated with labour productivity increases. Sub-Saharan Africa experienced low average labour productivity increases of 1.2 percent per year from 1991 to 2013. This is lower than any other developing-country region. Sub-Saharan Africa also has the lowest measures of digital readiness; the region is at least three years behind South Asia, on average.

Tanzania is a laggard in digital readiness, even compared to other Sub-Saharan African countries. According to the World Development Report 2016, Tanzania had the most expensive Internet amongst East African countries (slightly above the continental coastal average of US$206 per megabit per second), and some of the lowest levels of Internet use, at both firm and individual levels.[30] Field evidence suggests that this lag in use might not be insurmountable, and that younger generations in Tanzania may have much higher competence in digital technologies that offer innovative potential. Nevertheless, an economy characterised by slow labour productivity improvements, a shortage of dynamic young firms, and exceptionally low digital readiness needs to change something if it is to take advantage of the opportunities presented by various disruptive technologies.

[30] In 2014, only 3.5 per cent of the population of Tanzania had Internet access, as compared with 26.3 per cent in Kenya; Fewer than 7.5 per cent of firms in manufacturing and services in Tanzania made use of the Internet in sales, inventory or marketing, as compared to more than 35 per cent in Kenya (WDR 2016).

4.4 Survey of selected industries

This case study reviews possible impacts of disruptive technology on particular industries in Tanzania. We selected industries that are susceptible to technological change, a global criterion; and industries that are important in Tanzania. (Labour productivity was not a selection criterion, given the falling labour productivity rates.)

The industries examined are: mining, textiles and garments, agriculture, digital technology, logistics, and business support services. These are important industries in the Tanzanian economy, but they are not necessarily the set of industries currently accounting for the highest output and employment shares. They are not the fastest-growing industries. (Top average growth rates are in ICT (15 per cent), construction (14 per cent), financial services (10 per cent), and transport (9 per cent), Bank of Tanzania data for the 2009-2016 period show.) They are not particularly productive sectors. (Highest levels of labour productivity are in plastics and rubber, publishing and printing, food, non-metallic mineral products, and retail, according to the Enterprise Surveys.) Nor are they particularly innovative sectors. (Plastics and rubber, publishing and printing, non-metallic mineral products, fabricated metal products and furniture have the highest levels of R&D spending, and product or process innovation, the Enterprise Surveys show.) That is, our focus is not on the perceived engines of growth and innovation. Instead, we examine industries that provide a combination of high relevance to the Tanzanian economy, and a strong disruptive potential for new technologies.

4.4.1 Mining

Tanzania has a significant mining sector with great future potential, which is only increased by the availability of disruptive technologies for extraction and exploration.

Sectoral data from the Bank of Tanzania show that between 2009 and 2016, mining and quarrying experienced an average annual growth of 7.72 per cent, slightly above the average GDP growth of 6.36 per cent over the period. In 2009, the sector had a share of 3.32 per cent of Tanzanian output; by 2016, its output share was 3.51 per cent. The sector makes the largest contribution to exports, and it makes major contributions to public-sector revenue through tax and non-tax revenues.

Risks to this sector relate to the investment climate generated by government. Tanzania's industrial strategy (URT 2016) places strong emphasis on manufacturing, including those manufacturing industries that add value to Tanzania's agricultural products and mined raw materials. In fact, in 2016, mining accounted for US$3.5 billion in exports, about 54 per cent of merchandise exports (MIT 2018). This dwarfs manufacturing exports, and makes mining a very strategic part of the economy. Mining is a very capital intensive, and high-tech industry. Some characterise mining as an enclave of foreign-owned assets generating few linkages and little value added in the economy. However, if properly managed, mining can yield very significant public revenues, which can in turn stimulate demand and further growth. In some cases, significant employment and technical spillovers occur. For a long time, the application of engineering and new technology have offered mining the opportunity to realise massive productivity gains (Maloney and Lederman 2012). Disruptive technologies extend that potential further.

Opportunities for gains from disruptive technology relate to a combination of automation, automated data generation and high-intensity data processing to generate quality, yield and efficiency gains. This ranges from altering extraction technologies to better management of plants to avoid downtime. Mines can be early adopters of some automation, as exemplified by the replacement of costly worker drivers with automated driving of giant mining trucks in western Australia (Frey and Osborne 2013).

The great volume of Tanzania's current mineral exports is from gold (35 per cent of exports in 2016). The sector's potential extends to mining of other substance - other metals, precious stones, graphite, rare earth, helium and uranium, for example - and to incorporating some of the most high-tech industries in Tanzania. Though the next generation of disruptive technology is not yet being used in extraction in Tanzania, future extraction and processing of helium and rare earth deposits are likely to be very modern.

Offshore natural gas fields in Southern Tanzania offer the potential to generate more exports than gold by using very expensive gas liquification plants. Though such trains do not represent 'disruptive' technology per se, they are a key component of a very capital-intensive and high-tech mining enterprise.

Gains from disruptive technology are also possible in terms of exploration. One of the key informants in this study had personally conducted exploration using remote-sensing, satellite technology, which was found to be about 30 times faster than the corresponding traditional exploration.

In recent years, the government of Tanzania has changed mine licensing, banned the export of raw ores, and required payment of extremely heavy back-tax bills for gold miners. Evidence suggests that this led some gold mines to close, and gold exploration to stop. Gas field development is almost at a standstill, partly because of the uncertainty created by these government actions. Despite these government actions, mining operations focused on extraction of other substances seem less concerned about the investment climate so far.

4.4.2 Textiles and garments

Disruptive technologies have the potential to have diverse effects on the textiles and garments industries. At the upper end of the market, a mixture of extreme communication tools, highly automated cutting machines, 'sewbots', and 3D printers may produce bespoke products. This type of production may well be re-shored close to markets. However, the lower-middle and low-end market products are unlikely to experience such changes any time soon. These markets will likely to continue to produce garments as they do today: by relying on low-cost labour. Some East African countries have managed to target these lower-end markets.

In Tanzania, upwards of 20,000 labourers work in textile and apparel industries, which consist of a combination of microenterprises and five larger-scale factories, two of them fully export-oriented, foreign-owned enterprises. The latter rely on the highly favourable trade preferences offered by the U.S. African Growth and Opportunity Act (AGOA), which results in a trading advantage of between 16 per cent and 32 per cent. (The higher rate applies to garments made from synthetic cloth.)

Kenya has seized the opportunity of AGOA trading advantages to a much greater extent than Tanzania. Kenya now runs a trade surplus with the United States; this essentially grew out of its garment exports of US$280 million per year (Berg, Achim; Hedrich, Saskia; Russo 2015). Ethiopia has also attracted foreign investment and exports, though it is less dependent on the U.S. market than Kenya. Tanzania's two main export factories are on a much smaller scale.

Nevertheless, it is important to underscore that the potential for Tanzania to attract foreign direct investment for lower-end garments linked to low-cost labour is not about to vanish because of disruptive tech. The presence of some successful pioneer factories illustrate this. The power supply – a seemingly perennial problem in Tanzania - has improved in recent years, as evidenced by the Enterprise Survey data showing that electricity supply, while still a key concern, is no longer considered to be the biggest obstacle to investment (see Figure 11). Further expansion in power generation means garment manufacturers are much less troubled by unreliable electricity (Textile Development Unit).

Other issues affect the industry's potential, however. Access to finance is typically a problem for smaller businesses. At the same time, foreign investors face bureaucratic hurdles and, most seriously, problems in accessing secure land for factories. Though only 5 per cent of firms mentioned access to land as the main obstacle to investment in the Entrepreneur Survey, such access is considered to be the main constraint for foreign garment industry investors, according to the Textile Development Unit, a specialist, independently-funded programme within Tanzania's Ministry of Industry, Trade and Investment.

The Enterprise Survey data show that the average garment enterprise employs 16 people, a low average figure that arises from a long 'tail' in a line of very small firms. This sort of manufacturing might, in some countries, contribute to modern manufacturing by doing piece work coordinated by a larger firm. This doesn't happen in Tanzania. Once again, an opportunity exists for a digital platform to coordinate these manufacturing microenterprises to bring many of the benefits of formalisation. Fieldwork, however, did not discover evidence that this is taking place.

4.4.3 Agriculture

Agriculture still employs large numbers (still over 60 per cent of workers). Average productivity remains very low, and factor productivity has hardly increased since 1961 (Binswanger and Gautam 2010). Labour productivity has slowly increased since 2000, as many labourers left agriculture for self-employment in services, and as cultivated land area continued to expand. Thus, over half of the workforce is still involved in an agriculture that is barely more productive than peasant agriculture at independence. Most of this work takes place on smallholdings with very small marketed surplus.

However, opportunities exist for traditional and non-traditional exports to be produced in a less traditional ways. According to the MIT Atlas (MIT 2018), agricultural exports were worth US$1.9 billion in 2016 (compared to US$2.2 billion for gold).

There are - and are going to be - opportunities to use exciting, disruptive technologies for high-value farming. These include collecting and using high-resolution data for fine-tuned responses, such as reducing wasted inputs, optimising irrigation, increasing yields, and perfecting quality control. Such steps should greatly increase returns to capital inputs. In Tanzania, where capital inputs are currently hard to justify, the these new technologies present an opportunity to raise production and profits much more than is possible with current technology. Conversely, if the business environment limits the ability of farmers to capture returns, the same will be true with their ability to capture returns from new technologies. If this is the case, the advent of new technologies might not seem attractive to them.

New technologies might help Tanzania compete in producing much higher-value export crops such as expensive coffee, chocolate, horticultural products and flowers. Tanzania has broken into high-end coffee with single-estate coffee, green bean coffee, Tanzania peaberry coffee and Kilimanjaro AA, for example. Some farms use sophisticated input management and modern logistics (e.g., Olam International). During fieldwork, we were informed about a directive to market all coffee through the Tanzania Coffee Board auction, which is likely to be replaced by a single Tanzania commodity exchange in due course. Some producers expressed concern that such actions would interfere with some existing marketing arrangements that allow for a high degree of product differentiation, potentially killing future opportunities for even greater production of very high-value beans.

4.4.4 Digital technology – coordinating smallholders and microenterprises?

Tanzania is a land of microenterprises, including millions of smallholdings and millions of non-agricultural, mostly service-sector self-employment enterprises. Workers in these microenterprises, which might account for 90 percent of employment, have the lowest productivity levels. Increasing the productivity of these workers would have macroeconomic significance. Such a change would increase welfare, reduce costs, and stimulate competitiveness in other parts of the economy. Cheaper food, transport and security services mean potentially more competitive manufacturing.

Quite immediate possibilities exist for using the disruptive technologies of digital platforms to coordinate microenterprises for major efficiency gains. UBER is a well-known example applied to taxis. In the United States and other countries in the Organisation for Economic Co-operation and Development (OECE), UBER generates concerns. These largely revolve around shifting risks and costs from firms that hire employees to workers who are treated by such platforms as independent operators. In Tanzania, by contrast, the alternative work scenario for most workers would be employment in an uncoordinated microenterprise. Thus, UBER-like platforms could bring some of the benefits of formalisation, such as much better marketing and efficiency, and shared standards for safety, working conditions etc.

Examples are already emerging in agriculture. The interactive platform, M-Kilimo, has been running for about four years in Kilosa District (Sanga 2012); its members can upload questions and receive answers from extension officers, other farmers and other experts, and to see answers to other submitted questions. The platform thereby pools highly relevant agricultural advice and market information, and also acts as an early warning system/ pre-emptive response mechanism for problems, such as diseases and pests, as they emerge locally. This experience is qualitatively different than the traditional exchange that occurs when farmers simply share information with one another because the platform pools relevant information from people who don't know each other. This initiative could no doubt be adapted and enhanced further with emerging technology.

Truki is an UBER-like platform, still in testing, aimed at smallholders who want to freight small amounts of farming produce. The platform's unique feature enables farmers to respond to market signals quickly. Farmers can send a relatively small consignment to a distant market by finding affordable transportation. Farmers may book, say, 10 per cent of a cargo truck, rather than chartering an entire truck, which may be prohibitively expensive for them. Though such platforms do not solve all of Tanzania's freight transportation problems, such options clearly have potential to increase efficiency, both for farmers and trucking companies, which can fill empty space.

Barriers to entry exist for innovative start-ups that might provide these platforms. Setting up a new formal business requires a significant amount of administrative work. A physical address is required even for a virtual business. Tax must be paid in advance, in anticipation of future revenues in order to acquire a tax identification number (TIN). Though streamlining of these processes has recently occurred, difficulties remain. Some public action has taken place to try to ease the emergence of innovative start-ups. These efforts are rather fragmented and often conducted at inadequate scale. The Tanzania Commission for Science and Technology (COSTECH) has launched an 'incubator' for tech start-ups, for example. Another incubator, Hub 255, also exists. These are the two lone examples of such operations in a country that, perhaps, should have 100 of them. The need for additional start-up support has been noted by others. The Consultative Group to Assist the Poor (CGAP), a global partnership seeking to advance financial inclusion, has noted the fragmented and unaligned nature of small business support in Tanzania.

4.4.5 Logistics

Transport costs in Africa are much higher per kilometre than in other parts of the world, even though wages for truck drivers are much lower. Evidence shows these high transportation costs have almost nothing to do with the quality of road infrastructure (Teravaninthorn and Raballand 2009) and much more to do with the way markets are organized. Tanzania has good inter-city roads. Freight prices are not the highest in Africa, but are still high, even though research shows no evidence of regulatory constraints to competition (Teravanithron and Raballand), and prices appear to be sensitive to demand and cost (Eberhard-Ruiz, Andreas; Calabrese 2017). Analysis of Enterprise Survey data also shows transport to be an 'unconcentrated' sector. At the same time, evidence suggests that inefficiencies, such as the movement or empty trucks, persist. The sector consists of two or three major operators and a larger number of small operators. More competition may occur amongst the small operators than between the larger operators.

Digital platforms and related technologies offer some potential for increasing efficiency and competition in the transport market. Trucking companies themselves can use better monitoring technology to improve use of their assets, to limit parked time and under-laden time, for example. TradeMark East Africa (Annex 2) has offered some assistance with this technology. It has also sponsored technology for reporting harassment at road blocks. This harassment has been a major mechanism for extracting rent and pushing up freight costs in Tanzania and elsewhere. Truki, a similar platform geared towards smallholders, also could also boost efficiency by filling empty truck space.

4.4.6 Business support services and extreme communications

Business support services, including financial services, represent a large (4.5 per cent of GDP) and growing component of Tanzania's economy. Output per worker in the sector has fallen significantly as employment has increased; nevertheless, output per worker in this particular sector remains around 10 times the average level in Tanzania. These services are not outsourced business support, such as call centres, which might face the challenge of automation; rather, they are financial services and other quite costly business services, such as legal, accounting, marketing and advertising services; and security and real estate maintenance.

Such services, which rely on exceptionally high-quality communications technologies, resonate with the discussion in Section 2, and with one of the six most promising development pathways put forward by the initial research paper of the Pathways for Prosperity Commission on Technology and Inclusive Development. Very high-quality communications will allow much more sophisticated services to be exported, and could allow international service value chains to emerge. An example is transporting a patient to a healthcare centre in a low-labour-cost location, and conducting his surgery with oversight or with remote-robotised surgical work supervised by a highly skilled surgeon on another continent.

What could disruptive technology mean for Tanzania? At present the country faces shortages of highly skilled personnel to meet domestic demand for services. It has quite restrictive visa arrangements and, therefore, high costs for high-end services. One possibility is that some high-end business support services currently offered in Tanzania at quite high cost might be offshored to centres in higher-cost countries (such as the UK or the United States), or, more likely, to lower-cost destinations (such as India) with skilled workers.

4.5 Policy Stocktake

Tanzania's development visions are documented in the Vision 2025 for mainland Tanzania and Vision 2020 for Zanzibar. Vision 2025 sets forth the 'driving forces' for the realisation of its component parts. Providing an incentive system for innovation is considered a key element of creating a 'developmental mind-set and empowering culture'. Competence and competitiveness are said to be required for the promotion of science and technology education, and the promotion of information and communication technologies (URT 1999).

The development visions are complemented by the Long Term Perspective Plan 2011/12-2026/26 and medium-term strategies such as the National Strategy for Growth and Reduction of Poverty (MKUKUTA) and the national five-year development plans. For the financial year 2013/14, Tanzania adopted the Malaysian-style Big Results Now initiative (which was abandoned following elections in 2015).

In 2015, Tanzania elected a new president, John Joseph Magufuli. Magufuli's presidential campaign centred on corruption, industrialisation and education (Andreoni 2017). Currently in force is the second Five Year Development Plan 2016/17 – 2020/21, Nurturing Industrialisation for Economic Transformation and Human Development (FYDP II). In line with the new president's agenda, the FYDP II puts industrialisation firmly in the focus. It also states an intention to address the provision of infrastructure, including power infrastructure, and to improve the environment for small- and medium-sized enterprises; these steps are required for technology uptake.

There has been longstanding scepticism of the government's capacity to implement its policies (Voeten, Kirama, and Macha 2016). For example, the Small and Medium Enterprise Development Policy (2003) was intended to foster job creation and income generation by promoting the creation of new businesses and improving the performance and competitiveness of existing ones. Evaluation studies conducted in 2013 showed that 'the policy faced a number of drawbacks that held back its growth, including inadequate resource mobilisation and a weak implementation framework, relying on the parent ministry at all levels' (Voeten, Kirama, and Macha 2016). President Magufuli's keynote introduction to the FYDP II seems to acknowledge such concerns (URT 2016).

Consultations with representatives from a parliamentary standing committee did not reveal much optimism that this had changed. In our consultations in July 2019, we were told that more specific policies are required to implement the FYDP II, and that such policies had been in the final stages of development in January 2018 (our interlocutors were not aware of any more recent update). We were told that no budgetary or legislative measures had been, but that parliamentarians saw the FYDP II's implementation as a priority. Though questions surrounded the plan's implementation, stakeholders reported that power supply had improved dramatically during the past two years, and further power projects are forthcoming.

A challenge is coordination of policies. The President's Office - Public Service Management has overall responsibility for coherence of national policies. Nevertheless, several sectoral ministries are involved, and a major challenge concerns the lack of clarity on which government entity has overall responsibility for technology policy. Voeten et al. (2016) noted that innovation is 'not a widely used concept in policy documents, and existing policy frameworks show that innovation is first and foremost associated with science and technology policy'. They conclude that the main ministry responsible is the Ministry of Communication, Science and Technology.

The Tanzania Commission for Science and Technology (COSTECH) was established in 1986 as a parastatal organisation to co-ordinate and promote research and technology development activities in Tanzania. The value of COSTECH as a coordinating body was well recognised during consultations. However, multiple stakeholders (including those within the organisation itself) indicated that

COSTECH's mandate appeared to exceed its resources. For example, COSTECH has an incubator for start-ups, but several times this number were thought to be needed. Under-resourcing has led to issues with coordination, including with other government bodies.

Our consultations revealed that the President's Office – Public Service Management is currently finalising a large public-sector reform programme: the Public Service Reform Programme 3. The programme includes a component on innovation, and intends to create an innovation fund for systems and structures. In addition, the e-Government Agency (within the President's Office – Public Service Management) has created an innovation centre in Dodoma for attracting, remunerating and retaining innovators.

In addition, the Ministry of Education and Vocational Training informed us that a new technology, science and innovation policy is being developed. It has undergone stakeholder consultations, and is now in the final stages of approval. There are plans to develop a 'technology roadmap', showing the likely impacts of technology and the appropriate policy measures to take in response.

Legal and regulatory environment

The OECD (OECD 2015) found that conditions for domestic and foreign investment had been greatly enhanced by the legal framework, but that significant room remained for improvement. Particular areas for improvement included: land tenure and access, investment incentives, and protection of intellectual property rights. Access to land remains a challenge in most economic sectors, particularly for agriculture. Stakeholder consultations reinforced this view: they considered lack of land to be the key impediment to expansion of industrial activity in the textile sector. In addition, slow procedures for issuing permits further impede investment. For example, a special economic zone took two years to set up due to administrative requirements. In the view of one stakeholder, this puts Tanzania at a significant disadvantage compared with Ethiopia, for example, in terms of industrial development.

Tax and incentives are also seen as an area for improvement. The OECD (2015) recommended a systematic evaluation. It found that taxes in the mining sector, for example, were excessively high and, coupled with burdensome regulation, were an inhibitor to investment. This ultimately reduces the revenues government is able to receive from this sector. The incentive system in the agricultural sector was found to be skewed towards large exporters; it offers insufficient support to smallholders. Stakeholders identified the tax registration system as overly cumbersome: acquiring a tax identification number (TIN) requires paying tax in advance on anticipated future revenues.

Competition is regulated under the Fair Competition Act 2003.The Fair Competition Commission (FCC), which was put in place in 2007, enforces the act. The regime prohibits anti-competitive agreements and abuse of dominant position; it also regulates mergers above certain thresholds. Energy and water, surface and marine transport, civil aviation and communications are regulated separately. Despite having a sound legal and institutional framework in place, the FCC seems to deal with relatively few cases (UNCTAD 2012). The Global Competitiveness Index 2017-2018 ranked Tanzania 113 among 137 countries, compared to Kenya at 91 and Ethiopia at 108 (Schwab 2017b). In a focus group discussion on innovation, stakeholders raised the lack of competition as a key barrier to innovation.

In response to this, the government of Tanzania recently launched a Blueprint for Regulatory Reforms to Improve the Business Environment. The goal of the blueprint is to respond to the poor business regulatory framework by removing hurdles. Strategies have been adopted to bring clarity to the regulatory regime with the aim of ensuring that the private sector operates in a friendly and predictable business environment. This holistic approach to reviewing the policy and regulatory framework governing institutions and agencies aims to streamline and rationalise the taxes and levies to ensure inclusive participation of the private sector.

Skills and education

Analysis conducted by the United Nations Industrial Development Organization (UNIDO) showed that, in Tanzania, businesses involved in some form of innovation in products or processes employ relatively more high-skilled workers not engaged in innovation. This indicates that an increase in the skills base is required for Tanzania's manufacturing sector to progress towards higher-value addition and technology intensity (URT and UNIDO 2012). A 2011 survey by the Government of Tanzania and UNIDO revealed very low levels of literacy, numeracy and information technology (IT) skills among workers. Managers expressed dissatisfaction with employees' skills in certain areas. For example, while managers were fairly satisfied with the academic background and communication skills of their employees, the found that employees' problem-solving and initiative skills lacking) (URT and UNIDO 2012).

In focus group discussions with stakeholders, inadequate education consistently surfaced as a major impediment to the use and development of technology in Tanzania. Education almost uniformly emerged in discussions even when questions aimed at different subjects. A youth workshop discussed in detail the curriculum and the fact that it has not caught up with technological change. Young people did not think that their educational background had equipped them to enter the job market. The importance of 'mindset' also received emphasis. That is, participants said that the education system steered people towards a focus on research and academia rather than towards the building of skills to innovate. This chimes with the findings of the 2011 survey mentioned above.

Access to finance

Financial depth in Tanzania is 'very limited' (Kibwe et al. 2017). In 2015, its ratio of total financial assets to GDP was 43 per cent; the ratio for banking system assets to GDP stood at 30 per cent; and the ratio for credit to the private sector to GDP was 17.1 per cent. The high costs of and limited access to formal financial services are a critical inhibitor to business development. The World Bank (Kibwe et al. 2017) reports cases of small businesses being repeatedly denied credit due to lack of sufficient collateral; collateral requirements can be up to 265 per cent of loan value. In addition to high finance costs and collateral requirements, short loan tenure also constrains business growth (Kibwe et al. 2017). This limits Tanzania's capacity to push forward its production possibilities frontier, and acts as a serious constraint to productivity increases and economic growth. Tanzania's National Council for Financial Inclusion has set up a National Financial Inclusion Framework to address these challenges.

Counteracting this, the mobile money revolution has increased access to finance considerably over the past decade (Kibwe et al. 2017). For individual entrepreneurs and micro-businesses, mobile money services open up access to short-term micro-loans, which provide finance to potentially grow their businesses. Mobile money services also reduce transaction costs, and increase the safety of transferring money (previously, transfers would have been done physically) (Kibwe et al. 2017). The impact of the mobile money revolution received extensive comment from stakeholders: the youth, in particular, spoke of the opportunities that mobile banking opens for micro-entrepreneurs.

4.6 Outcome of Stakeholder Consultations

The OPM team conducted a series of key informant interviews and focus group discussions over one week in Dodoma and Dar es Salaam. Findings of these consultations are incorporated throughout the report. We briefly summarise the multi-stakeholder and youth workshops here.

Multi-stakeholder workshop

A multi-stakeholder workshop brought together key individuals from government; private-sector organisations, including manufacturers' associations, tech-start-ups, and telecommunications companies; local think tanks, international organisations, civil society organisations; and academia. A plenary opening session, launched by Benno Ndulu, governor of the Bank of Tanzania and a member of the Pathways for Prosperity Commission, presented some initial findings of the desk-based research and the framing of the study. Following this, participants separated into groups to discuss issues around technology in areas of interest.

The break-out sessions aimed to address the following questions:

- **Innovation:** What forms does innovation take in Tanzania? Which technologies are most relevant? What are the barriers to innovation? What could be done to remove these barriers?
- **Mining and natural resources:** What is the potential for technology uptake in the mining and natural resources sectors? What are the barriers to technology uptake?
- **Communication, manufacturing and robotics:** Do reduced communication costs provide opportunities for participation in global value chains? What are the opportunities for manufacturing?
- **Social protection:** What are the frameworks for social protection in the case of rapid technological disruption? How should they be financed? How might new technologies support the provision of social protection?
- **Agriculture and logistics:** What is the potential for 'smart agriculture' in Tanzania? Can digital platforms coordinate microenterprises to overcome transaction costs and to raise productivity in agriculture? Could they also be used to reduce transportation costs?
- **Digital readiness and policy options:** What is the status of digital readiness? What are issues surrounding training and education in digital skills?

Some common themes emerged from the break-out sessions, as follows:

- **The importance of education:** Although education was not a prompting question for any of the break-out sessions, participants nevertheless raised the importance of education to technological uptake. The ability of the education system to equip young people with the mindset to become innovators and entrepreneurs was seen as paramount.
- **The enabling environment:** Similarly, the significance of the enabling environment to technological uptake surfaced as a crucial factor in several break-out sessions. Participants suggest that issues around regulatory requirements and the business environment, including market competitiveness, will determine whether Tanzania can respond to technological change. Participants in many break-out sessions cited challenges around infrastructure provision and logistics.
- **Communication and coordination:** Across sectors, information mismatches were seen as key inhibitors to success. For example, in the agricultural sector, a lack of understanding on the part of farmers of industrial sector requirements has led to bad outcomes, resulting in suppliers with insufficient produce, or famers with unsellable surpluses. Participants said that the potential for technology to overcome these issues was a key opportunity could be seized across sectors.

Youth workshop

The perspective of the youth is invaluable to this study because they stand to be most affected by technological change. We organised a youth workshop to explore issues around young people's digital readiness and preparedness for the job market, and their perceptions of their opportunities as entrepreneurs. Fourteen young people attended a lively two-and-a-half-hour discussion. The participants were a mixture of university students, youth panel representatives, and budding entrepreneurs. Key points from the discussion are:

- **Education:** The importance of education on digital readiness and technology uptake received major emphasis. Participants felt that the education system was out of date, and did not equip young people with the requisite skills for going on to become innovators or to prepare them for the job market.
- **Opportunities from technology:** Debate unfolded about whether technology should be seen as posing risks or opportunities in terms of employment prospects. Several examples of using technology to generate business opportunities received mention, such as the use of Instagram by young entrepreneurs to sell food items online. Participants recognised that jobs may be displaced due to technology, and that government has a role to play in ensuring that people can be re-trained to respond to such displacement.
- **Distributional impact:** Participants recognised that youth (and people in general) based in Dar es Salaam (the case for all of our participants) are better placed to respond to technological change than inhabitants of rural areas and smaller cities. Participants expressed caution about targeting education towards digital skills, particularly because they recognised that for many people, basic literacy and numeracy remain the key priorities. Participants expressed concern about the potential for technology to increase inequality.

4.7 Conclusion

The Tanzania case study is a preliminary diagnostic exercise that characterises the pattern of the country's growth and innovation system. The main feature of structural change in Tanzania since 2000 has been the shift of labour out of traditional agriculture to non-agricultural employment with associated 'between-sector' labour productivity gains. Informal employment remains massive, accounting for over 80 percent of the workforce. Exports and dominated by natural resources and tourism. In the formal sector, a small number of larger firms dominate production; these are also the most productive, most innovative firms. A 'missing middle' of medium-sized firms indicates a difficult environment for the growth of small, innovative firms.

Disruptive technology could have some direct, positive impacts on large export sectors, including mining and high-value agriculture. Uptake likely depends most on the climate for investors, including foreign investors. Disruptive technologies seem unlikely to directly or indirectly impact manufacturing industries that are established or those that may grow quickly in Tanzania, because manufacturing competitiveness is based on natural protection or very low labour costs, neither of which are likely to be strongly affected by automation in the foreseeable future. Significant positive opportunities may lie in the potential of digital platforms to coordinate and serve informal microenterprises. These are hugely important to workers in Tanzania. Digital platforms may provide a shortcut to the benefits of larger, more coordinated firms - possibly with even greater competition and efficiency - without waiting for reforms and adjustment to the conditions that produce microenterprises today. Platforms are often devised by small, innovative start-ups. This is a good reason to improve conditions for these firms.

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