Indonesia Case Study: Rapid Technological Change - Challenges and Opportunities

Final Report

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Executive Summary

This report sets out a theoretical framework and empirical methods through which to assess the challenges and opportunities presented to developing countries by rapid and disruptive technological change. It applies the framework and methods to a case study of Indonesia, based on extensive desk-based research into the Indonesian innovation system, a policy stock-take, and also the findings of a workshop, series of focus-group discussion and key informant interviews with Indonesian stakeholders conducted in Jakarta between 13 August and 20 August 2018. It is intended to complement 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 they are addressed in the literature. These accounts tend to be **technologically deterministic**, reflecting what is technologically rather than economically or politically feasible; **western-centric** in their representation of employment and of the mechanisms through which technology may generate disruptive effects; and **neglects policy**. We use these criticisms to motivate our approach, focused on identifying the **specific mix of country factors and policy choices** that determine outcomes in developing countries.

The current debate over the impact of new technologies is driven by a set of interrelated claims concerning: the unprecedented pace and scope of change; the relationship between change and inequality; the potential for new technologies to dramatically reduce the costs of and barriers to the transfer of information and knowledge. Examining each of these claims identifies challenges and opportunities for developing countries. We argue that the debate over technologically-driven unemployment is methodologically flawed and has distracted from more significant questions regarding distributive effects of new technologies and inequalities, as well as the potential pathways through which technology might generate job creation, productivity gains and learning. The capacity for new technologies to reduce communication costs and transfer information could have significant effects in the domestic economy, solving information problems, strengthening linkages between sectors, engaging the informal sector and improving transparency and accountability, for example, in the delivery of public services. But evidence suggests that technological solutions in these areas do not always succeed; 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 (GVCs), could have serious implications for industrial strategies, especially those oriented towards export-led manufacturing. At the same time, there may be opportunities for globalised learning, tradable services and new forms of industrial policy.

Underlying all of these debates is the crucial question of how to think of technological change. We review a range of theoretical approaches to this question, from neoclassical and endogenous growth theories to the national systems of innovation (NSI) approach. Of fundamental importance is that technological diffusion, adoption, adaption and innovation are embedded in political, institutional and social structures. We find that the concept of 'capabilities' – at the 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 be the factors that constrain or enable the acquisition of capabilities. In implementing this approach, we single out the issue of firm-level capabilities as being key – this will be the focus of our desk-based research, which applies qualitative and quantitative analysis of firm Enterprise Surveys (ES) and other data to build up a picture of the innovation system and capacity for technological change. The more general aspects of a country's capability structures are to be addressed through the policy stocktake and the workshops.

The case study for Indonesia shows that, while it is still a lower middle-income country (LMIC), its economic history has not been uneventful and there has been considerable structural change and dynamism since the 1960s. Important features include:

- Throughout the period there has been a steady flow of workers out of traditional agriculture into more productive services and manufacturing which has produced 'between sector' gains in labour productivity.
- There has been enough 'innovation' to sustain strong 'within sector' labour productivity gains in almost every industry throughout this period as well, although Indonesia lags behind its ASEAN neighbours in this area.
- The 1997/98 financial crisis was a major issue for Indonesia – extreme depreciation and a collapse in domestic demand produced an export share above 50% of gross domestic product (GDP) in 2000 and this has been slow to decline, so that Indonesia still exports the same share of GDP as China – Indonesia has very diverse exports including minerals, agricultural products, food and diverse manufactures.
- Alongside this apparent openness, Indonesia has a long history of intervention and protecting the interests of particular investors, or groups of workers, or latterly to foster capability in target industries.

Macro- and sector-wide statistics suggest growth driven by innovation – but beyond the averages we detect a blend of greater and lesser innovation – through this there is fairly clear evidence that life is difficult for small, innovative start-ups. Surveys of innovation suggest very low levels of innovation – but this does not seem to square with the high levels of labour productivity growth at industry level. Large firms are most productive and dominate output, and also have the fastest productivity growth – even faster than industry averages. One cause for concern is that the potentially important channel for innovation and adaptation – small, innovative start-ups – seemed to be largely absent. This was corroborated by Indonesia being 144th on "starting a business" in the Doing Business indicators, and also by the broader literature.

The country case study found that, in some large industries where there could be positive direct impacts from disruptive tech, but also direct challenges via the alteration of GVCs – parts may be unaware they are in GVCs, and many industries could benefit from some co-ordination to think through the challenges. The case study is preliminary to a diagnostic, and cannot claim to have undertaken the comprehensive industry-by-industry analysis that a more definitive diagnostic exercise would do. Garments, electronics and food processing are all major manufacturing industries in Indonesia, combining competitive, outward-facing firms, sometimes under pressure from low labour cost competitors, and also from firms producing for the domestic market that may feel more insulated from competition. They are all in GVCs and need to make decisions about whether to give way to low labour cost competition or invest and upgrade to occupy strong niches in GVCs. The GVCs are going to change and this might be too much for individual firms to predict. There is a role for government in co-ordinating readiness. Meanwhile, in mining, competitiveness derives from natural resource deposits – but there are still major efficiency gains possible from disruptive tech in mining, provided the incentives are right for investment.

The report concludes that there is high potential for digital platforms to co-ordinate informal micro-enterprises and bring the benefits of formalisation and reduced transactional frictions in a large part of the economy. Examples include Grab or GOJEK – but there are also opportunities for many other sorts of business besides taxis: platforms for sharing information and advice; platforms for allocating freight space; platforms sharing assets. There are significant opportunities for using digital co-ordination to reduce waste and improve efficiency in highly decentralised supply networks. This is highly relevant for Indonesia because services are the fastest growing part of the economy since 2010. This trend is likely to continue because services are still too small by international standards. Indonesia's services involve some large firms but also many under-the-radar micro-enterprises. Co-ordination through platforms can reduce market frictions and bring the benefits of intra-firm co-ordination without a large firms. A major issue is that the developers of platforms are themselves small, innovative start-ups so, reforms or shortcuts such as incubators are needed to allow them to thrive.

The policy-stocktake reviewed statements and progress in a number of relevant policy areas. There were strengths and weaknesses. Indonesia has a National Industrial Policy which is future oriented and contains many of the sorts of policies which might help industry adjust to the impacts of disruptive technologies – policies that help investment, innovation and spillovers in industries calculated to be high potential. It is possible that this policy could be refined with more specific consideration of the challenges and opportunities arising from disruptive technology. It is also true that government is engaged, sometimes slowly, in unwinding a stock of protectionist or restrictive regulations from the past. Labour market regulation is a concern. There is also concern that the education system does not produce enough high-skilled workers and managers. In terms of creating a better environment for small, innovative start-ups, there is a recognition that the financial sector serves such companies poorly, and steps are discussed to address this. There is also an explicit recognition that digital readiness needs to be invested in and needs to be archipelago-wide, not just in Jakarta/Java.

The workshop, focus group discussions and key informant interviews formed a critical part of this study – as a means of obtaining expert local knowledge across a range of sectoral and policy issues, and in terms of engaging with stakeholders to explore practical ways Indonesia might prepare itself for rapid and disruptive technological change. As such, this fieldwork constituted a set of research findings in its own right, and also helped Oxford Policy Management to develop and refine the research methods of this study and, hopefully, future work in this area. At the main workshop in Jakarta, launched by Minister Sri Mulyani Indrawati, three main findings emerged:

1. Technological capacity alone is not enough to guarantee success. We need to enable a conducive social, political and economic environment.
2. To understand the challenges of technological change in employment, we have to look at the growth engine and economy as a whole. The technology needs to be adapted to the country, not the country to the technology.
3. Capturing opportunities of technology is possible with appropriate business models and policies. Successful technology should enable pathways for inclusive growth. This must include the involvement of private sector, government and civil society to create a national ecosystem for success.

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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 Tanzania), 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,

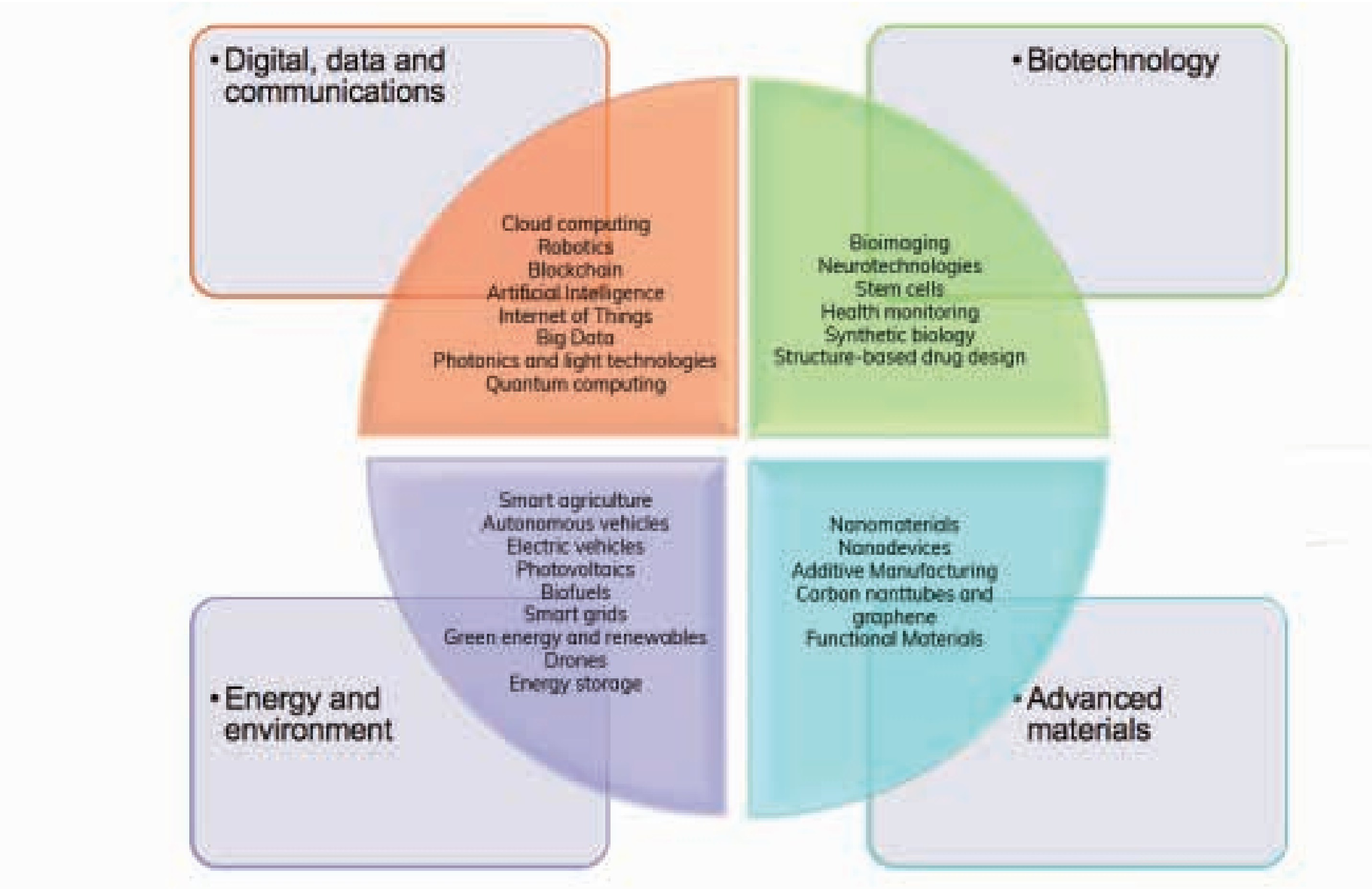
[7] See, for example, (World Bank 2018b), (ADB 2018), (Schwab 2017a)

[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).

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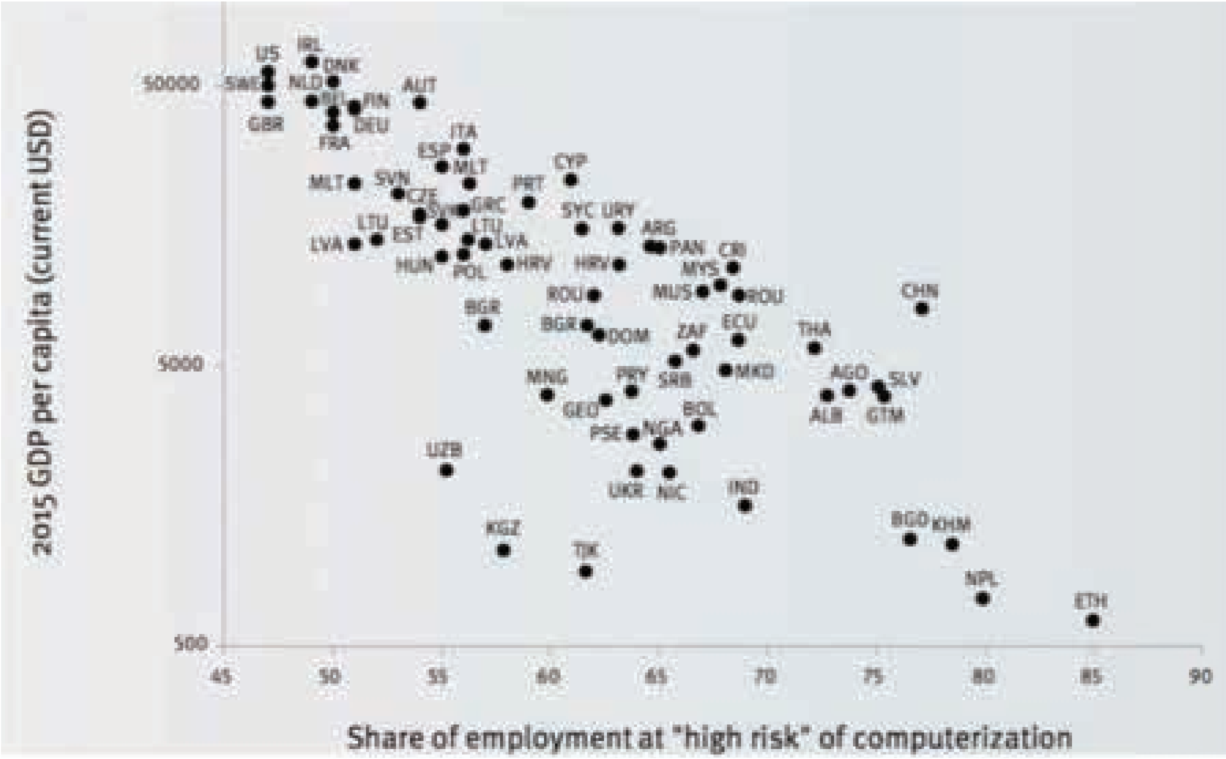
[14] See also (Acemoglu and Restrepo 2017; Autor 2015; Autor, Dorn, and Hanson 2015) for further discussion of the task-based approach.

[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.

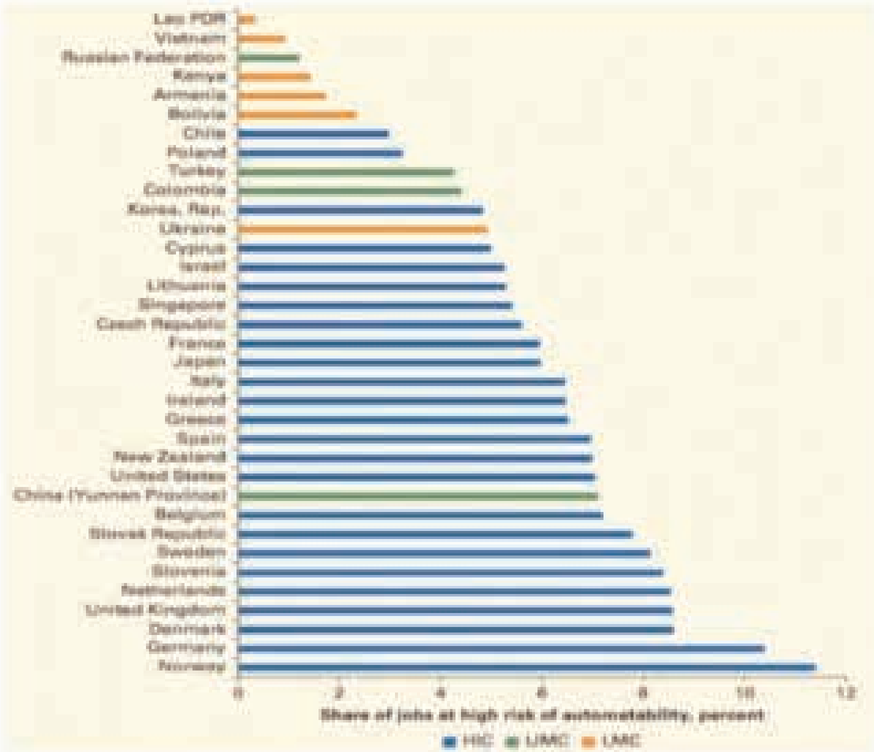
Figure 2: GDP Per Capita versus Share of Employment at “high risk” of computerisation



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).

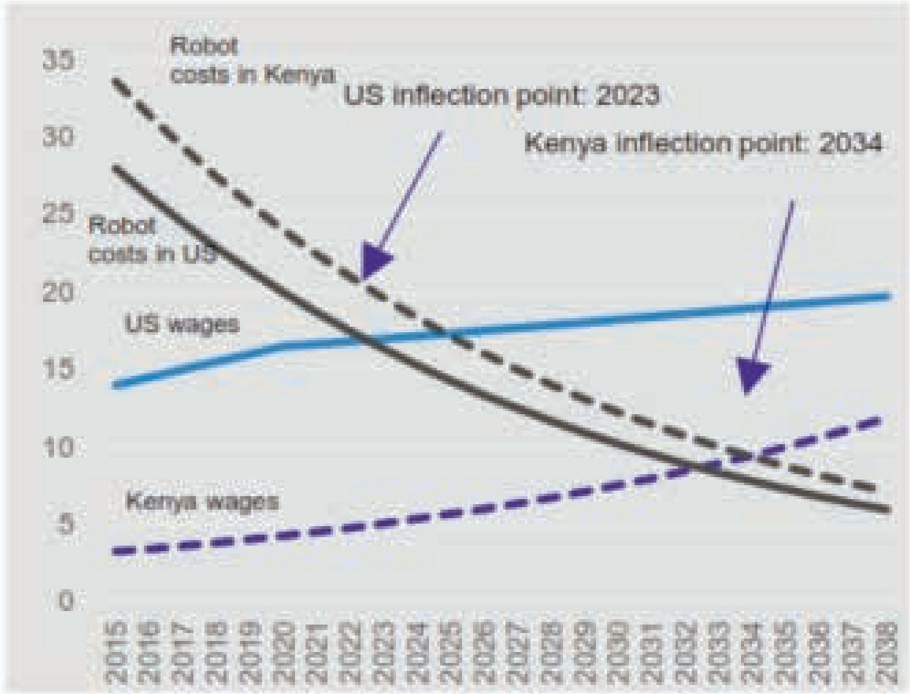
In his book *The Great Convergence*, Baldwin's argument is that there are three main costs to trade over distance: the costs of moving, goods, ideas and people (Baldwin 2016). 'Old' globalisation – the globalisation of the 19th century – is driven by the low cost of moving goods (shipping) but the high 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



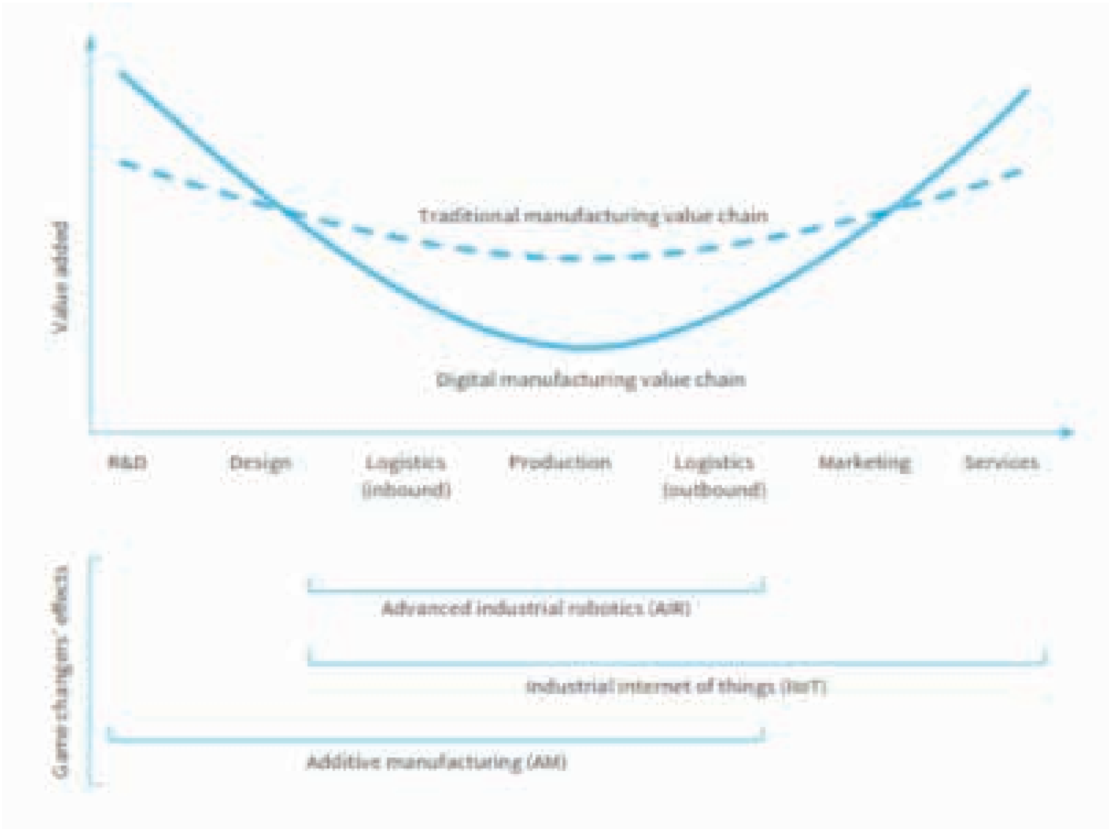
Source: (Banga and te Velde 2018)

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. Indonesia Case Study

4.1 Approach to country case studies

Our general approach to country case studies is as a preliminary diagnostic exercise. We describe the conditions which prevail in the case study setting, using existing data, secondary sources and a limited amount of fieldwork. Taking into consideration the global features of the technology in question, and specific features thought to prevail in the setting, we test a hypotheses about the country's exposure to challenges and opportunities arising from disruptive technology. We look at its detail and its macroeconomic magnitude, and the country's ability to adapt to challenges and take advantage of opportunities. We also review the policy stance and how that 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 a broader pattern of technological change which encompass both frontier and non-frontier technologies, and which have been in place for some time. In LICs, therefore, disruptive technologies will be impacting on economies that are already dynamic, where jobs are already being replaced and the structure of production is already shifting. The starting point of the case studies is a quantitative analysis of national accounts and labour force survey data to describe the pattern of growth and structural transformation, and the evolution of productivity that we see in the recent period.

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 this trajectory may be disrupted or otherwise impacted on by technological advances. It also allows us to start to identify the industries that are important to the economy but also susceptible to impact from disruptive technology, according to global evidence.

We examine recent trends, spot shifts in average productivity and describe whether productivity gains result from workers shifting between sectors and/or from productivity gains within sectors (Diao, McMillan, and Rodrik 2017). This description allows a first assessment of whether and how disruptive technologies are likely to impact on 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, others may be little affected.

Innovation system: Theoretical approaches to innovation, such as those of Nelson and Winter, Lall or Lundvall were discussed in Sections 2 and 3 (Cimoli et al. 2010; Lall 1992; Lundvall 1997, 2007; Nelson 2008). 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 adapt to technological advances.

Here, 'innovation' does not just mean adopting the very latest technology, but rather lots of technology which is merely new to the country or new to the firm, including the 'technology' of management practices and commercial practices.

To characterise innovation in this setting, we use macroeconomic data and ES data to examine production and labour productivity dynamics in the recent period. This allows distinctions to be made about performance in different industries and also across different types of firm – for example, according to size or age. We are careful to examine hypotheses, *"big firms are innovative", "innovative small firms are absent"*, by interrogating the data. However, this is not a fully identified exercise. Therefore it is vital to collect supporting evidence in the wider literature and about specific industries, and to derive key hypotheses from this wider evidence before examining them in the data.

Sector-specific findings: In the 'preliminary diagnostic' study, we cannot achieve a comprehensive exploration of each and every productive sector, so we have to be selective. We select industries that are important for level of production, or that are fast-growing, that are achieving fast productivity growth and/or that seem likely to be highly susceptible to the impacts of disruptive technology based on global evidence. The assessment of productivity and growth macroeconomic and ES data gives us very useful pointers towards a relevant selection of industries for deeper study. The country case study is preliminary and rapid, so cannot be comprehensive and definitive. Nevertheless, a combination of desk-based evidence assessment and fieldwork interviews and workshops is designed to capture a good number of the major issues and to extend the accuracy of the findings well beyond conclusions based solely on analysis of survey data.

Policy stocktake: We review 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. Secondary sources were consulted to build up a picture of the policy environment and other aspects of the innovation system. We reviewed major recent reports and consulted policy documents (again, this exercise has not been exhaustive).

Interviews and workshops: We supplemented our desk-based research with findings from in-country consultations. The in-country consultations were designed to: (i) gather insights and preliminary findings of the review and gain insight on country-specific analysis; (ii) identify gaps and priorities, drawing on local knowledge; and (iii) build momentum and initiate discussion among 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
- A multi-stakeholder workshop, with breakout 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 tech start-ups, law firms and telecommunications companies; (iv) academia and research and; (v) youth organisations.

For the key informant interviews and focus group discussions we used a semi-structured interview format, targeted to the interviewee 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

Some lessons for a fuller diagnostic are learned well in the case study exercise. These include:

• Describing the pattern of growth and augmenting this with specific industry knowledge gives some good insights into where opportunities and challenges may lie. It would be possible, useful, but time-consuming to add a lot more detail and be more comprehensive in the review of industries and possible future industries that are exposed to impact from disruptive technology.

• Describing the pattern of growth, the evolution of labour productivity and the structure and dynamics in the population of enterprises, and surveys of 'innovation measures', allows hypotheses to be tested relating to the capacity to innovate and adapt. Examining this data alone stops a long way short of proof about the pattern of innovation. It would be possible to fit stories to patterns seen in the data – 'fishing' – and this would be unreliable. Any more thorough diagnostic exercise needs to guard against that. Review of secondary sources and supporting research was very important in forming conclusions. An issue that became obvious was that even industry disaggregation may mask an even more heterogeneous situation in terms of innovation – there could be very different types of firms with different markets and capacity within the same industry. Again, perhaps primary work on an industry/firm level would be necessary to be more definitive.

• In-country consultations have been extremely important to ensure that the findings are are grounded. They help form the hypotheses we examine in the data, help us interpret the secondary sources, and ensure that we address prevailing perceptions in the country setting.

The case studies seem a lot more useful than, for example, a local application of Frey and Osborne's modelling to assess the vulnerability of jobs to automation, based on opinions about job roles in the US. The case studies and preliminary diagnostics at least give an impression of the pattern of development and change. They allow us to examine the country-specific challenges and opportunities that might therefore arise, and the probable adaptability of the private sector to those challenges and opportunities. They also provide a commentary on the way government is supporting that adaptability and how it might provide more support in the future.

4.2 Pattern of growth

Indonesia is a lower middle income country (LMIC), with GDP per capita at US$3,570 in 2016 compared to Tanzania (the parallel case study), a low income country (LIC) at US$818 and the US at US$57,600. Indonesia is extremely large – a huge population of 260m, but also a huge landmass of 1.9 million km^2 spread over thousands of islands, including several very large ones. For reference, South Africa is 1.2 million km^2 and Argentina is 2.8 million km^2. Bangladesh has 147,000 km^2 and a population density almost nine times greater than Indonesia. Indonesia is rich in people and natural resources.

We start by characterising the pattern of growth in Indonesia in terms of the structure of production and employment, and productivity progress. This gives vital grounding for the whole case study, and immediately makes it obvious why a case study or 'diagnostic' approach is necessary. Indonesia is not like the US and so applying a methodology such as that of Frey and Osborne (2013), which is based on extrapolations from the US job market, might be very misleading. As discussed in Section 2, a mapping of jobs that may or may not be replaced by machines will not give us good insights into the impacts of new, disruptive technologies in Indonesia. This is because it neither takes into account the opportunities presented by job creation, productivity gains, or improved communication costs, nor the challenges posed by rising inequalities, polarisation or disruptions to industrial strategies. In the 20th century, Indonesia was itself a LIC, its economy is in motion, the structure of production is now very different from most LICs and OECD countries, which might mean that parts of the economy are very vulnerable to technological change; it could also mean that Indonesia is well placed to capitalise at least on some types of technology.

Today, as an LMIC, Indonesia is much less agricultural than a typical LIC – but still has a larger agricultural sector than most OECD countries, and a smaller service sector. By any standards, the manufacturing sector is now very large. In 1970, agriculture was 29% of GDP and 66% of employment. By 2012, agriculture was 12% of GDP and 34% of employment. There were substantial gains in labour productivity within agriculture, especially in the second half of that period (1990–2012), but value added per worker stayed well below that in all other productive sectors. This means that, as a 31% share of the workforce shifted out of agriculture, there were major gains in average productivity across the economy – a major 'between sector' productivity gain following the methodology of (Diao, McMillan, and Rodrik 2017) – a 10% share of employment shifted to industry (up to 20% in 2012) and a 21% share shifted to services (up to 46% of employment by 2012). Indonesia has arrived at a similar workforce distribution to China, even though the pace of change has been somewhat slower in Indonesia. In the future, it is likely that both agricultural and industrial employment will give way to more services – this trend is clear in the most recent data below.

In terms of output, there was a steep decline in agriculture's share up to 1975 as mining (including oil) expanded. In the period between 1975 and 1990, there was a steep increase in the share of manufacturing from 10% to 25% of GDP, a very high share by international standards.

Figure 6: Sectoral shares of output and employment

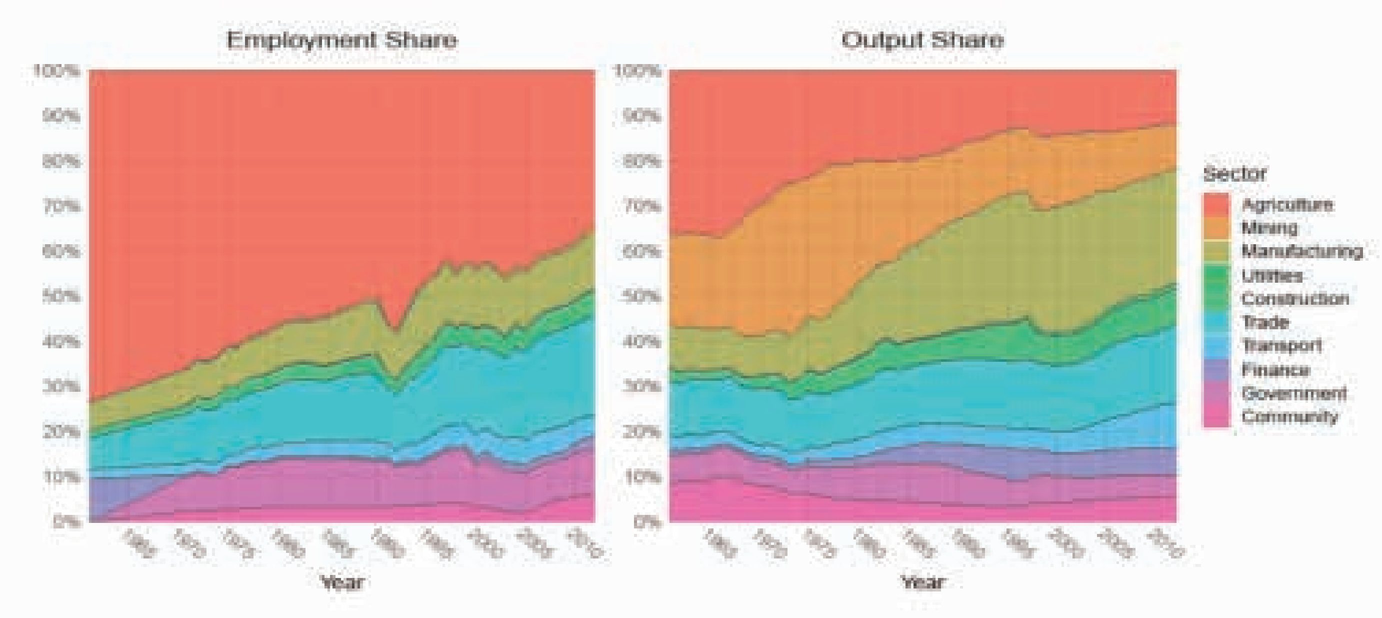


Figure 7: Output per worker (10 sectors)

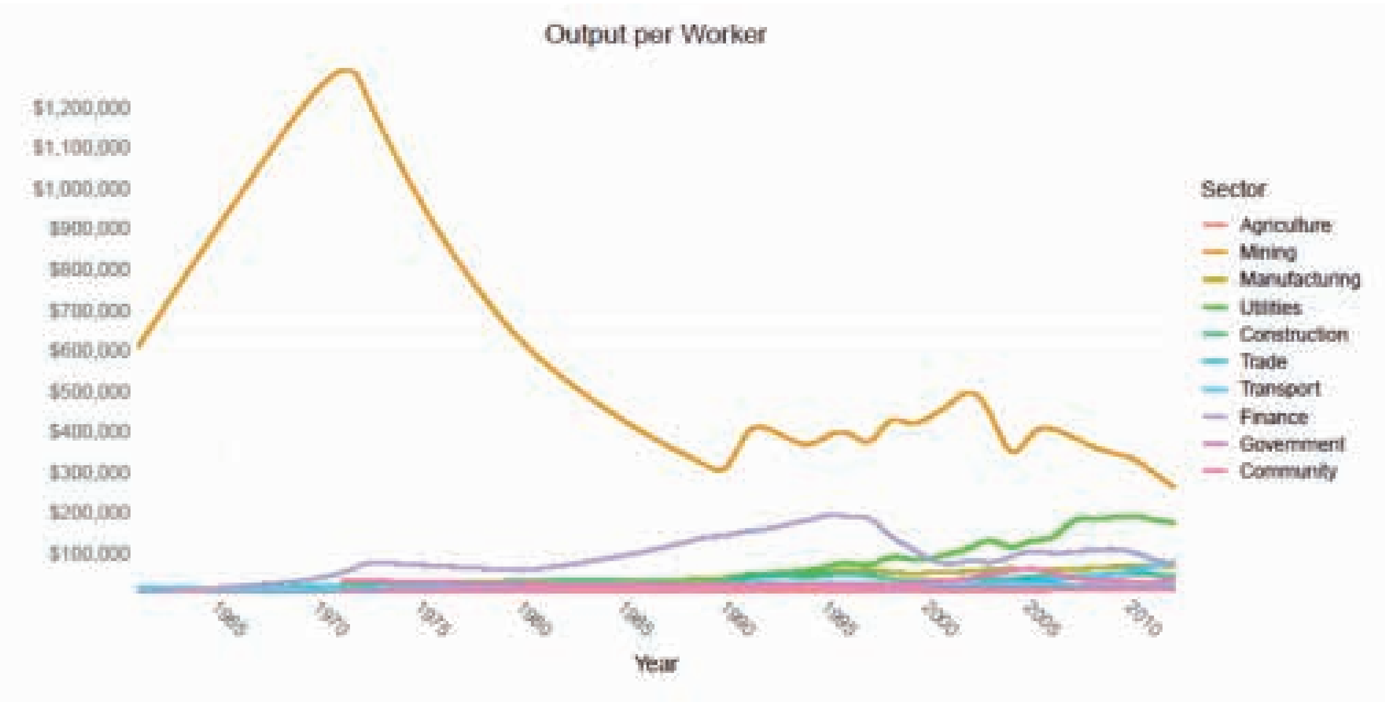


Figure 8: Output per worker (7 sectors)

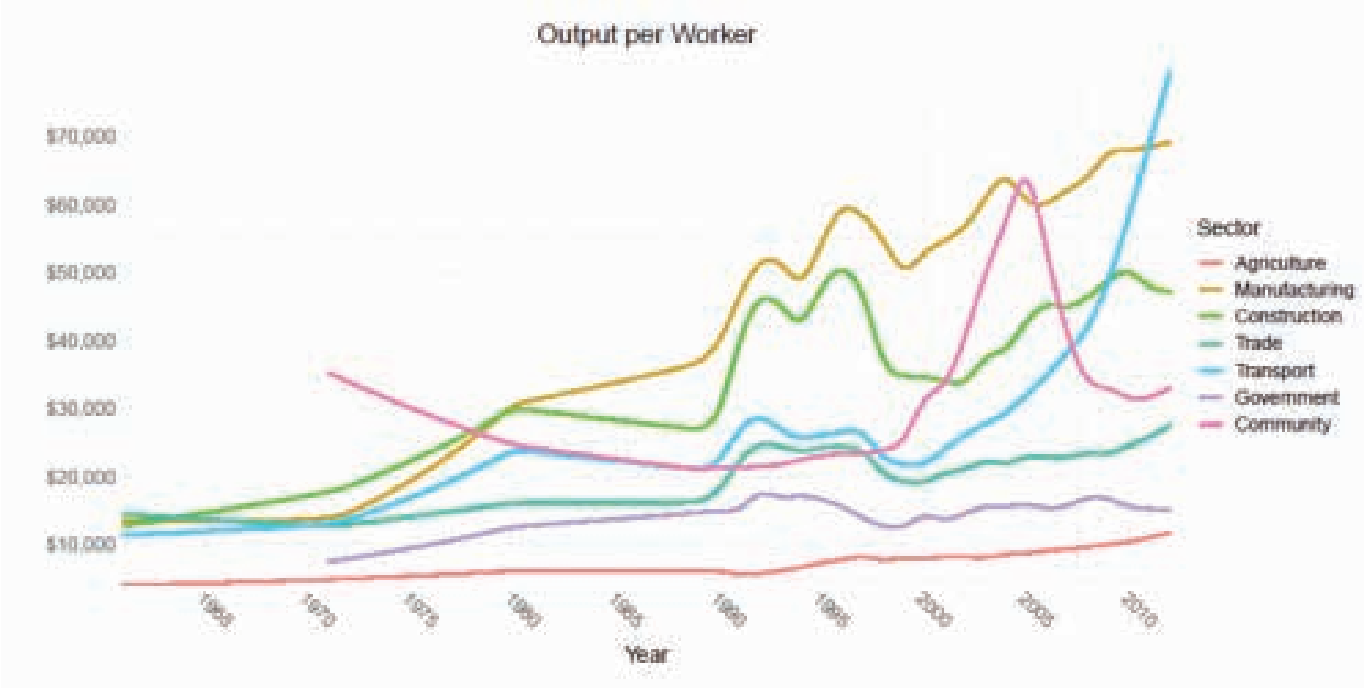
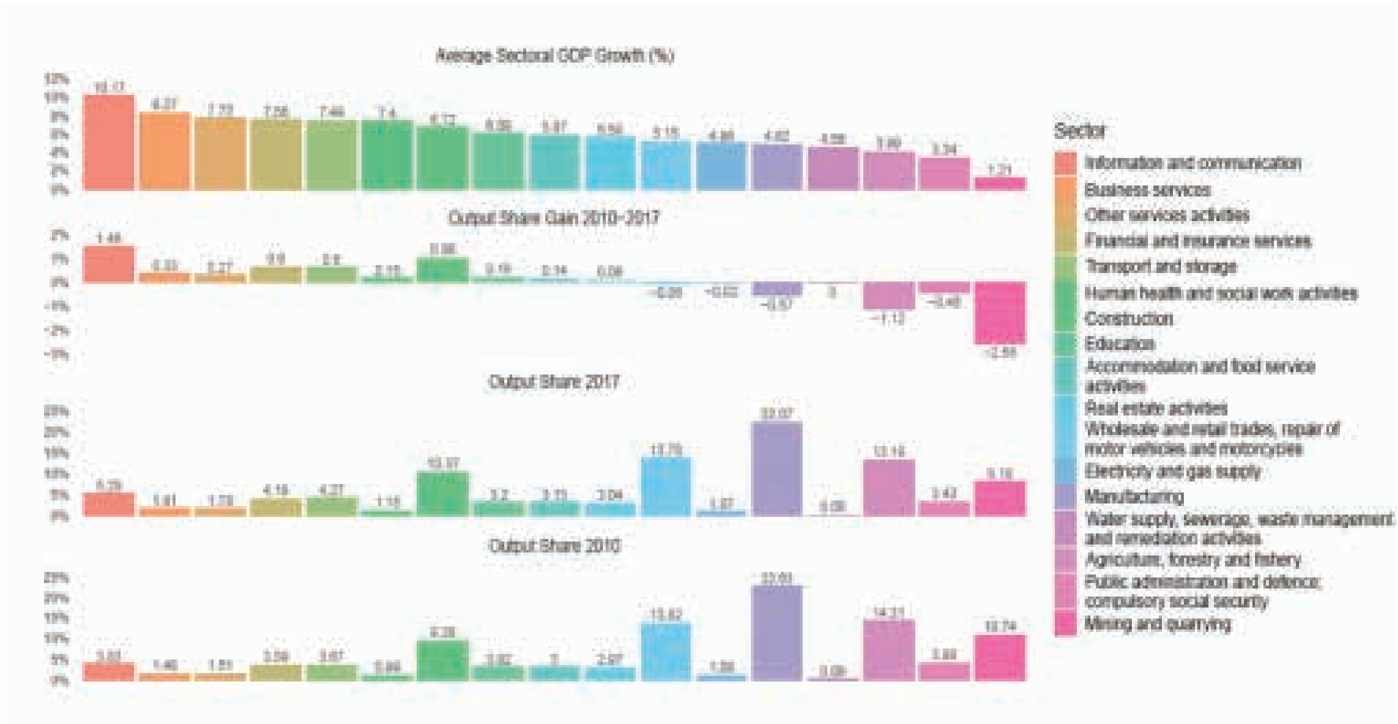


Figure 6, above, shows the longer-term trends in the shares of different productive sectors in employment and output in Indonesia. Figures 7 and 8 show output per worker. They are based on the Groningen University 10 Sector Database – similar to the Africa Sector Database – a highly accessible and standardised data set allowing the inspection of the structure of production in the long term (Groningen 2018). In all, these data cover 39 countries.

The major structural shift of labour away from agriculture generated a significant 'between sector' productivity gain, but it took place over a long period. During that period there were major labour productivity gains within the agriculture and also within manufacturing, which averaged 2.6% per year increases in value added per worker 1990–2012. Both 1970–1990 and 1990–2012, dominated between-sector productivity gains. Both were positive. 1990–2016, per capita GDP increased 132%, or 3.3% per year on average. Headcount poverty fell from 59% to 6% in the same period. Even despite the 1997 financial crisis, Indonesia is a fast-growing economy with innovation, technological absorption and strong productivity gains and welfare gains. However, findings from the workshop suggested that the government do not have adequate strategy and plan in place to facilitate these innovations, including weak policy and low supply of skilled workers.

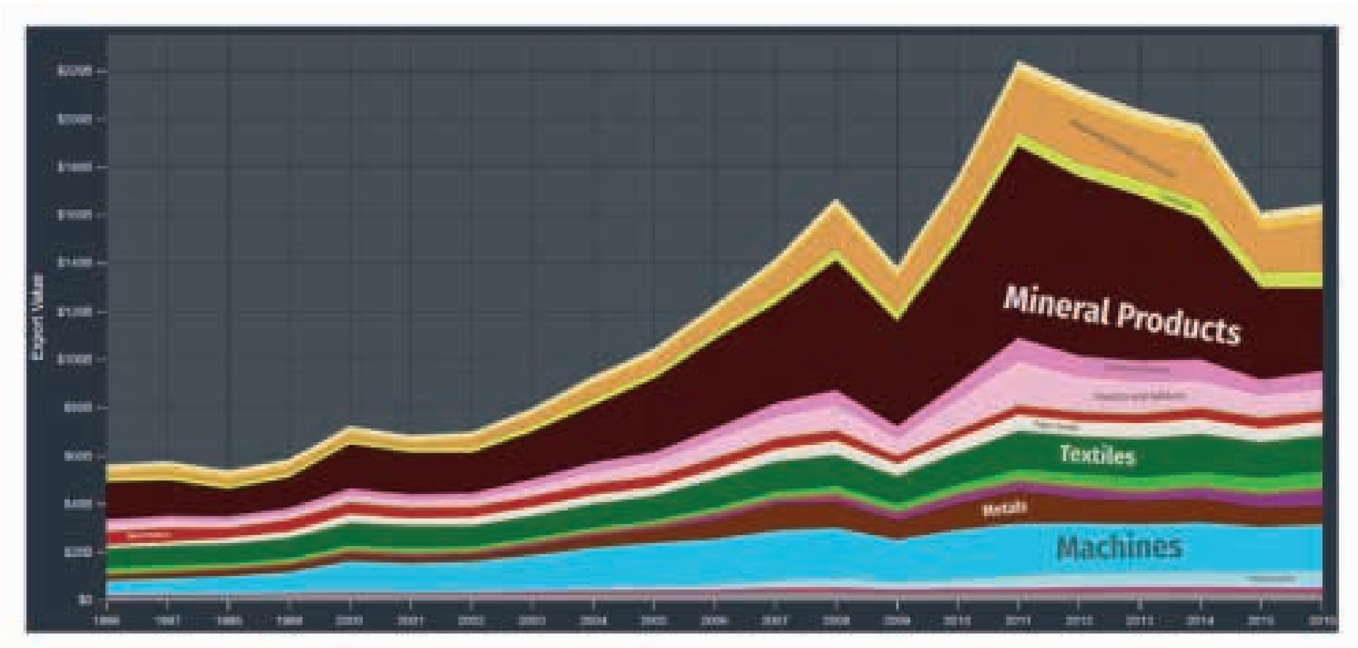
The picture can be extended to the present day using Bank of Indonesia data for 2010–2017. Figure 9 ranks industrial sectors by output growth rate. It is clear that non-tradeable services, including IT, plus construction, lead growth in this period. As a whole, the manufacturing sector grows at 4.8%, which is lower than the average GDP growth rate of 5.11% over this period, and thus decreasing in output share. There are, however, many industries within manufacturing, such as food processing, chemicals and pharmaceuticals, transport/automotive and fabricated and basic metals that grew at above average rates. Note that, although mining is still a very strong contributor to exports even as some commodity prices have fallen, it continues its long-term decline as a share of GDP. Some mining sectors such as iron ore, crude petroleum and natural gas, coal and refined petroleum products have shrunk with average growth rates of -1 to -2% over this period.

Figure 9: Multi-sector growth breakdown



Although this performance is strong, Indonesia lags behind other ASEAN countries such as Thailand, Cambodia and, in particular, Malaysia in terms of labour productivity gains in manufacturing. Indonesia has many characteristics in which it differs from an East Asian Tiger (Page 2009).

Figure 10: Indonesia's diverse exports



Source: MIT 2018

The disruption to the Indonesian economy during and after the Asia financial crisis in 1997 was among the most severe anywhere in the world and has had effects which last to this day. Preceding the crisis, Indonesia experienced rapid growth. The crisis struck at a point where Indonesia was already running a substantial trade surplus but where Indonesian companies, including those serving the domestic market, had become very exposed to dollar-denominated debt. Contagion in Asian currency markets caused steep depreciation in the Indonesian currency, bankrupted companies with dollar debts and collapsed demand, leaving much reduced consumer purchasing power. Extreme depreciation created extreme incentives to export pushed exports to an elevated level of GDP – over 50% (World Bank 2018c) – a high level for an LMIC. While there was some readjustment, exports remained high for some time, higher than China's until 2005, when the level declined gently in both countries. Although it is 20 years ago, this crisis might help to explain why Indonesia's exports are diverse: minerals, agricultural products and foodstuffs and manufacturers are all produced for the regional and global markets. Visible in Figure 6(a) is a retreat of workers into agriculture from other (domestic-facing) sectors in 1998–2000. The crisis caused major political upheaval and regime change.

Indonesia's economy is open in some senses but is not liberal. It is open in the sense that it has a good share of trade in GDP. However, government is prepared to use trade protection, tariffs and quantitative limits, subsidies and tax exemptions to favour particular industries (WTO 2013). There has been some active promotion of competition in recent years, but there are still state-owned monopolies and monopsonies. Some aspects of industrial policy are squarely aimed at maximising efficiency and competitiveness. Others are more to do with protecting interests of investors and/or workers (Tijaja and Faisal 2014). An example of this, which was highlighted in the workshop on August 20 2018 is the energy sector. The energy sector in Indonesia is has been slow in comparison to others in picking up innovation, especially in regards to renewable energy, as the sector is heavily regulated with the state utility dominating the industry. There is a paradox in that imported technologies are tax free, however, when local companies develop technologies it is subject to tax. Therefore there is no incentive to produce technology in Indonesia, but instead import and assemble it.

One way or another, these policies and history have produced a diverse economy. There is a very large manufacturing sector at 25% of GDP and which exports internationally, perhaps benefitting from the weak exchange rate, and also supplies the significant domestic market, perhaps in some cases protected from international competition. It also has a large and diverse agriculture and food processing industry. The largest single export is palm oil at US$13.9B making up 8.4% of exports (MIT 2018). Processed foods are major exports as well as other raw materials and, of course, there is a massive internal market of 260m people to feed. Very large and diverse non-renewable mineral exploitation has helped to push exports to very high levels since the 1970s. Indonesia is the World's leading producer of nickel and tin, and, along with Australia, coal. There is a variety of other metals, gas and non-metallic minerals. Services are relatively small at 42% of GDP.

For the purposes of our case study, the diversity is very important. In general, diversity is good protection against macroeconomic shocks, and this is the case with the shock of disruptive technology. Non-manufactured exports and manufactures for the domestic market might both be a bit less vulnerable to disruptive technology than highly mobile, export-oriented light manufacturing. There are great opportunities for productivity increases in mining, agriculture and some manufacturing.

While there have been steady productivity increases in the economy and manufacturing as a whole, for a long period, within manufacturing, and even within broad industries like textiles, there has been a range of performance and likely to be a range of exposure to the challenges or openness to new opportunities.

The position of individual manufacturing industries in GVCs will have a bearing on the exposure to challenges and opportunities. We can think of four categories:

- Facing competition from competitors in countries with lower labour costs (e.g. low-end garments)
- Facing potential 'reshoring' and/or need to upgrade within GVCs (e.g. high-end garments)
- Highly competitive but still needing to upgrade to stay at the forefront of productivity (e.g. chemicals, automotive)
- Domestic facing, protected, vulnerable to external competition of protection becomes inadequate (e.g. some producers of electronics and electrical goods)

4.3 Innovation system

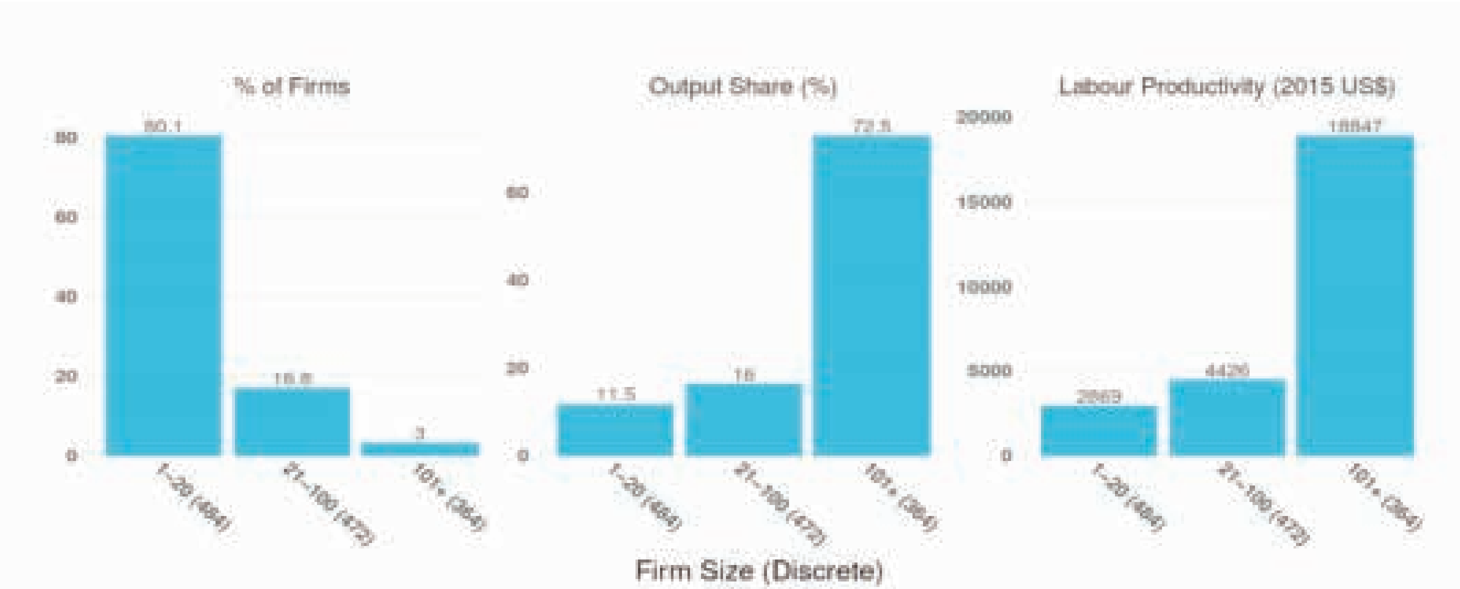
A second component of the Indonesia case study involves characterising the innovation system. As discussed in Section 2, the concept of an innovation system attempts to describe the flows of technology and information between people, enterprises and institutions, which generate innovative activity (Tijaja and Faisal 2014). The extent to which these flows achieve that end depends on the levels of various forms of capabilities, and policies of one kind or another can help to develop these capabilities and so improve technological diffusion and capitalise on rapid technological changes. Because the locus of most innovation is the firm, we are especially interested in firm-level data and make use of World Bank ES as our primary data source for this part of the study, as well as wider literature. The ES are available for a wide range of countries, are produced in a highly consistent way across countries, and so are suitable for an exercise that needs to be replicable. The surveys cover a sample of formally registered private firms in industry, including mining, and also in service sectors. This is a large share of GDP in Indonesia.

We can use ES to describe the distribution of firms by size. Figure 11 shows results from the 2015 survey. We find, as with Tanzania (the parallel case study), that 80% of formal firms are small, below 20 employees. In the US, for comparison, the share is 88%. Also in common with Tanzania and the US is a small share of large firms (over 100 employees). In Indonesia this is 3% of firms. The large firms are few but they produce 72.8% of the value added in the formal non-agricultural sector. Since 2009, the proportion of medium-sized firms has grown substantially but the share of output of medium and smaller firms has fallen. Comparing the firm size distribution and output shares in 2015 with those of 2009, the share of small firms (one to 20 employees) has decreased from 90% to 80%, while the share of medium (21 to 100 employees) and large firms (100+ employees) increased from 8% to 17% and from 1.7% to 3% respectively.

At the same time, the output share of medium-sized firms decreased from 29% to 16%, while the output share of large firms increased from 51% to 73%. More medium-sized firms indicates that smaller firms can grow, but larger firms have become considerably more dominant in output, even in this short period.

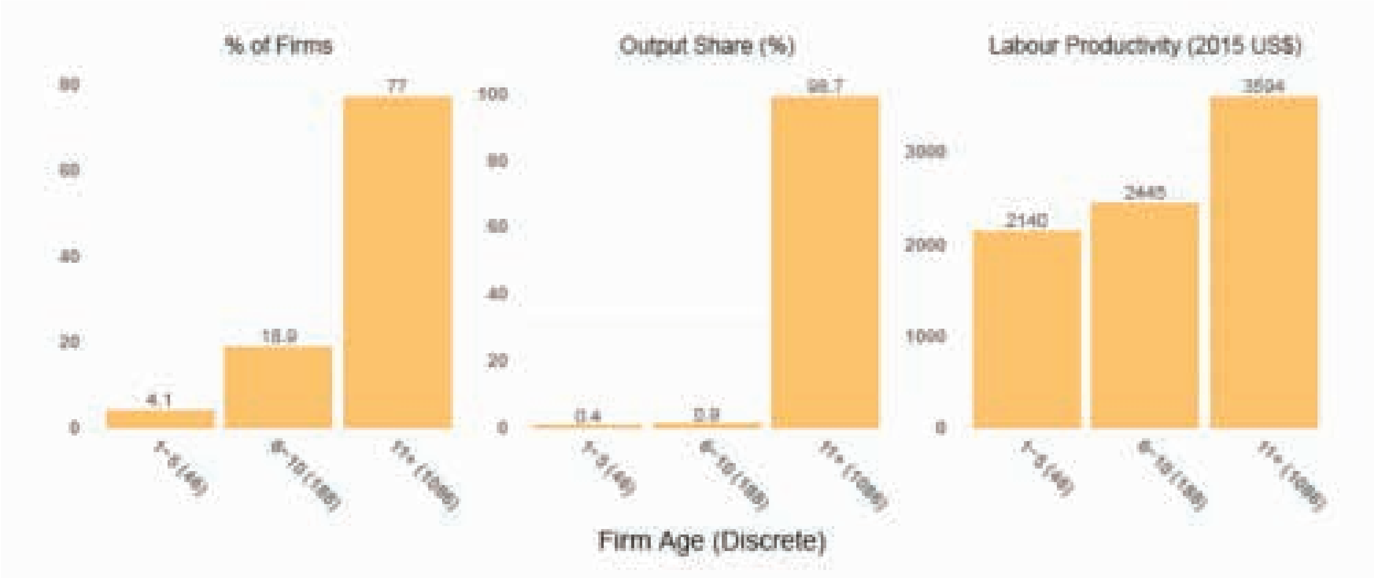
The reasons behind this 'hollow-middle', as minister Sri Mulyani Indrawati put it in her keynote speech, were discussed at the workshop. They include regulatory challenges, for example, getting licences. There are no incentives for smaller businesses to get a BPOM[29] licence, as multinationals and SMEs follow the same process, and multinationals seem to be getting licences much faster. An example is that, for multinationals, it takes a few months to process the licence, whereas for start-ups and small businesses, it can take up to a year. As a consequence, these start-ups and small businesses need to manage their own distribution system and cannot sell their products in the formal market chain. Large firms are more capital intensive with much higher average labour productivity – a common finding worldwide. What is also true in Indonesia is that labour productivity is increasing much faster in the large firms than in SMEs: In 2015, large firms outperform small industries with a labour productivity on average 6.6 times higher than that of small firms (one to 20 employees). In 2009 this margin was still 4.4 times higher.

Figure 11: Firm size profile



[29] BPOM is the national agency of drug and food administration in Indonesia. They have the absolute authority to control the circulation of drugs and foods in Indonesia.

Figure 12: Firm age profile

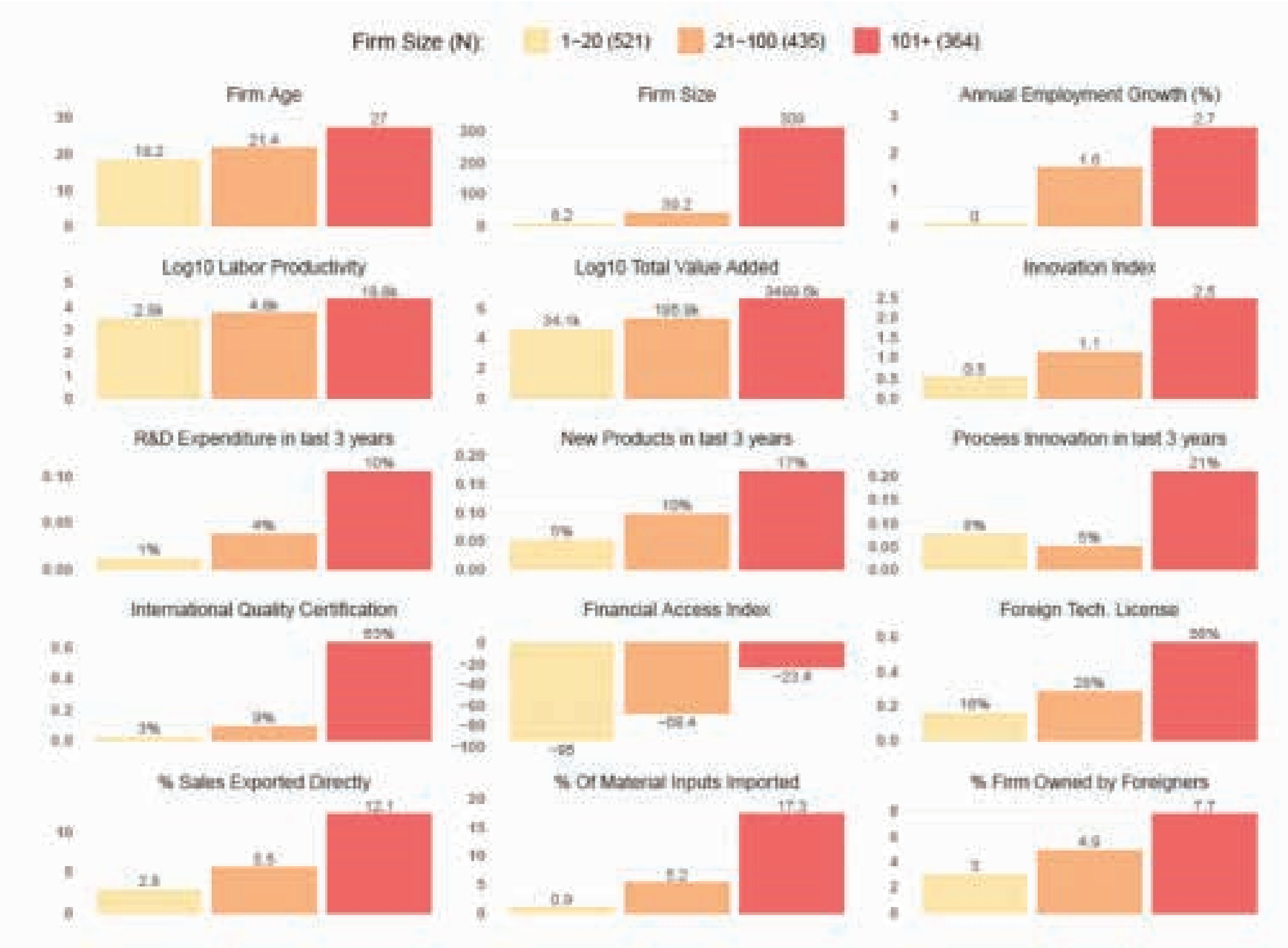


The ES also allows us to estimate the age profile of firms in the wider economy (Figure 12) and this is where Indonesia reveals a more striking result – far fewer young firms than the US or even than in Tanzania. Only 4.1% of firms in the ES sectors are less than five years old compared to 33% in the US. 70% of firms are more than ten years old compared to only 42% in the US. An extremely high share of output seems to come from firms that are very established (more than 20 years old), and these firms have also experienced faster labour productivity growth than younger firms. *(Caveat: while the ES results are representative of the wider population of firms on firm size, they may not be representative on firm age).*

The ES contains a number of questions directly concerning innovation. It is notable that Indonesian firms, on average, score very low on these indicators compared to the East Asia regional average and global average. For example, 6.2% of firms claimed to have introduced a new product and 11.4% a new process in the reporting period, compared to East Asia averages of 36.7 and 33.4% respectively. Only 1.9% of firms indicated formal R&D spending in the last three years, compared to 14.4% in East Asia. We should not over-interpret this result because there is room for subjectivity and national idiosyncrasy in the way these particular questions are answered: one person's routine managerial decision is another person's process innovation, perhaps. Certainly Indonesia's labour productivity gains seem too high to be the result of very low innovation.

Examining more closely the correlations between various key variables in the data reveals that, in the aggregate, there is a correlation between firm size, and labour productivity (r=0.3). Product, process and marketing innovation indicators are uncorrelated to firm age and productivity estimates, and only weakly related to firm size (r=0.1). Labour productivity and firm size are, however, both significantly related to formal R&D expenditure (r=0.2), technological infrastructure (r=0.3) and even more strongly to the use of foreign technology licences (r=0.5). The import of foreign technology seems important. Some firms innovate via formal R&D spending, whereas smaller firms seem to innovate less. In general, however, R&D spending in Indonesia is low, with both government and firms investing very little. Figures from 2013 indicate that less than 0.1% of GDP was spent on R&D and mostly funded by public research organisations, according to the OECD. The challenges of this were felt by ministries attending the workshop, as it only allows them to focus on certain sectors.

Figure 13: 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.

The combination of production and productivity gains concentrated in larger firms – in some cases using imported technologies – and few smaller, younger firms, which appear to be innovating strongly and growing fast, does create some concern about the innovation system in Indonesia. This suggests a system that is kind to incumbent firms who may or may not innovate, but is not very friendly to incoming innovators. This finding was strongly echoed in the key informant interviews and workshop discussions. Participants indicated that the main two reasons for this were: (i) access to finance; and (ii) difficult regulatory environment and requirements, making it costly for smaller businesses to comply.

Doing Business Indicators (World Bank 2018a) rank Indonesia as 144th in terms of ease of starting a new business in 2018 – that is a very low ranking. The sorts of reform and policy change that might encourage start-ups and 'disruptors' at any time may become even more important if disruptive technology is going to require a faster pace of innovation. At the same time, if production is very dominated by established old firms, these firms may need assistance and co-ordination in terms of being ready for disruptive technology, including the changes to GVCs this may cause.

An important caveat is that ES covers only formal sector firms. Start-ups may not formalise – the sort of firms that, in the US, would set up and fail or grow based on the success of their innovations may exist 'under the radar' in Indonesia. But, if this is so, it's problematic. Informal enterprises find it difficult to grow, even if they are genuine businesses and not just self-employment vehicles. For example, it is very hard to access financial services and mobilise external investment if you are an informal enterprise with no proper accounts, no credit rating and grey-area property rights. As discussed in Section 2, this may be a key area in which new technologies can have a positive impact. Evidence from the interviews suggest that this is the case, with financial services and fintech rising, in particular peer-to-peer lending.

Although the empirical evidence suggests that larger firms dominate the innovation space, according to the interviews, Indonesia has a thriving start-up environment: out of the seven 'tech unicorns' in ASEAN, four are from Indonesia. This was highlighted in the keynote speech of Minister Sri Mulyani Indrawati, when she stated that Indonesia is blessed with young entrepreneurs that are competing with global platforms such as Go-Jek, Traveloka, Bukalapak and Tokopedia.

In 2016, roughly US$1.7 billion was invested in start-ups in Indonesia, according to McKinsey, largely in the fintech and financial services sector. The government predicts that education and healthcare sectors will see a lot of innovation, due to the large amount of government spending in these areas. The 20% of national budget spent on education, for example, can support technological innovation.

In the 2017–18 World Economic Forum Global Competitiveness Index, Indonesia is ranked in 36th place out of the 137 countries in the study. Yet, in terms of Technological Readiness, the 9th Pillar of the Index, Indonesia's ranking is only 80th. In large part, this is due to comparatively low rankings for the sub-pillars of ICT use (93rd place); and while there have been improvements in recent years in terms of the percentages of the population who are internet users, and who have access to internet and mobile subscriptions, the quality of internet bandwidth remains extremely low.

Digital infrastructure is uneven across the archipelago, with some islands, such as Java, benefiting from significantly faster and cheaper internet than others, such as Papua. Indonesia's geography poses a unique set of difficulties in addressing this divide, but the government, through the 'Tol Informasi' programme, intend to provide high-speed internet in an equal manner to all regional capitals by 2019. Until this happens, however, the differential access to new technologies only serves to deepen existing inequalities between urban population centres, especially Jakarta, and the regions. In addition, participants, especially the youth workshop, highlighted that access to internet is not enough; digital literacy needs to be improved to ensure that access is truly inclusive. Data is largely used for accessing social media, rather than accessing information to improve livelihoods.

Indonesia's economy is large, with GDP approaching US$1trillion, so we must be careful and be ready to look beyond average statistics. On average, Indonesia has produced sustained diversification and productivity gains, and evidence shows that innovation and productivity gains are greater in older, larger firms. These results reinforce the impression that the environment for small, highly innovative start-ups is quite difficult. However, these average results can hide a lot of variation – there are some industries and firms that are highly innovative with high capacity to absorb technology and achieving fast productivity growth. There are other industries where most firms have been postponing investment and upgrading for 20 or 30 years – perhaps these can seize opportunities if they finally make investment decisions. Other industries are quite protected and may not be very innovative. Qualitative evidence suggests that some of Indonesia's programmes for promoting innovation are effective (see below).

Barriers and obstacles to business

An alternative way to gain qualitative information about potential constraints to innovation and the growth of firms is to ask firms themselves about their greatest business obstacles. This is done systematically in ES over a number of years. From a list of 15 commonly chosen items, respondents were asked to rank the biggest obstacle faced by the firm for its day-to-day operations.

Figure 14: Biggest business obstacles in 2009 and 2015 (% of firms choosing)

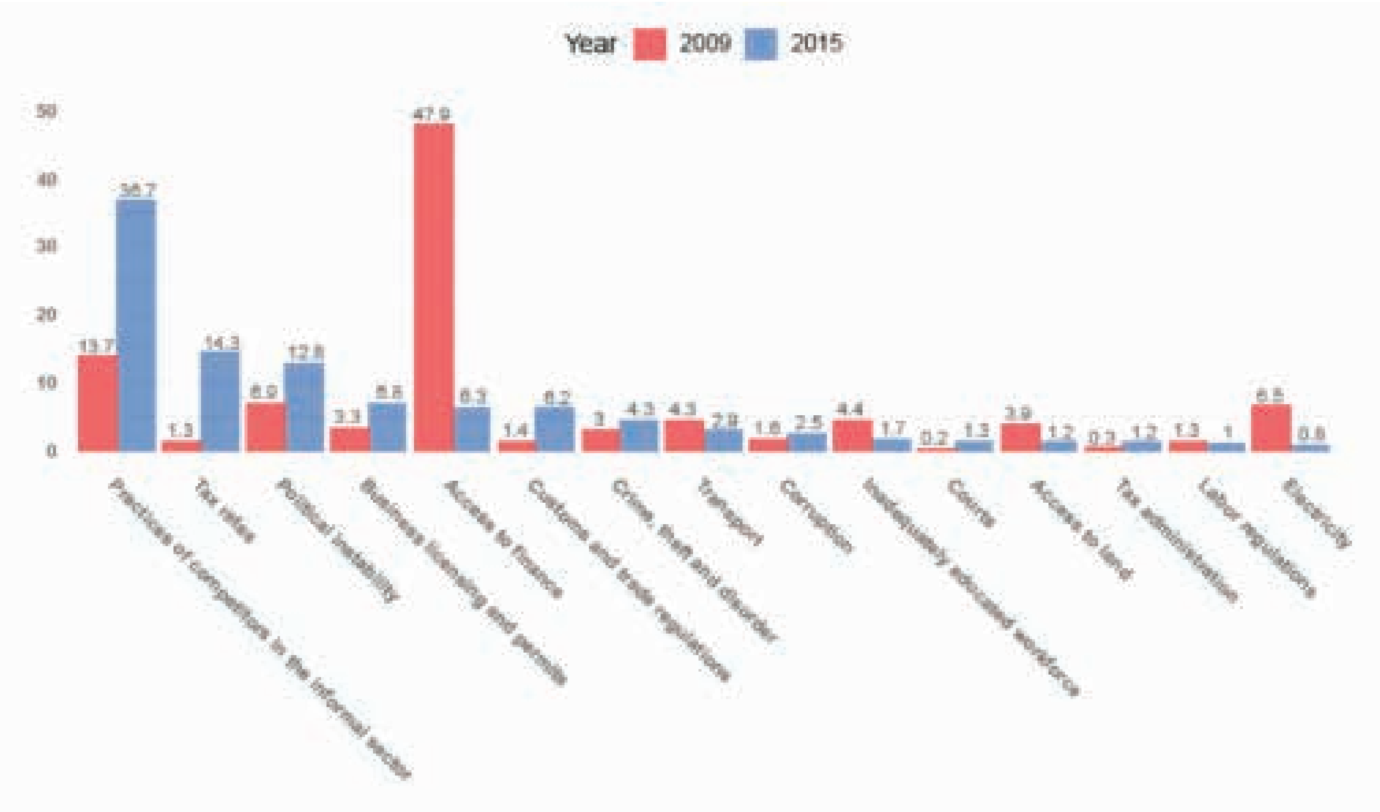
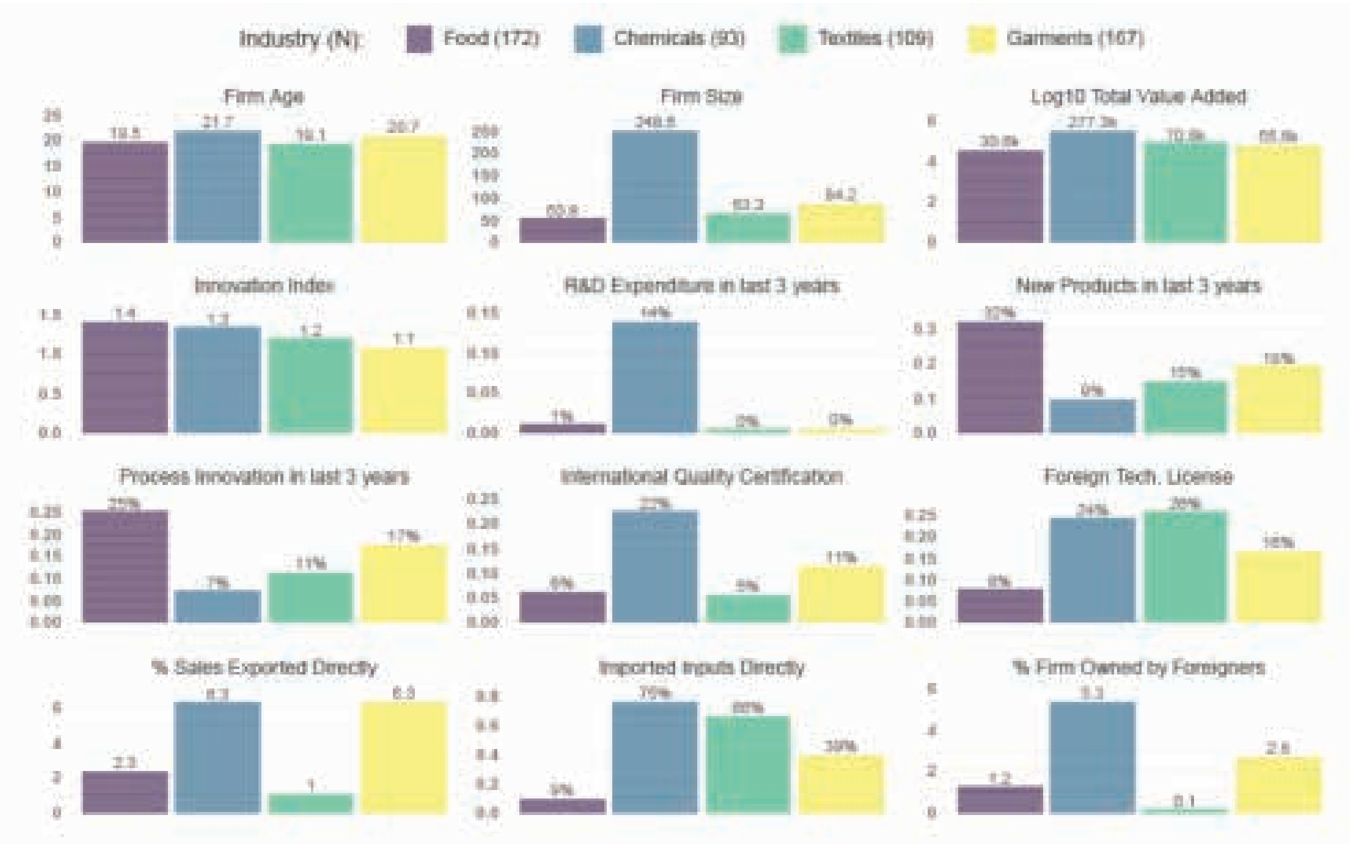


Figure 14 shows the three most commonly chosen top business obstacles by Indonesian firms in the two ES implementations. The change is striking: Whereas access to finance was the towering issue in 2009, the problem appears to be nearly solved in 2015 (in a qualifying question only 17% of firms said access to finance was a major constraint), whereas informal competition is now the biggest obstacle (this presumably is also linked to tax rates growing at 12.5% per year on average since 2010, more than twice the rate of GDP growth). We note, however, that such data can be misleading as the categories of responses are not independent of one another. According to the interviews, financial access, especially for seed-funding is still extremely hard to source in Indonesia. In addition, common responses to the challenges of setting up a business included: licensing and permits, taxes, issues around intellectual property (most intellectual property applications are from foreign firms, rather than local companies, and applying for this has not been internalised as being part of business set-up) as well as skills. For example, relatively few respondents cited corruption as a barrier to doing business, yet many of the other categories may themselves be strongly affected by corruption. Further detail is included at Annex 1. In the workshop, one start-up 'tech unicorn' mentioned their readiness to comply with the government's regulation. However, the path for compliance is not clear. The start-ups expect the government to have the willingness and capacity to embrace new technology, rather than prohibit them due to the lack of familiarity.

4.4 Survery of selected industries

The following sections will examine in more detail a selection of industries that are likely to be significantly impacted by technological change. The industries examined are: garments, electronics, food, chemicals and pharmaceuticals, mining, and digital platforms. The first four are important industries in the Indonesian economy, and are also industries where the direct and indirect impacts of disruptive technology could be strong. Digital platforms are themselves a disruptive technology that could co-ordinate microenterprises, and reduce transaction costs even more widely to the benefit of enterprises, consumers and other businesses (as discussed). It is important to note that a general feeling was that the industries such as manufacturing (garments, electronics, food), mining and natural resources, which are the backbone of the economy, still lag behind in terms of innovation. There was a concern among participants that the government is largely supporting digital innovation over innovation in the other sectors.

Figure 15: Innovation across industries



4.4.1 Garments

Since the 1960s (if not earlier), garments have been viewed by many in Indonesia as a "sunset industry" (Mokyr, Vickers, and Ziebarth 2015). However, the sector grew very strongly prior to the 1998 crisis and since then has roughly maintained its share of Indonesian GDP, declining somewhat from 2010 to 2017, when growth reduced to 2.8%. It employs 3.7m people (with textiles) compared to 5m in Bangladesh. Unlike in Bangladesh, this is 25% of the manufacturing workforce (Bangladesh – about 90%) but it is clearly enough to make Indonesia a global player. ES evidence suggests that the employment share decreased between 2009 and 2015 (from 8.1% to 6.3% inside the formal private sector). Sector exports in 2016 were US$14.8bn – so the scale of production is two orders of magnitude bigger than Ethiopia, let alone Tanzania. The workforce is about 200 times that of Tanzania's, with higher output per worker. This large industry embodies a large pool of skilled labour and management.

The history of the industry involves less explosive growth than in some East Asian Tigers but nevertheless robust growth in low-labour cost garments in the 70s through the 90s and has included large-scale manufacture of many international brands like Nike and Gap and latterly Decathlon. Some sporting products, like shoes, face challenges from disruptive technology which might lead to reshoring of highly automated, bespoke manufacture. In 2016, Adidas announced its intention to close a large factory in Vietnam, and reshore production to a very low labour input, new factory in Germany using 3D printing and a high degree of automation.[30] On the other hand, manufacturing for big international brands with great logistics networks may offer some insulation from disruptions associated with design and a need for very short supply chains.

Figure 16: Evidence from enterprise surveys

Significant, rapid increase in firm size: consolidation

Flat capital to labour: slow to upgrade

Significant increase in labour productivity, 15% per year: innovation

Significant increase in innovation measures

[30] See, for example, www.economist.com/business/2017/01/14/adidass-high-tech-factory-brings-production-back-to-germany

The sector is not homogenous. Part of it is facing stiff competition from manufacturing bases with much lower labour costs: Vietnam, Bangladesh, even Ethiopia. This part of the industry as seen postponement of new investment – factories are reported as being 20 years out of date (World Bank 2012). There are many mergers and acquisitions and a shrinking number of larger firms. This certainly generates pessimistic industry news, with lots of smaller firms going to the wall. But there is some evidence, from ES data, that this consolidation is producing productivity gains and increases in innovation, for example, R&D programmes. The sector is still "highly unconcentrated", that is, a large number of competing firms, see Annex 1. In Indonesia (as elsewhere) ES data shows clear correlation between firm size and productivity – there might be few small firms entering and a lot of concentration in larger firms but this doesn't necessarily mean zero innovation (notwithstanding the generally low innovation scores in Indonesia ES). ES data show that labour productivity increased by more than 10% every year between 2009 and 2015. In the same period, the percentage of firms owning foreign technology licences increased from 5% to 16%, and the prevalence of international quality certifications increased from 1% to 11%. The combination of out of date plant but also larger firms could create conditions for investment and upgrading. There is perhaps an important role for government in advising or co-ordinating firms' assessment of their future prospects in GVCs given technological and competitive pressures.

Handcrafted or hand-made textiles and garments are another feature of Indonesian textiles, notably batiks from Bali, including garments made from batiks. This part of the industry is probably quite resilient to disruptive technology – but garments are made to designs for foreign markets and there may be opportunities to expand the scale of uniquely designed garments by using new communications and manufacturing tech – a combination of service and manufacturing GVCs. Currently this part of the industry is much smaller than large-scale factory production in Java – perhaps 2% in terms of export value. As noted, this is larger than Ethiopia's entire industry.

4.4.2 Electronics

Indonesia has a substantial electronics industry, although it is much smaller than the garments sector in terms of employment and output. Much of it assembles products for sale in the domestic market but there are substantial exports (and imports). Electronics tend to be part of a GVC, even if they are just finishing goods at the end of the chain. Design and manufacturing could be highly affected by disruptive technology.

The electronics industry can be categorised into three segments: consumer electronics, industrial electronics, and components electronics. In Indonesia, the consumer electronics segment is the most developed owing to a large domestic market of 62 million households, while the industrial electronics segment (such as office equipment, telecommunications, and data servers) has been developing due to the expanding telecommunications sector. The components electronics segment (for example, microchips, motherboards, and transistors), which has potential to feed into GVCs, is relatively weak. The electronics sector is dependent on imported components.

Indonesia's electronics industry has quite a long history and it has become more sophisticated and somewhat more outward oriented over time (Aswicahyono, H; Hill, H; Narjoko 2010) The electronics industry in Indonesia started in the 1950s with the establishment of the PT Transistor Radio Thayeb Mfg. Co. as the first producer of Tjawang transistor radios in the economy. In the 1970s, the government encouraged joint ventures between domestic firms and foreign electronics companies in a bid to spur technology transfer. In the 1970s, the electronics sector shifted from assembling imported components to producing components in Indonesia. In the mid-1980s, the introduction of several deregulation measures shifted policy in the electronics industry from import substitution to export-orientation, encouraging the establishment of more electronics firms and IT companies (Andres 2015).

For the electronics industry, the 1997 financial crisis coincided with new competition from China. The crisis, and the resulting decline in household purchasing power, led to the closure of many domestic electronics firms in Indonesia – conversely, electronics exporters recovered quickly after the crisis due to favourable terms of trade (that is, extreme depreciation of the Indonesian Rupiah). However, the electronics parts and components industry found itself unable to compete with China. As domestic demand recovered, there was also a ready supply of cheap imports from China.

Indonesia has not been able to integrate its electronics industry into global production networks in the same way as Malaysia and Thailand have (Andres, 2015), nevertheless Indonesian firms do occupy a niche in GVCs. The industry would be affected by alterations to the pattern in GVCs – changes in production location are affected by taxation arrangements, but could also be affected by technological disruption. Indonesia has highly competitive labour and utilities cost but it does not manufacture high-value components like screens and complicated micro-processors. It makes simpler own-brand products for the domestic market, like rice-cookers. It also assembles higher value products for international companies, which are sold both in Indonesia and in the region (Toshiba, Sony, LG, Panasonic etc.) – these latter are perhaps most vulnerable to technological disruption.

4.4.3 Chemicals and pharmaceuticals

The Indonesian chemical and pharmaceuticals sectors are growing very fast. Between 2010 and 2017, the sector experienced an average annual growth of 6.9% making it the fastest-growing manufacturing sector behind 'food'. The sector now accounts for 1.9% of Indonesian output (Bank of Indonesia 2018). ES data show that, among the formal-private sector, industries tend to be the largest, with 250 employees on average. Chemical firms are also most innovative in terms of R&D spending. In 2015, 14% of firms indicated to have spent on formal R&D in the last three years. This was followed, with some distance, by printing (8%) and machinery (7%), and 9% of chemical firms introduced a new product in the last three years. ES data also suggest very large increases in labour productivity and value added of more than 10% per year between 2009 and 2015. Between the two implementations, chemical firms gained more access to finance, acquired significantly more foreign technology (whereas 4% of firms had foreign technology licenses in 2009, 24% had them in 2015), and became more internationally oriented (the percentage of firms with international quality certifications increased from 6% in 2009 to 22% in 2015).

Chemicals

Growth in the chemical industry is primarily driven by demand from the construction and automotive industries, and an increasing population with rising incomes.

Indonesia itself has abundant raw materials to support the chemical industry, such as its production of certified palm oil and rubber. It is home to a large number of consumer and industrial goods manufacturers in need of chemical products for production purposes (GICC 2016).

The chemicals sector mainly consists of a large number of smaller players, with only a few bigger companies active. Firms are mainly serving the domestic market, although there is plenty of market access within ASEAN.

Despite the abundance of raw materials, Indonesia's industry is integrated into GVCs. During 2015, the imports of chemical products represented 19.18% of overall imports to Indonesia, rising from 15% in 2012. Indonesia experienced 14% outbound average annual total trade growth in the period 2007–2013 and a 38% average growth of imports under HS Codes 29 and 39 in 2010–2014 (valued at US$ 3,256 billion). For example, 90% of the raw materials for the cosmetics industry needs to be imported, comprised mostly of chemical mixtures for cosmetic treatment.

One possible reaction to this, partly reflected in Indonesia's currently policies, is to try and integrate the industry more within Indonesia's borders; to encourage upstream parts of the value chain, such as the agro, oil, gas, and coal-based chemical industries to supply related downstream industries. This will not be easy or quick – the development of that upstream industry is usually capital-intensive (GICC 2016). The government also intends to support the development of oil refineries that could supply petrochemical centres (PMAG 2012). The government recently introduced regulations in order to reduce gas prices for the fertiliser and petrochemicals segments.

Advantages of this policy would be that capability would be built across the industry. Disadvantages could include reducing the value of raw material production, with price controls and directed supply, in order to supply the domestic industry with costly and internationally uncompetitive goods. If those disadvantages are quite marginal, they could be worth it for the built capacity.

Disruptive technological change will impact on the chemicals industry. As with a mine or a modern farm, chemicals works are likely to achieve a step change in efficiency and quality control through intensive monitoring and fine tuning of processes. It is not clear which parts of the value chain will be most affected and when.

Asia, especially ASEAN, is at present the most promising region, with high growth for chemical industries compared to other regions. There has been a significant growth of exports and imports among ASEAN countries, thus many chemical producer's investment plans focus on this region. Certain chemicals, especially those under Harmonised System (HS) Codes 29 and 39, are considered among the top 10 commodities being traded within ASEAN countries, as their total shares reached 5.85% with a total value of US$ 147,84 billion, in 2014 (a 1.25% raise from 2013) (GICC 2016).

The risk with using protection and controls to build an integrated domestic industry is that it is initially uncompetitive and cannot supply the massive ASEAN market. These risks may be exacerbated if there is technological change which makes some part of the domestic value chain even less competitive compared with the 'frontier' in GVCs. As an alternative, or even to complement the chemicals industrial strategy, government could co-ordinate the industry to think about its future niches in GVCs, factoring in technological change. Most likely Indonesia will be most efficient at supplying a mixture of its own market and the wider ASEAN market.

Pharmaceuticals

The Indonesian pharma market is valued at US$6.5 billion (around 0.5% of GDP). The sector recorded 85% growth from 2007 to 2013, with domestic companies holding 70% of the market share compared to the 30% owned by multinationals. The market is predicted to reach US$10.11 billion by 2021 (PEX 2017).

Key market drivers are the introduction of 15 economic policy packages to attract foreign investors, the implementation of Universal Health Coverage scheme (introduced in 2014), the growing urban population and increasing ASEAN regional integration. The universal healthcare scheme aims to provide health insurance to all Indonesians (250m people), a very ambitious target that does not come without budget pressures. Key features to the plan's execution are the development of primary healthcare systems and doctors. Universal healthcare benefits especially local manufacturers, for it raises the demand of generic drugs, whereas the 30% foreign companies tend to focus on more expensive ethical drugs (prescription medicines).

As with chemicals, the industry is integrated into GVCs – as much as 90% of production inputs are imported. As with chemicals, there is some concern that this is unsustainable (GICC 2016), and that there should be greater vertical integration in the domestic industry.

State-owned enterprises in the pharmaceutical industry have considerable market shares, but overall, there is no single company monopolizing the market. Nevertheless, in the prescription drug market and the drug-free sector, it is Kalbe Farma Group that is the top supplier in Indonesia.

The Indonesian pharma market is set for growth, and overseas companies are providing foreign investments that could lead to innovative partnerships with domestic manufacturers in the long term. Such partnerships allow local players to access new technologies and move their businesses towards operating as regional Contract Development and Manufacturing Organisations and give overseas manufacturers the ability to navigate Indonesia's challenging distribution pathways. Co-operation with local drug-makers and distributors and acquisitions proved to be an effective channel to enter the market for foreign companies. There is now more room for foreign investment in the upstream pharmaceutical industry in Indonesia after the government made several revisions to its Negative Investment List.

There is also an opportunity in the local market for exports. During the next two years, domestic players will benefit from the increasing demand for over-the-counter drugs, and also a sharp surge in prescription generic drugs. The market is also expected to become more export oriented. Currently, almost all locally produced pharmaceuticals go to the domestic market. Yet sales to other ASEAN countries become an increasingly interesting proposition for higher-value brands, where the sourcing of raw materials has less impact on total costs. Turning Indonesia into a regional pharmaceutical hub, however, will depend on the provision of supportive regulations and infrastructure.

As with chemicals, there may be a choice between protected integration of the domestic industry and fully exploiting the opportunities of technological change as they arise through GVCs.

4.4.4 Food-processing

Indonesia's production of agricultural products for export is huge. According to the MIT atlas of complexity (MIT 2018), palm oil is the single largest export product, worth US$13.9bn in 2016. Exports of coconut oil were worth US$2.7bn. Indonesia exports more coffee than Tanzania – US$1bn in 2016.

Food processing is in the same value chain as agriculture and fisheries but counts as manufacturing and is bigger and more dynamic than the garment sector. It employs 4.3m people, and is worth about US$70bn, of which nearly US$7bn is exported. In the period, 2000–2017, food processing grew at 8.6% per annum and is now nearly 7% of GDP. ES data suggest that labour productivity in the sector almost doubled between 2009 and 2015, the use of foreign technology licences increased from 2% of firms in 2009 to 8% of firms in 2015, and similarly the prevalence of internationally recognised quality certifications increased from 0% to 6%. It is clear that the combination of Indonesia's 250m population and its robust agriculture and fisheries sector create an almost ideal operating environment for a large food and beverage industry. We pick out food processing for special review because there is room for disruptive technology to have significant impacts and it is a fast-growing industry in Indonesia. It is targeted by industrial policy because of its ability to face the domestic and increasingly export markets, generate productivity gains and jobs (Tijaja and Faisal 2014).

As with other industries in Indonesia there is a lot of variation, which means different parts of the industry face different tech-related opportunities and challenges. For example, 70% of workers are micro-enterprises. These workers might benefit from the kind of co-ordination that digital tech can provide. The growth in employment at about 10–15% yearly is largely the result of growth of micro and small enterprises (Nelson 2008).

Large firms dominate production: 83% of value added, including a few very large companies like Indofood, Garuda and Mayora. The substantial domestic market has been the key driver for the industry, with export offering future potential. Compared to other food exporters like Malaysia and Thailand, where food products have become more internationally competitive, Indonesia's trade policy remains rather protectionist, with many non-tariff barriers to trade in the food sector. Integration into GVCs is less advanced than in Malaysia and Thailand.

ES data revealed the top obstacles to investment in the sector in 2015 were informal competitors (39%), tax rates (21%), and customs and trade regulation (11%). The government lists the food and beverage industry as one of the ten priority industry groups designated for accelerated development in the Master Plan of National Industry Development 2015–35 (MIT 2018).

There is often quite a long value chain which brings food to the consumer. There is scope for disruptive technology to impact on several parts of the chain. Examples of this were provided at the workshop. There are a number of start-ups and platforms to improve the agri-business sector through several measures. As an example, PanenID, RegoPantes, TaniHub, and SayurBox cut out the middle men and connect farmers directly with buyers – both retails and larger markets such as hotel and catering. Some platforms, such as 8Villages and Simbah, help to connect farmers with experts to consult about agriculture techniques. For financial support, platforms such as Crowde, Angon, and Eragano help farmers, who may be largely unbankable, to connect with various types of investors. In agriculture, new, intensive monitoring, processing and possibly mechanisation can make much more precise use of inputs and achieve efficiencies and extreme quality control. One participant in particular highlighted the role self-made drones and other forms of technology can play in monitoring crops. The participant's non-governmental organisation (NGO) has lowered the barrier to accessing technology by providing farmers with the skills to build a basic drone, which they can use to monitor crops and fisheries and make post-disaster risk assessments, as was done with the recent earthquakes in Lombok.

Logistics can move basic or finished foodstuffs efficiently and quickly to achieve low costs and/or very high freshness. However, it was agreed among workshop participants that logistics remains one of the key obstacles in Indonesia. The cost of logistics is extremely high, and it is often being cheaper to import from China than to transport goods within the country.

There are possibilities for merging food processing (classed as manufacture) and food preparation (often classed as service) to deliver (literally) the consumer complete or near-complete meals and to split that value chain in innovative ways.

In actual food processing, there is room for new technology to reduce waste and improve quality control. For example, the US Commercial Service Portland in its 2010 market analysis aims squarely at selling sophisticated equipment to the sector: machinery for filling and closing containers, machinery for packing and wrapping, cutting machines, presses, crushers and sorting machinery. Anticipating the rapid advances in robotics and AI, technologically advanced high-volume food processing machinery has the potential to put large food processing companies at a far greater advantage in the Indonesian market than they already enjoy.

By regional standards, Indonesia still has an undeveloped distribution and retail infrastructure, with a relatively limited reach beyond major towns and cities. This has limited upstream sectoral development (Nelson et al., 2015). Lead firms, such as Indofood and Delfi, have responded by downstream vertical integration of their own distribution networks. The modernisation of retail and distribution will also likely lead to greater competition between local and imported products. Over the long term, modern retail distribution channels are expected to become more efficient as centralised warehousing and distribution centres expand around the country. A more decentralised type of service support may also emerge, given the way disruptive tech can co-ordinate very small firms.

Better policies regulating the diverse market and a higher openness to trade are also likely to increase growth opportunities in the sector. They could also to lead to more competition and job losses in SMEs.

4.4.5 Mining

Like Tanzania, mineral resources constitute a large part of Indonesia's production and exports. But Indonesia is a much larger economy and Indonesia's extractives are diverse and massive – natural gas, the world's biggest producer of tin and nickel, almost as much coal as Australia. Mining continues to grow, although its share of GDP is in long-term decline.

The disruptive technological issues are a combination of automation, automated data generation and high-intensity data processing to generate yield, quality and efficiency gains. This ranges from altering extraction technologies to better management of plant to avoid downtime. (Frey and Osborne 2013) note that mines can be earlier adopters of some automation, for example, automated driving of giant mining trucks in Western Australia, replacing very costly workers. This should have the advantage of raising the use of the trucks as well as the direct savings on wages. There are also innovations in exploration including remote sensing (from space) and more intensive, automated monitoring/observational technologies.

These new technologies expand the possibilities for productivity gains in mining. Sometimes there can be a short-cut assumption that technology choice in mining is trivial – yes it is capital intensive, but its rents derive from the richness of deposits, (mining is extraction rather than production). However, good incentives and conditions for innovation (such as a good supply of skilled engineers, as well as a good ability to for firms to retain gains from innovation) mean there can be very substantial gains in productivity in mining. After all, mining is often very high tech, using engineering and chemistry, and very capital intensive (Maloney, William; Caicedo 2017).

Mining can also be very polluting, and disruptive technologies can be very good at reducing waste and may be able to reduce environmental impact. Blockchain will make it possible to differentiate commodities according to the way they are produced – so that meeting environmental standards can carry reward (PWC 2017). The use of blockchain in mining and in several industries is actively being discussed in Indonesia.

A critical feature of the innovation climate in Indonesian mining seems to be that, since 2009, there has been a hesitant implementation of an industrial development policy that aims to stimulate refinement of minerals within Indonesia, by limiting the export of unrefined ores and substances. This policy was diluted in 2014, and again in 2017, without being abandoned. The mining industry has not responded strongly to the policy – there is uncertainty. And full refinement – for example, of nickel, tin, lead, iron – requires heavy infrastructure investments, including in supporting transport and especially power infrastructure. It is not impossible for Indonesia to host this heavy infrastructure (it's notable that its power generation expansion is based on relatively un-green thermal coal).

This attempt to divert part of the mineral value chain based in regulation and protection could stimulate investment in some sophisticated plant. However, this is not the same as creating a rewarding climate for innovation and productivity increases – instead this is an example of Indonesia's tendency to consider trade-distorting rules and charges an instrument of industrial policy. The fear is that uncertainty around the period in which it is possible to exploit some mines – the ones where further refining is definitely not economic – could be a strong disincentive to further investment, including in tech upgrades.

4.4.6 Digital tech – co-ordinating microenterprises?

Indonesia has a substantial informal and SME sector engaged in non-traded services. Apart from farming, these are among the lowest productivity workers and increasing their productivity would have macroeconomic significance, welfare benefits and also reduce costs and stimulate competitiveness in other parts of the economy. Cheaper food, transport and security services means potentially more competitive manufacturing. Non-traded services are growing fast in Indonesia – perhaps the timing is advantageous, and Indonesia can 'leapfrog' in services (see Section 2).

There are quite immediate possibilities for using the disruptive tech of digital platforms to co-ordinate micro-enterprises for major efficiency gains. This is disruptive because it allows the emergence of efficient, demand-led services without the creation of large, integrated firms to deliver them. In the OECD, there is concern, for example, from trade unions, that a 'gig economy' based on very short-term contracts or co-ordinated self-employment, damages workers' rights compared to long-term, formal employment. However, what is the counterfactual for Indonesia?

If regulation is right, there can be good competition between digital platforms, with suppliers as well as consumers able to switch between services. Essentially, digital platforms should be a great way of co-ordinating micro-enterprises and radically reducing transaction costs and frictions.

Uber is an international example applied to taxis, although in Indonesia it has been replaced by Grab and Go-Jek is also in this market. There is potential in services for consumers and for businesses – for example, consider an app that enables a farmer to respond to market signals and send a relatively small consignment to a distant market by finding space in a truck – for example, 10% of a truck, rather than chartering an entire truck, which is impossibly expensive.

A critical issue for digital platforms is digital readiness: in terms of infrastructure so that the whole population can participate in the efficiencies that digital platforms and communications will allow; in terms of a regulatory system that gives the right protection for intellectual property rights, but also promotes competition and protects standards including on data usage; and in terms of skills and education which are weak in Indonesia compared to its ASEAN peers and much weaker in some parts of Indonesia compared to others.

Some interview respondents suggested that, to ensure inclusive development, it is imperative to improve digital literacy in Indonesia. A large part of the country, such as the rural population or older generation, faces basic issues with digital media. This includes the inability to differentiate facts versus hoax, and to formulate basic keywords for online searches.

Another critical issue is the barriers to entry for innovative start-ups that might provide these platforms.

As mentioned above, there is a strong emphasis on developing digital technology and platforms, however, participants felt strongly that too much emphasis was put on this area. They felt that more emphasis should be on developing innovation for 'hardware' such as agricultural and manufacturing tools.

4.5 Policy stocktake

The Long-Term Development Plan 2005-2025 (RPJPN)[31] is implemented via Medium-Term Development Plans (RPJMN), currently running from 2015 to 2019. The RPJPN acknowledges the urgent need to improve transportation, communication, energy and technology, and focuses on the industrial sector as the main pathway to development.

The 2008 Presidential Regulation on National Industrial Policy sets out a long-term vision for Indonesia to be a strong industrialised nation by 2025. This is complemented by the 2010 Regulation of the Ministry of Industry, which sets the agenda for being a new industrially developed country by 2020. The distinction between these two goals is not entirely clear, and has led to confusion (Tijaja and Faisal 2014). One of the criteria for meeting the latter goal is to have "advanced technology that has been at the forefront of development and market creation". In addition, there are medium-term development plans.

The industrialisation goal is complemented by the vision set forth in the Master Plan for Acceleration and Expansion of Indonesia Economic Development (MP3EI) to become a high-income country by 2025. There are three phases of implementation. The second and current phase, strengthening economic and investment basis 2015–2020, includes strengthening the innovation ability to increase the competitiveness of main economic activities. Phase 3 (2020–2025) includes promoting the adoption of technologies that would support sustainable development. The MP3EI was the first express policy recognition of the contribution of science and technology to economic development (Tijaja and Faisal 2014).

The Ministry of Research, Technology and Higher Education has the following strategic objectives for the period 2015–2019:

1. Improvement of the higher education learning process and student quality
2. Improvement of science and technology institutions and higher education quality
3. Improvement of relevancy, quality and quantity of human resource for higher education and science and technology
4. Improvement on relevancy and productivity of research and development;
5. Strengthen innovation capability.[32]

The strategic objectives of the ministry strongly align with the findings from the key informant interviews and workshops. It was highlighted that the curriculum lags behind the technological changes that are happening in Indonesia and worldwide. This is partly due to the fact that there is no dialogue between education institutions and the private sector.

Among its e-services are a technology business incubator fund, which aims to develop and improve the ability of new innovative entrepreneurs. When speaking to individuals who work in the sector, the general consensus was that these incubators are in short supply and cannot cope with the demand – meaning that innovation is lost, as they are unable to provide adequate funding.

[31] Law No. 17 year 2007

[32] http://international.ristekdikti.go.id/policies-and-programs/

Furthermore, there was a feeling that there is a mismatch in types of degrees and careers. For example, although many young people study engineering, they do not work in engineering, but instead move to finance as it is higher paying. In addition, foreign firms often offer higher salaries, which means that Indonesia also suffers from a 'brain drain' of high-skilled labour. Overall, the respondents suggest that there is incoherence between the supply and demand side of the workforce, caused by producing a good number of workers with certain skills set that are eventually not meeting the qualification in the workforce. Some interviews strongly encourage the need to connect and build good communication between the upstream (education) and downstream (workforce) to avoid further mismatch.

Voeten, Achjar and Utari (2016) found that, although innovation policies were defined and implemented by various ministries, these had not reached the SME owners that they interviewed. No firm that they interviewed received government support for innovation.

Legal and regulatory environment

Recent years have seen steps towards easing regulation for businesses in Jakarta and Surabaya. 2010 saw the introduction of online services for starting a business and legal changes have been implemented since 2010 to strengthen minority investor protections and to increase the ease of contract enforcement. In 2018, capital gains tax was reduced, and online filing and payment of taxes promoted. Start-up fees for limited liability companies were also reduced, as well as transfer tax on registering property (World Bank 2018a). Stakeholders consulted in-country reported that e-government services work well in Jakarta and in cities, due to higher levels of digital skills among citizens. However, there were discrepancies in the quality of online services provided among government agencies.

A 2011 regulation of the Ministry of Industry[33] provides for corporate income tax exemption or reduction for "pioneer industries", which include base metals, oil refinery/basic petrochemicals, machinery, renewable resources and telecommunications equipment. The Ministry of Finance can determine additional pioneer industries, subject to fulfilment of criteria including that the industry introduces new technology and has strategic value add for the national economy. Applications for exemptions or reductions for any pioneer industry need to include details on proposed steps for technology transfer (Tijaja and Faisal 2014).

Indonesia enacted its Competition Law in 1999,[34] and established a Commission for the Supervision of Business Competition (Komisi Pengawas Persaingan Usaha, KPPU) in 2000. In 2010, the OECD deemed that the KPPU had "played an active role in instilling a competition culture among enterprises, government officials and the general public", and that the competition legal and institutional framework had "contributed greatly to a fairer business environment" (OECD 2010).

Indonesia has also made progress with liberalising trade and investment, and has been removing monopoly and monopsony status from state-owned enterprises, although the Competition Law has

[33] Ministry of Industry Regulation No. 93/M-ID/PER/11/2011
[34] Law 5/1999 prohibiting monopolistic practices and unfair business competition

a specific exemption for these enterprises. A weak judicial system undermined early enforcement of the Competition Law, although the KPPU's had a better start at finding against anti-competitive practice than other young jurisdictions (UNCTAD 2009). Indonesia's ranking in the 2017–2018 Global Competitiveness Report was 36 of 137, compared to Malaysia's 23 and Thailand's 32, with Vietnam and the Philippines at 55 and 56 respectively (Schwab 2017b).

A 2003 provision introduced to bolster workers' rights and make hiring more flexible was coupled with a compulsory severance pay of a minimum of 100 weeks. The World Bank (World Bank 2014) argues that this provision is counterproductive – it is onerous and discourages firms from engaging employees via formal, long-term contracts, resulting in 80% of the workforce being without formal arrangements in 2014. In 2011, only 7% of workers received the full severance pay when dismissed – the provision is not achieving its intended outcome (World Bank 2014). SMEs interviewed by Voeten, Achjar and Utari (2016) tended to confirm this practice, and reported avoiding entering into formal employment contracts, with one interviewee stating that the legal requirement for formal contracts is not enforced in practice, and that unions do not intervene. In fact, firms interviewed by Voeten et al. (2016) also reported reluctance on the employee side to enter into formal contracts as well as problems retaining unskilled staff. This may be in part due to poor incentives – accommodation and transport costs to and from the workplace may account around for 35% of wages (Tijaja and Faisal 2014).

In 2017, a long-awaited E-Commerce Road Map for 2017–2019 was launched via Presidential Regulation, aimed at supporting government agencies to promote and accelerate development of e-commerce by measures in eight areas: tax, customer protection, education and human resources, telecommunication infrastructure, logistics, cyber security and the establishment of a coordinating function.

This includes streamlining tax obligations as well as passing regulations on the registration of e-commerce businesses and consumer protection of e-commerce customers. The Road Map is to be delivered via 26 programmes, which include increasing access to credit facilities for micro and small e-commerce businesses (Kredit Usaha Rakyat), education for local e-commerce businesses and local start-up incubators (Assegaf Hamzah & Partners 2017). We were told in consultations in-country, that progress on implementation has stalled since late 2017, possibly due to unclear ownership over the issue, given its cross-cutting nature.

Skills and education

Lack of suitably qualified employees is reported as a constraint to business, with two-thirds of firms complaining that finding appropriate employees for professional and managerial positions is either "difficult" or "very difficult" (World Bank 2014). Firm-provided training is apparently not a popular option compared to regional neighbours, although the Voeten et al. note that, due to a lack of practical skills in graduates from colleges and universities, most companies have to provide additional in-house training (Voeten, Achjar, and Utari 2016). The ADB notes that vocational training for workers is rare, particularly in labour-intensive sectors. Where training is provided, it is concentrated in areas of low value-add. Some respondents suggested that the manufacture industry often disregards whether their employee is graduated from high school or vocational school, as they will provide standardised training.

In the agricultural sector, there are 1,800 schools that provide vocational training across Indonesia. However, the training is outdated. For example, students learn how to milk a cow manually, while the industry uses machinery. Employers therefore need to re-train new recruits.

The Ministry of Manpower provided free competence-based trainings and certifications aimed to produce skilled and ready-to-use workforce to meet the demand from the industry. Currently they have 300 training centres across Indonesia, comprising 17 centres owned by the national government. The rest are distributed in the provincial or district/city level. However, some respondents mentioned the lack of effectiveness of this centre to connect the trainees with the job field or to encourage them to be self-employed.

The Ministry of Trade provides some training, for example, a course on export, but the services provided by government-funded training centres are very limited and often irrelevant to the needs of the industry (Tijaja and Faisal 2014).

Indonesia has made progress in the Programme for International Student Assessment (PISA) tables in recent years, yet still remains around the 25th percentile in both numeracy and literacy tables, well short of the 75th percentile that is sometimes seen as the threshold for global competitiveness. According to one recent estimate, at the current rate of progress, Indonesia will reach that threshold in 2060.[35] Current research[36] indicates that a framework of mechanisms of accountability may be relevant for explaining why significant resource allocation seems not to have brought about improvements in learning outcomes. We were told in consultations in-country that there is a mismatch between education and skills needed for the workplace – this gives rise to a question about whether the youth will be able to absorb technological changes. In addition, although vocational training is being encouraged, it is unclear whether this is translating across into the workforce. Companies are therefore often obliged to re-train employees in-house.

A youth workshop revealed concerns that the current curriculum encourages memorisation, and insufficiently develops analytical skills. This is strengthened by the respondents in the workshop questioning the adequacy of skills owned by students, considering the conventional way to measure their education level is only through their enrolment in school. Some studies suggested that high enrolment does not necessarily translate to good-quality students. There are three elements needed to ensure this good quality of education: students, teachers, and headmasters – and these must be treated integrally.

Exchange learning on high-quality and creative learning needs to be encouraged, especially to teachers and headmasters in remote areas. The intensity of relations between students, teachers, and headmasters should also be improved. Technology can be used to facilitate this issue by using apps such as Quipper to enable the intensive communications, or by recording good teaching methods and distributing the video through simple social media such as YouTube and WhatsApp. This will help reduce the disparity of quality, especially in the remote areas.

35 www.smeru.or.id/sites/default/files/publication/whiteelephant.pdf

36 www.riseprogramme.org/countries/indonesia/overview

Access to finance

Despite major efforts to improve the banking sector in the early 2000s (OECD 2010), access to finance is thought to be a constraint to innovation in Indonesia (World Bank 2014), although it was not picked out strongly in field discussions. To some extent, this is due to the terms of accessing finance – high interest rates and complex paperwork decrease the attractiveness of loan finance (Voeten, Achjar, and Utari 2016). In addition, financial behaviour has tended to be risk-aversive (World Bank 2014), and religious beliefs prevent some companies from paying interest on credit (Voeten, Achjar, and Utari 2016). This means that investment decisions are largely dependent on current cash flow. As young firms are unlikely to have this in the first years of operation, this is a constraint to innovation. SMEs may use savings or informal loans (for example, from family members) to make investments, and generally tie investments to the receipt of large orders. For SMEs, the government is addressing lack of access to finance through a funding facility which guarantees loans by banks to SMEs through an allocated budget for SME development (Voeten, Achjar, and Utari 2016). In addition, as noted above, a new facility for e-commerce businesses has been launched under the E-Commerce Road Map. There have also been recent improvements in the regulatory environment, with the 2017 establishment of a modern collateral agency, and in 2018 a new credit bureau has improved access to credit information (World Bank 2018a).

Enterprise Survey evidence suggests that the use of bank financing for investments has improved over the period 2009–15. In 2009, 6% of all investments were financed by banks; by 2015 this percentage had grown to 13%, slightly higher than the average for LMICs (12%). Even more striking is the improvement in the percentage of firms using banks to finance investments, which tripled between 2009 and 2015 from 12% to 37%, and comfortably surpassed the average for LMICs (22%) (World Bank Group 2015). Financial access remains significantly greater for larger firms with more than 100 employees, but has improved by about 14% annually since 2009 (annualised growth rate of financial access index, see also Figure 9). Furthermore, in 2015 around 27% of firms had a loan or a line of credit from a bank, and 60% had a checking or savings account, which, however, still falls short of the East Asia average of 85%.

4.6 Outcome of stakeholder consultations

The Oxford Policy Management team conducted a series of key informant interviews and focus group discussions over one week in Jakarta. Findings of these consultations are incorporated throughout the report. We have briefly summarised the final workshop and the youth focus group discussion below.

Final workshop

The Indonesia workshop was co-hosted with the Ministry of Finance and aimed to elicit ideas, reflections and experiences on how Indonesia can seize the opportunities from rapid technological change and mitigate the challenges with effective public policies. The workshop was attended by 72 participants, comprising 16 non-governmental organizations (including NGOs, academicians), two private sectors/companies, and 12 government institutions.

The workshop was opened by Professor Benno Ndulu as Research Co-Director of the Pathways for Prosperity Commission, with a brief introduction and background on the work of the commission. Subsequently, the Minister of Finance, Sri Mulyani Indrawati highlighted the importance of this topic for inclusive economic growth and outlined some key areas of further discussion. Dr Mark Henstridge, Oxford Policy Management's Chief Economist then presented a summary of findings and highlighted distinct features of Indonesia's growth, which resulted in a lively discussion around further areas of research and aspirations of the study.

Following this, participants were divided into three breakout groups: (i) Technology for the Economy: Manufacturing, Natural Resources & Energy, Mining and Agriculture; (ii) Technology in Public Policies; and (iii) Technology for inclusive growth: Education and Social Protection.

Key insights from the workshop include:

- Technological capacity alone is not enough to guarantee success. We need to enable a conducive social, political, and economic environment.

- To understand the challenges of technological change in employment, we have to look at the growth engine and economy as a whole. The technology needs to be adapted to the country, not the country to the technology.

- Capturing opportunities of technology is possible with appropriate business models and policies. Successful technology should enable pathways for inclusive growth, and this must include the involvement of private sector, government and civil society to create a national ecosystem for success.

Youth focus group discussion

In Indonesia, six youth representatives participated in the discussion, including representatives from NGOs that work with disadvantaged youth, researchers and lecturers working at universities, as well as young people who have just entered the job market. The discussion was lively and centred around how technological advancements impact on youth as job-seekers and entrepreneurs, especially as this can have a varying effects, depending on geography and income. Key findings include:

1. One participant highlighted that rural Indonesia is in Industrialisation 2.0, Jakarta in 4.0. Therefore a lot needs to be done to level the playing field. Urban youth have a clear advantage in adopting technology and entering the job market.
2. Levels of education between male and female youth are similar in terms of enrolment and graduation, however, this drastically changes when entering the job market. There are more males seeking employment, especially related to technology.
3. Mismatch in skills – there is a big gap between education and skills required in industry, which has led many companies to develop their own training centres. Curricula needs to be more in line with industry needs, to ensure that young people are prepared for the job market.

4.7 Conclusion

Indonesia became high-trading in the wake of the 1997 financial crisis and still has a good amount of foreign trade for such a large and diverse economy. However, it also retains a volume of protective trade barriers and other interventions. Natural resource industries, including mining and agriculture, can take advantage of coming disruptive technologies to improve efficiency as long as the investment incentives are right. Many of Indonesia's manufacturing industries are a mixture of innovative, internationally competitive firms alongside less-innovative, domestic-facing producers which seem insulated from foreign competition and GVCs. It seems to be difficult to set up a new business and there is a shortage of small, innovative, fast-growing enterprises – this is a problem for innovation.

This case study is not exhaustive, but it seems that several of Indonesia's industries are integrated into GVCs which are likely to alter because of disruptive technology, including garments, electronics and food. Some of the domestic-facing parts of these industries are more exposed to GVCs and changes than they may realise. Parts of the same industries are also under pressure from low labour cost competitors. Export-oriented and domestic-facing industries face a choice about how to invest and upgrade in order to meet coming challenges and take advantage of coming opportunities. The Government of Indonesia does have an active industrial policy – it could play a useful role in co-ordinating firms to think through future challenges related to disruptive technology. However, translation of the policy into practice remains a challenge, with the president requesting cabinet to design what industrial 4.0 would look like for different sectors.

References

Abramovitz, Moses. 1986. "Catching Up, Forging Ahead, and Falling Behind." Journal of Economic History XLVI.

Acemoglu, Daron, and Pascual Restrepo. 2017. "Robots and Jobs: Evidence from US Labor Markets." SSRN Electronic Journal. https://www.ssrn.com/abstract=2940245.

Aghion, P., and P. Howitt. 1994. "Growth and Unemployment." The Review of Economic Studies 61(3): 477–94. https://academic.oup.com/restud/article-lookup/doi/10.2307/2297900.

Allen, Robert. 2016. EDI - Pathfinding Papers Technological Change, Marxist Contradictions and Institutional Revolutions: A Historical Perspective. https://edi.opml.co.uk/research-cat/path-finding-papers/.

Andreoni, Antonio. 2013. "Manufacturing Development Structural Change and Production Capabilities Dynamics." Cambridge University.

---. 2014. "Structural Learning: Embedding Discoveries and the Dynamics of Production." Structural Change and Economic Dynamics 29: 58–74. http://dx.doi.org/10.1016/j.strueco.2013.09.003.

Andres, Emmanuel. 2015. "Manufacturing of Consumer Electronic Appliances in Indonesia." In Services in Global Value Chains, ed. Gloria Low, patrick; Pasadilla.

Arntz, Melanie, Terry Gregory, and Ulrich Zierahn. 2016. "The Risk of Automation for Jobs in OECD Countries: A Comparative Analysis." OECD Social, Employment and Migration Working Papers 2(189): 47–54. https://ideas.repec.org/p/wbk/wbrwps/7487.html.

Asian Development Bank. 2018. Asian Development Outlook 2018 - Technology and Jobs. https://www.adb.org/publications/asian-development-outlook-2018-how-technology-affects-jobs.

Assegaf Hamzah & Partners. 2017. "Indonesia E-Commerce Road Map." (3): 1–6.

Aswicahyono, H; Hill, H; Narjoko, D. 2010. "Industrialisation after a Deep Economic Crisis: Indonesia." The Journal of Development Studies 46(6).

Autor, David H. 2015. "Why Are There Still So Many Jobs? The History and Future of Workplace Automation." Journal of Economic Perspectives 29(3): 3–30. http://pubs.aeaweb.org/doi/10.1257/jep.29.3.3.

Autor, David H., and David Dorn. 2013. "The Growth of Low-Skill Service Jobs and the Polarization of the US Labor Market." American Economic Review 103(5): 1553–97.

Autor, David H., David Dorn, and Gordon H. Hanson. 2015. "Untangling Trade and Technology: Evidence from Local Labour Markets." Economic Journal 125(584).

Autor, David H., F. Levy, and R. J. Murnane. 2003. "The Skill Content of Recent Technological Change: An Empirical Exploration." Quarterly Journal of Economics 118(4).

Backer, Koen De, and Dorothée Flaig. 2017. "The Future of Global Value Chains: Business as Usual or 'a New Normal'?" OECD Science, Technology and Industry Policy Papers (41): 58. http://www.oecd-ilibrary.org/science-and-technology/the-future-of-global-value-chains_d8da8760-en.

Baldwin, Richard. 2016. The Great Convergence: Information Technology and the New Globalization. Harvard: Harvard University Press.

Banga, Karishma, and Dirk te Velde. 2018. Digitalisation and the Future of Manufacturing in Africa. https://set.odi.org/wp-content/uploads/2018/03/SET_Future-of-manufacturing_Brief_Final.pdf.

Bank of Indonesia. 2018. "GDP by Industrial Origin at 2000 Constant Prices."

Barro, Robert. 2012. "Convergence and Modernization Ervisited." NBER Working Paper Series (18295).

Behrendt, C., and Q. A. Nguyen. 2018. "Innovative Approaches for Ensuring Universal Social Protection for the Future of Work." ILO: Future of Work.

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

Cabral, R., J. Mayorga, and M. Clemence. 2018. "Rapid and Lasting Gains from Solving Illegal Fishing." Nature Ecology and Evolution 2: 650–58.

Castro, Simone di, and Lara Gidvani. 2014. "Enabling Mobile Money Policies in Tanzania." Gsma (February): 1–13. http://www.gsma.com/mobilefordevelopment/wp-content/uploads/2014/03/Tanzania-Enabling-Mobile-Money-Policies.pdf.

Chang, Ha-Joon, and Antonio Andreoni. 2016. "Industrial Policy in a Changing World." Cambridge Journal of Economics Special Issue.

Chang, Jae-Hee, Gary Rynhart, and Phu Huynh. 2016. ASEAN in Transformation: How Technology Is Changing Jobs and Enterprises. http://www.ilo.org/public/english/dialogue/actemp/downloads/publications/2016/asean_in_transf_2016_r1_techn.pdf.

Cimoli, Mario. 2018. "Industrial Policy in an Hyper-Connected World." In DIE - Industrial Revolution 4.0

Cimoli, Mario, Giovanni Dosi, Richard Nelson, and Joseph E. Stiglitz. 2010. "Institutions and Policies Shaping Industrial Development: An Introductory Note." In Industrial Policy and Development: The Political Economy of Capabilities Accumulation.

Comin, Diego, and Bart Hobijn. 2008. "An Exploration of Technology Diffusion." The American Economic Review 100(1997): 1–49. http://www.nber.org/papers/w12314.

Cummings, Jeffrey. 2003. Enhancing development effectiveness through excellence and independence in evaluation Knowledge Sharing: A Review of the Literature. http://www.emeraldinsight.com/Insight/viewContentItem.do?contentType=Article&contentId=863981.

Dauth, Wolfgang, Sebastian Findeleisen, Jens Südekrum, and Nicole Wößner. 2017. "Industrial Robots on Workers." : 57. http://doku.iab.de/discussionpapers/2017/dp3017.pdf.

Deichmann, Uwe, Aparajita Goyal, and Deepak Mishra. 2016. "Will Digital Technologies Transform Agriculture in Developing Countries?" Agricultural Economics 47(S1): 21–33. http://dx.doi.org/10.1111/agec.12300.

Diao, Xinshen, Margaret McMillan, and Dani Rodrik. 2017. The Recent Growth Boom in Developing Economies: A Structural-Change Perspective. http://www.nber.org/papers/w23132.

Eurofound. 2018. Game Changing Technologies: Exploring the Impact on Production Processes and Work Future of Manufacturing. https://www.eurofound.europa.eu/sites/default/files/ef_publication/field_ef_document/fomeef18001en.pdf.

Frey, Carl B., and Michael A. Osborne. 2013. "The Future of Employment: How Susceptible Are Jobs To Computerisation?" : 1–72. https://www.oxfordmartin.ox.ac.uk/downloads/academic/The_Future_of_Employment.pdf.

Frey, Carl B., Michael A. Osborne, and Craig Holmes. 2016. Citi GPS Technology at Work v2.0: The Future Is Not What It Used to Be. https://www.oxfordmartin.ox.ac.uk/downloads/reports/Citi_GPS_Technology_Work_2.pdf.

Galbraith, J.K. 2014. The End of Normal: The Great Crisis and the Future of Growth. New York: Simon and Schuster.

GICC. 2016. Chemical Industry.

Gordon, Robert J. 2004. Productivity Growth, Inflation, and Unemployment: The Collected Essays of Robert J. Gordon Productivity Growth, Inflation, and Unemployment: The Collected Essays of Robert J. Gordon. Cambridge: CUP.

Groningen. 2018. "10-Sector Database."

Hallward-Driemeier, Mary, and Gaurav Nayyar. 2018. Trouble in the Making: The Future of Manufacturing-Led Development. Washington DC.

Hausmann, Ricardo. 2008. Final Recommendations of the International Panel on ASGISA. https://www.hks.harvard.edu/sites/default/files/centers/cid/files/publications/faculty-working-papers/161.pdf.

Hausmann, Ricardo, Bailey Klinger, and Rodrigo Wagner. 2008. "Doing Growth Diagnostics in Practice: A 'mindbook.'" Center for International Development (177).

Hornstein, Andreas et al. 2005. "The Effects of Technical Change on Labor Market." NBER Macroeconomics Annual 2009, Volume 24: 1–130. http://www.econ.nyu.edu/user/violante/Books/GrowthHB_final.pdf.

IGC. 2014. IGC Evidence Paper Evidence Paper: Firm Capabilities and Economic Growth. https://www.theigc.org/wp-content/uploads/2014/09/IGCEvidencePaperFirms.pdf.

ILO. 2017. World Social Protection Report 2017-2019: Universal Social Protection to Achieve the Sustainable Development Goals. Geneva.

Jack, William, and Tavneet Suri. 2011. "Mobile Money: The Economics of M-PESA." NBER Working Paper Series (16721). http://www.nber.org/papers/w12314.

Kale, Yemi; Doguwa, Sani. 2015. "On the Compilation of Labour Force Statistics for Nigeria." CBN Journal of Applied Statistics 6(1(a)): 183–98.

Khan, Mushtaq. 2013. "Technology Policies and Learning with Imperfect Governance." In The Industrial Policy Revolution I, eds. Joseph Stiglitz and Justin Lin. Basingstoke: Palgrave, 79–115.

---. 2015a. "Industrial Policy Design and Implementation Challenges." In Development and Modern Industrial Policy in Practice: Issues and Country Experiences, ed. Jesus Felipe. Cheltenham: Edward Elgar, 94–126.

---. 2015b. "The Role of Industrial Policy : Lessons from Asia." New Perspectives on Industrial Policy for a Modern Britain: 79–98.

Kozul-Wright, Richard, Diana Barrowclough, Stephanie Blankenburg, and David Bicchetti. 2017. UNCTAD: Trade and Development Report. http://unctad.org/en/PublicationsLibrary/tdr2017_en.pdf.

Lall, Sanjaya. 1992. "Technological Capabilities and Industrialisation." World Development 20(2): 165–86.

---. 1998. Competitiveness, Technology and Skills. Cheltenham: Edward Elgar.

---. 2000. QEH Working Paper Series Skills , Competitiveness and Policy in Developing Countries.

Levy, F., and R. J. Murnane. 2004. The New Division of Labour: How Computers Are Creating the Next Job Market. Princeton University Press.

Lipsey, Richard, and Ken Carlaw. 2000. "What Does Total Factor Productivity Measure?" International Productivity Monitor 0(1)(604): 31–40.

Lundvall, Bengt-Åke. 1997. "The Globalising Learning Economy: Implications for Innovation Policy." European Commission, Luxembourg (December): 2–175. http://scholar.google.com/scholar?hl=en&btnG=Search&q=intitle:The+globalising+learning+economy:+Implications+for+innovation+policy#8%5Cnhttp://scholar.google.com/scholar?hl=en&btnG=Search&q=intitle:The+globalising+learning+economy:+implications+for+innova.

---. 2007. Innovation System Research: Where It Came from and Where It Might Go. http://www.globelicsacademy.org/2011_pdf/Lundvall_(post scriptum).pdf.

Maloney, William; Caicedo, Felipe Valencia. 2017. Engineering Growth: Innovative Capacity and Development in the Americas. CESifo WP Series 6339.

Maloney, William F., and Carlos Molina. 2016. "Are Automation and Trade Polarizing Developing Country Labor Markets, Too?" (December). http://elibrary.worldbank.org/doi/book/10.1596/1813-9450-7922.

Manyika, J. et al. 2013. “Disruptive Technologies: Advances That Will Transform Life, Business, and the Global Economy.” Mckinsey Global Institute.

---. 2017. “A Future That Works: Automation, Employment, and Productivity.” Mckinsey Global Institute (January): 148. http://njit2.mrooms.net/pluginfile.php/688844/mod_resource/content/1/Executive Summary of McKinsey Report on Automation.pdf.

McMillan, Margaret, Dani Rodrik, and Íñigo Verduzco-Gallo. 2014. “Globalization, Structural Change, and Productivity Growth, with an Update on Africa.” World Development 63.

MIT. 2018. “The Observatory of Economic Complexity.” 2018.

Mitchell, Tom, and Erik Brynjolfsson. 2017. “Track How Technology Is Transforming Work.” Nature 544(7650): 290–92.

Mokyr, Joel, Chris Vickers, and Nicolas L. Ziebarth. 2015. “The History of Technological Anxiety and the Future of Economic Growth: Is This Time Different?” Journal of Economic Perspectives 29(3).

Molony, Thomas. 2008. “Running out of Credit: The Limitations of Mobile Telephony in a Tanzanian Agricultural Marketing System.” Journal of Modern African Studies 46(4): 637–58.

Nelson, Richard R. 2008. “Economic Development from the Perspective of Evolutionary Economic Theory.” Oxford Development Studies 36(1): 9–21. http://www.tandfonline.com/doi/abs/10.1080/13600810701848037.

Norton, Andrew. 2017. “Automation and Inequality. The Changing World of Work in the Global South.” (August): 1–18.

OECD. 2010. OECD Investment Policy Reviews Indonesia 2010.

Oxford Policy Management (OPM), and S. Haldrup. 2018. What Makes Technological Innovation Work?

Page, John. 2009. “The East Asian Miracle: Four Lessons for Development Policy.” NBER Macroeconomics Annual 2009, Volume 24.

PEX. 2017. “Indonesian Pharma Market Value $10.11 Billion by 2021.” Pharmaceutical Executive.

Piketty, Thomas; 2014. Cambridge: Harvard Uni Capital in the 21st Century. http://piketty.pse.ens.fr/files/Piketty2014Capital21c.pdf.

PMAG. 2012. “Indonesia to Invest Heavily in Petrochemical Industry - Processing Magazine.” Processing Magazine.

PWC. 2017. We Need to Talk About the Future of Mining.

Robinson, James, and Daron Acemoglu. 2012. Why Nations Fail. London: Profile.

Romer, Paul M. 1986. “Increasing Returns and Long Run Growth.pdf.” Journal of Political Economy 94(5): 1002–37.

---. 1987. "Growth Based on Increasing Returns Due to Specialization." The American Economic Review 77(2): 56–62.

---. 1990. "Endogenous Technological Change." Journal of Political Economy 98(5): S71–102.

Schlogl, Lukas, and Andy Sumner. 2018. "The Rise of the Robot Reserve Army : Economic Development , Work , and Wages in Developing Countries Working Paper 487 July 2018." (July): 41. https://www.cgdev.org/sites/default/files/rise-robot-reserve-army-automation-and-future-economic-development.pdf.

Schwab, Klaus. 2017a. Insight Report. http://www3.weforum.org/docs/GCR2017-2018/05FullReport/TheGlobalCompetitivenessReport2017–2018.pdf.

---. 2017b. The Global Competitiveness Report 2017-2018. World Economic Forum.

Siegel, Christian, and Zsofia Barany. 2015. Job Polarization and Structural Change. https://pubs.aeaweb.org/doi/pdfplus/10.1257/mac.20150258.

Solow, Robert. 1987. "We'd Better Watch out." New York Times Book Review: 36.

Sutton, John. 2005. Competing in Capabilities: An Informal Overview. http://personal.lse.ac.uk/sutton/competing_capabilities_informal_washington.pdf.

Tijaja, Julia, and Mohammad Faisal. 2014. "Industrial Policy in Indonesia: A Global Value Chain Perspective." Asian Development Bank Economics Working Paper Series (411).

UNCTAD. 2009. "Voluntary Peer Review on Competition Policy: Indonesia."

UNIDO. 2016. Industrial Development Report 2016: The Role of Technology and Innovation in Inclusive and Sustainable Industrial Development.

United Nations. 2014. "Transfer of Technology and Knowledge Sharing for Development Science, Technology and Innovation Issues for Developing Countries." United Nations Conference on Trade and Development: 71. UNCTAD/DTL/STICT/2013/8.

Voeten, Jaap, Nuzul Achjar, and Karina Utari. 2016. Qualitative Study on Innovation in Manufacturing Small and Medium- Sized Enterprises (SMEs) in Indonesia Exploration of Policy and Research Issues.

Voeten, Jaap, Stephen Kirama, and Slavatory Macha. 2016. Qualitative Study on Innovation in Manufacturing Small and Medium- Sized Enterprises (SMEs) in Tanzania Exploration of Policy and Research Issues.

Wood, Adrian. 2017. WIDER Working Paper 2017 / 34 Variation in Structural Change around the World , Patterns , Causes , and Implications Adrian Wood.

World Bank. 2012. Picking Up the Pace: Reviving Growth in Indonesia's Manufacturing Sector. Jakarta.

---. 2014. Indonesia: Avoiding the Trap. Development Policy Review.

---. 2016. World Development Report: Digital Dividends.

---. 2018a. “Business Reforms in Indonesia - Doing Business.” : 1–2.

---. 2018b. WDR The Changing Nature of Work: WDR 2019 Working Paper.

---. 2018c. “World Development Indicators.”

WTO. 2013. Trade Policy Review, Indonesia.

Yusuf, Shahid. 2017. Center for Global Development - Working Paper Automation, AI, and the Emerging Economies. https://www.cgdev.org/publication/automation-ai-and-emerging-economies?utm_source=170919&utm_medium=cgd_email&utm_campaign=cgd_weekly&utm_&&&.

Zanello, Giacomo, Xiolan Fu, Pierre Mohnen, and Marc Ventresca. 2016. “The Creation and Diffusion of Innovation in Developing Countries: A Systematic Literature Review.” Journal of Economic Surveys 30(5): 884–912.

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