EVIDENCE REPORT
No 207

Digital and Technology

The Impact of Digital Technology on Economic Growth and Productivity, and its Implications for Employment and Equality: An Evidence Review

Kevin Hernandez, Becky Faith, Pedro Prieto Martín and Ben Ramalingam

November 2016

The IDS programme on Strengthening Evidence-based Policy works across seven key themes. Each theme works with partner institutions to co-construct policy-relevant knowledge and engage in policy-influencing processes. This material has been developed under the Digital and Technology theme.

The material has been funded by UK aid from the UK Government, however the views expressed do not necessarily reflect the UK Government's official policies.

AG Level 2 Output ID: 712

THE IMPACT OF DIGITAL TECHNOLOGY ON ECONOMIC GROWTH AND PRODUCTIVITY, AND ITS IMPLICATIONS FOR EMPLOYMENT AND EQUALITY: AN EVIDENCE REVIEW

Kevin Hernandez, Becky Faith, Pedro Prieto Martín and Ben Ramalingam

November 2016

First published by the Institute of Development Studies in November 2016

IDS is a charitable company limited by guarantee and registered in England (No. 877338).

Contents

Boxes

Figures

Tables

Abbreviations

CPU	central processing unit
FDI	foreign direct investment
GDP	gross domestic product
GNI	gross national income
GPT	General Purpose Technology
ICT	information communication technology
IMF	International Monetary Fund
IR	industrial revolution
MIS	Market Information Systems
M4P	Markets for the Poor
OECD	Organisation for Economic Co-operation and Development
OO	Online Outsourcing
pp	percentage point
SME	small and medium enterprise
TFP	Total Factor Productivity

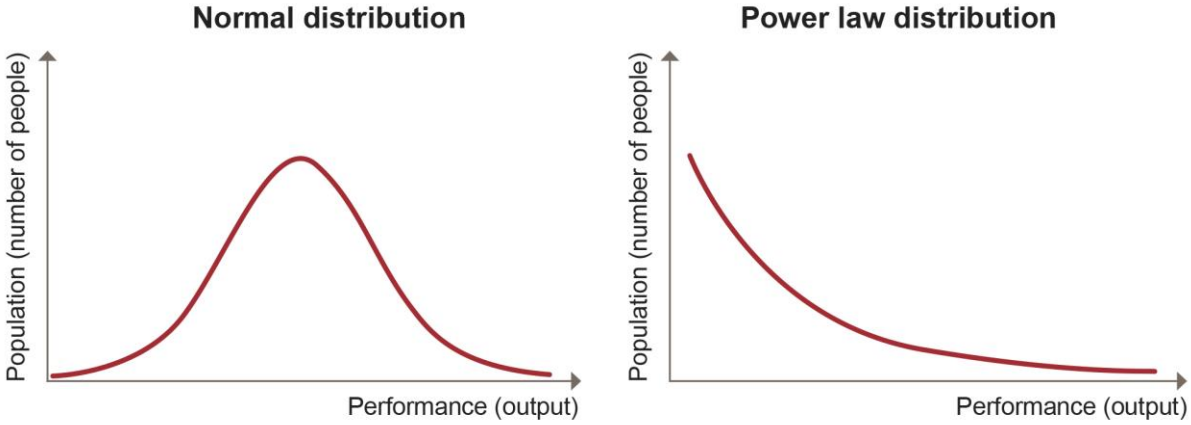
1 Introduction

Venture capitalist Marc Andreessen proclaimed in 2011 that 'software is eating the world', suggesting that economic and technological developments would see software companies poised to take over large swathes of the economy (Andreessen 2011). Digital technology [software] is capable of eating the world because of both its utility and its pervasiveness. Indeed, digital technology has been classified as a General Purpose Technology (GPT) due to its implications not just for the economy, but for all aspects of life (Brynjolfsson and McAfee 2014). According to Bresnahan and Trajtenberg (1995), GPTs have three key characteristics: (i) they must be 'pervasive' meaning they affect almost all sectors; (ii) they improve over time and thus lower the costs for users; (iii) they must facilitate innovation by making it easier to create and make novel products and/or processes. Digital technology is currently used in just about every sector in developed countries and increasingly in developing countries, the cost of personal computers has dropped from thousands of dollars a few years ago to a couple of hundred dollars, and even the smallest devices today have more processing power and memory than the most powerful supercomputers of the mid-twentieth century. Furthermore, digital technology has enabled the introduction of new products and services such as 3-D printing, artificial intelligence, driverless cars, cloud computing and the Internet of Things.

As digital technology has begun to 'eat the world' it has also influenced the way that humans interact and transact with each other. Thus, it has inevitably had an effect on global, regional, national and local economies. This Evidence Report reviews the literature assessing the economic impact of digital technologies – namely information communication technology (ICT) – on economies and people. In terms of the economic effects of digital technology on economies, this literature review summarises its relationship with economic growth and productivity. Although increases in ICT infrastructure/equipment investment and increased ICT adoption tend to be strongly correlated with economic growth and productivity, causality is yet to be resolved, and the potential for endogenous, simultaneous and reverse causality remains. In other words, there is still the possibility that the economic impacts of the internet are caused by a third variable, that the economic impacts lead to internet adaption at the same time that internet adaption leads to economic impacts, and that it is economic growth that causes internet adaption rather than vice versa. Furthermore, the correlations tend to be highly heterogeneous – different across space and time – suggesting that the relationship is not always given.

This review also summarises the literature concerning the effects of digital technology on employment and inequality. Although there is anecdotal evidence that ICTs have created more jobs than they have displaced, most scholars agree that digital technologies will mostly displace jobs in the short and medium term as digital technology continues to eat the world. Furthermore, the technological change accelerated by digital technology tends to be skill-biased, allowing workers capable of leveraging digital technologies to demand higher wages while decreasing the demand for workers unable to leverage technology. This leads to a decrease in their wages and to a hollowing out of the middle class, a decoupling of productivity and wages, and a move from a normal income distribution curve (in which the 'average person' is at the middle of the distribution and the amount of people continue to drop precipitously as you move away from the average towards either tail of the curve) to a power-law or Pareto income distribution curve in which the majority of the population are at the lower end of the income distribution as seen below (Brynjolfsson and McAfee 2014).

Figure 1.1 Normal and power-law income distribution curves



Source: Adapted from Brynjolfsson and McAfee (2014).

Although most of the aforementioned trends were first uncovered and felt in developed countries, the evidence now points to the emergence of similar trends in many developing countries. This Evidence Report consists of six sections. This introduction is followed by a synthesis of the evidence and debates in the literature concerning the impact of digital technologies on economic growth, productivity, employment and inequality in Sections 2 through 5 respectively. The sixth section concludes the report with a summary of the evidence and debates as well as some recommendations for researchers and policymakers.

2 Economic growth

2.1 Correlations between communication technologies and economic growth

Rather than being a set thing, *digital* is an adjective 'describing an increasing information intensity and connectedness of physical resources' (Accenture 2013). Due to its ubiquity and diversity, it is impossible to capture the impact of digital technology as a whole on economic growth. Instead, the term 'digital technology' is typically used interchangeably with 'ICT Investment' and different sets of ICTs such as computers, the internet or mobile phones. Thus, studies are typically limited to the impacts of one or a few instruments of digital technology rather than digital technology as a whole. ICTs are often touted as engines of growth. This chapter reviews the evidence behind such claims.

Early aggregate studies of the impact of the internet on economic growth such as Koutroumpis (2009) and Czernich *et al.* (2009) focused mainly on the European Union/United States, and OECD countries. These studies found that a 10 per cent increase in internet penetration correlates with a 0.9–1.5 and a 0.3–0.9 percentage point (pp) in gross domestic product (GDP) growth respectively. Other than Garcia Zaballos and Lopez-Rivas (2012), who found that broadband correlates with a 3.2 per cent increase in GDP in 26 Latin American countries, much less work has been done with sets of developing countries (Minges 2015). However, there are some studies that look at the impact of the internet and other ICTs at a global level while classifying countries into different economic development levels.

A study by Qiang *et al.* (2009)[1] has been widely cited as showing the impacts of ICT on economic growth (Dalberg 2013b; World Bank 2016; McKinsey Global Institute (MGI) 2014; Deloitte 2014; Minges 2015; among others). It showed that a 10pp increase in broadband penetration correlates with GDP growth of 1.38pp. Some studies mention this figure – 1.38pp – as proof that various types of digital technology lead to growth. However, attributing the same effects to all kinds of internet connections is misleading. The study shows that fixed telephony, mobile telephony, [dial-up] internet, and broadband all have different effects on economic growth in ascending order (Qiang *et al.* 2009). Similarly, in a study of 107 countries (although not categorised by income level) Vu (2011) finds that personal computers, mobile phones and the internet all have positive effects on economic growth in ascending order. Katz and Callorda (2013) found that broadband penetration led to an average annual increase in income of 3.67 per cent respectively overall in Ecuador, but that the gains were higher for computer and internet users at 3.92 and 5.01 per cent respectively. The discrepancy between mobile, dial-up and broadband may be partially explained by the fact that broadband users spend 64 per cent more time browsing the web and use it for more content-intensive and socially interactive purposes (Qiang *et al.* 2009).

[1] Often cited under World Bank rather than Qiang *et al.*

Table 2.1 Correlations with GDP growth for every 10pp increase in internet penetration

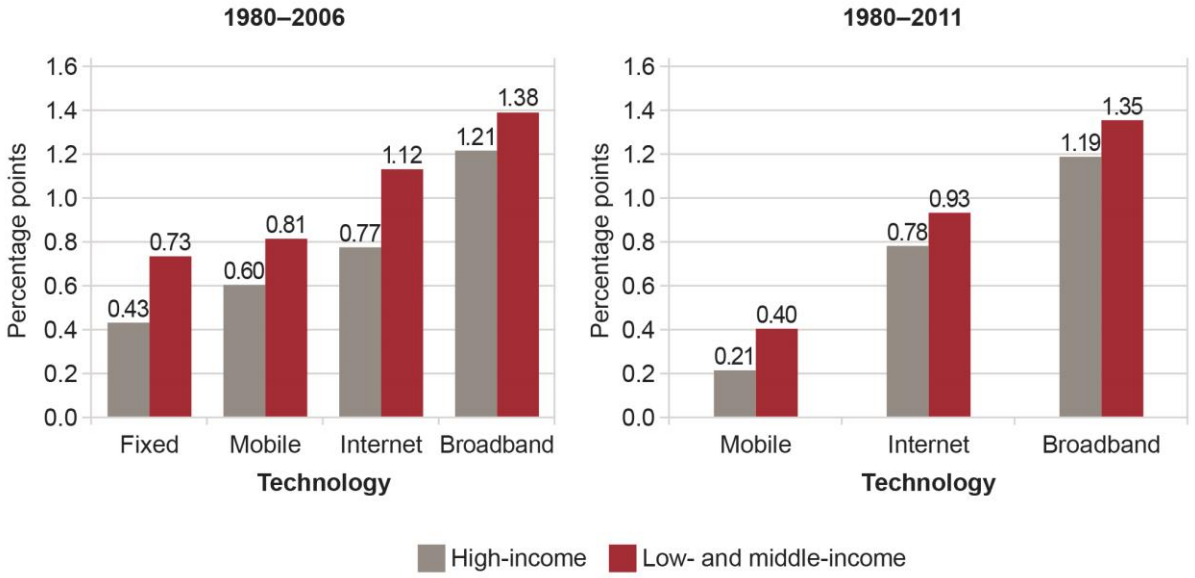
Study	Country/Region	Years	Correlation with GDP growth
Koutrompis (2009)	22 OECD countries	2002–2007	0.9–1.5pp
Czernich *et al.* (2009)	25 OECD countries	1996–2007	0.3–0.9pp
Garcia Zaballos and Lopez-Rivas (2012)	26 Latin American and Caribbean countries	2003–2009	3.2pp
Qiang *et al.* (2009)	120 countries Developed countries Developing countries	 1980–2006 1980–2006	 1.21pp 1.38pp
Scott (2012)	120 countries Developed countries Developing countries	 1980–2011 1980–2011	 1.19pp 1.35pp

Source: Author's own, based on Minges (2015)

Qiang *et al.* (2009: 45) found that an increase in national broadband penetration rate of 10pp would lead to a 1.21pp and 1.38pp increase in GDP per capita growth in developed and developing countries respectively. However, the broadband and internet results were less statistically significant in developing countries because of lower uptake levels. Much has changed since 2006 – the last year in their data. Broadband is now approaching ubiquity in many developed countries and internet adoption has tripled in developing countries since 2005 (World Bank 2016). Faster broadband technologies have been developed while most new internet users in developing countries are getting their first and only tastes of the internet via mobile phones. In 2006, 3G mobile internet was still an emerging technology. Today, 4G mobile broadband is already commonplace in many markets and 5G is already in the pipeline – its speeds are expected to dwarf anything around today (CNET 2015).

There is a lack of current studies measuring the effects of different speeds of ICTs as well as switching from older technologies to newer ones. These studies may need to be updated periodically to keep up with advancements in communication technology and speed. One such attempt was made when Qiang *et al.*'s study was replicated by Scott (2012) to include five extra years of data. The study seemed to confirm Qiang *et al.*'s finding about the returns to broadband and the literature often makes note of this (World Economic Forum 2015). However, although the extra five years yielded a very similar correlation between broadband and economic growth – 1.38pp and 1.35pp respectively – in developing countries, there were significant decreases in the effect of mobile and low bandwidth internet to economic growth – from 1.12pp to 0.93pp and 0.81pp to 0.40pp respectively. The figure below shows Scott's (2012) and Qiang *et al.*'s (2009) findings. The data in Scott (2012) goes as far as 2011.

Figure 2.1 GDP growth impact from 10pp increase in different ICTs



Source: Adapted from Minges (2015), based on data from Qiang *et al.* (2009) and Scott (2012).

Deloitte (2012) attempted to address the gap concerning the impact of switching ICT technologies by measuring the effects of switching from 2G mobile wireless to 3G. They found that a 10 per cent substitution of 2G for 3G correlated with an average increase of GDP per capita of 0.15 per cent in a group of 96 countries. Furthermore, adding 3G connections seemed to be more beneficial for countries with low 3G penetration. A doubling of mobile data use is associated with an increase in GDP per capita of 0.5pp. Furthermore, Ericsson (2013) also suggests that broadband speed matters. A doubling speed was correlated with a 0.3 per cent increase in GDP and increasing speed from 0.5 to 4 megabits per second (Mbps) was correlated with increases in income for households in Brazil, India, and China of US$46 per month.[2]

2.1.1 Causality and heterogeneity

The previous sub-section focused on correlations between GDP and economic growth at the aggregate level (e.g. entire regions or the world). However, it may not be representative to treat all countries in aggregate groups as homogenous and correlations alone do not establish causality. This section begins by questioning causality and then focuses on the heterogeneity of correlations in single countries. Not all studies conclude that the internet leads to economic growth. In a study of 162 countries, including 115 'non high-income countries', Meijers (2012) argues that the internet does not directly impact economic growth after controlling for standard variables.[3] Instead, he argues that increases in internet penetration increase trade leading to economic growth. This study built on past studies by Clarke and Wallsten (2006), Freund and Weinhold (2004), and Vemuri and Siddiqi (2009) which all showed that the internet had positive relationships with international trade. According to Meijers, 'internet use is impacting trade more significantly than the other way around and international trade impacts economic growth more significantly than internet growth' (Meijers 2012: 3).

Meijers also argues that increases in international trade facilitated by the internet have spurred more economic growth in developing countries than developed ones while the

[2] The authors warn that the sample size is small and the results are not statistically significant.
[3] Variables in Meijers' (2012) model include investment, government expenditure, rate of inflation, openness, and time dummies.

impact of economic trade on economic growth is the same for both sets of countries. A 10pp increase in internet use correlates with an increase in the openness ratio[4] of 3.12pp and 5.3pp which correlates with a 0.15pp and 0.27pp increase in GDP growth in high and non-high income countries respectively. He suggests that the internet reduces more barriers to market and information access and transaction costs in developing countries, whereas these barriers are already low in developed countries that have already achieved internet maturity (Meijers 2012).

To say that the internet has a greater effect on economic growth in developing countries treats them as a homogenous group but this is far from the case. Using a sample of 62 countries in different income levels, Yousefi (2011) finds that ICTs have a higher impact on GDP in upper middle-income countries than in low-income countries. This finding suggests that developing countries at different income levels extract value from the internet at different rates and that GDP growth is not necessarily dependent on ICT investment. Moreover, heterogeneity is further apparent when considering country-level studies. A 10 per cent increase in broadband correlates with increases in GDP of 0.44, 2.14, and 3.67 per cent in Panama, China and Ecuador respectively (Katz and Koutroumpis 2012a; Feng and Ma 2013 in Minges 2015; Katz and Callorda 2013; Minges 2015). Katz and Koutroumpis (2012b and 2012c) showed no significant impact of broadband on GDP between 2000 and 2010 in the Philippines and Senegal. The Senegalese did, however, show a 0.44 per cent increase in GDP associated with a 10 per cent increase in 2G mobile penetration, suggesting that whether or not broadband or mobile is more important to growth may also vary by country (*ibid.* 2012c). The table below summarises the findings of these studies.

Table 2.2 Correlations between GDP growth and internet penetration in single country studies

Study	Country	Years	Correlation with GDP growth for every 10% increase in internet penetration
Katz and Koutrompis (2012b)	Panama	2000–2010	0.44
Feng and Ma (2013 in Minges 2015)	China	2004–2009	2.14
Katz and Callorda (2013)	Ecuador	2008–2012	3.67
Katz and Koutrompis (2012a)	Philippines	2001–2010	0.02 (statistically insignificant)
Katz and Koutrompis (2012c)	Senegal	2003–2011	-0.03 (statistically insignificant)

Source: Author's own, based on data from Minges (2015).

It is also important to note that although GDP growth is the most widely used metric for economic growth, its use is contested. Many scholars, including the Nobel Laureate Joseph Stiglitz, argue that an increase in GDP per capita does not necessarily coincide with an increase in living standards or citizen wellbeing.

> GDP per capita does not say anything about how well most citizens are doing; it can be going up even though most citizens' incomes are declining (as has been happening in the United States). GDP focuses on production in the country, not on incomes earned by those in the country, and takes no account of environmental degradation or resource depletion, or, more broadly, of sustainability.
> (Stiglitz 2011: 235)

[4] 'The openness ratio as measured by imports plus exports as ratio of GDP is expected to catch the benefits coming from international trade' (Meijers 2012: 6-7).

Moreover, although economic growth and digital technologies tend to have strong correlations, no one has yet resolved causality. A widely cited 2009 study by Qiang *et al.* was unable to disprove that the relationship between internet penetration and economic growth was due to chance, while Scott (2012) stated that he did not have time to test the null-hypothesis. Thus, the jury is still out on whether the relationships uncovered in these two widely cited studies are causal or due to chance or an unobserved variable. 'Faster growing countries have more resources and economic opportunities available to invest in ICT infrastructure; thus, the direction of causality may run from growth to ICT rather than the other way around' (World Bank 2016: 56). Therefore it is possible to argue that the economic impacts of the internet are caused by a third variable; that the economic impacts lead to internet adoption at the same time that internet adoption leads to economic impacts, and that it is economic growth that causes internet adoption rather than vice versa. The heterogeneity of findings and the lack of established causation warrant a few questions. Is reverse, mutual, or third variable causality possibly at play? Why do countries seem to gain from the internet differently? If ICTs do lead to growth, through what mechanisms do they do so?

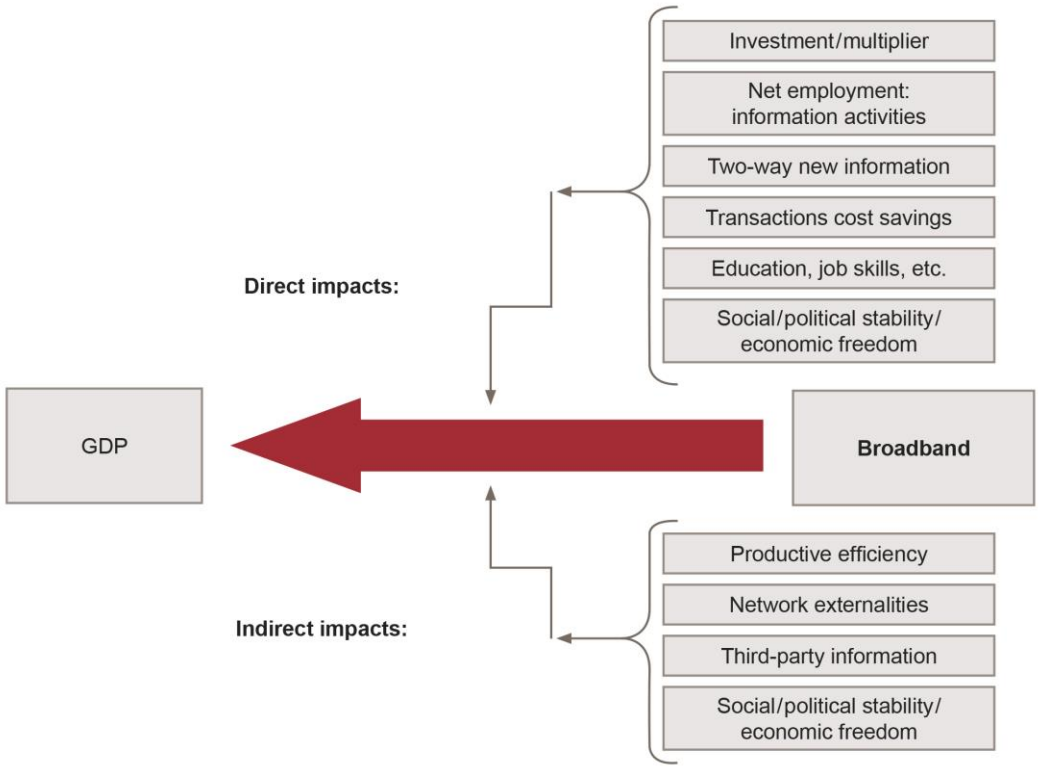
2.2 Mechanisms

The two previous sub-sections focused on the relationships between digital technology adoption and economic growth at the aggregate and country level respectively. Although the potential for reverse or no causality has not been widely explored in the literature – other than in Meijers (2012) – mechanisms have been identified by which it is believed that the internet facilitates economic growth. Currently, these mechanisms are mostly mentioned in passing and taken as given without much effort to prove that they are occurring or to quantify their economic impact. There is a need for studies that delve deeper into these mechanisms to determine which mechanisms are most important and under what conditions. Having an understanding of these mechanisms could prove beneficial in being able to forecast whether increasing internet penetration in developing countries will have an impact on growth and what kind of impact it will have. The following are *some* of the mechanisms mentioned in the literature:

- Fostering inclusion through access to information; increasing efficiency and productivity through automation and coordination; increasing innovation through scale economies and cooperation; reducing barriers to newcomer firms (World Bank 2016)
- Helping companies to reach economies of scale (Brynjolfsson and McAfee 2014)
- Fostering technology diffusion; improving decision-making quality for households and firms and resource allocation
- Reducing production costs and increasing demand and investment (Vu 2011)
- Increasing international trade, lowering transaction costs, improving quality and lowering the cost of offshoring functions thus stimulating international trade (Meijers 2012)
- Increasing information flows, innovation, financial capital access, entrepreneurship, and enhancing labour; increasing access to markets and giving rise to the micro-multinational (small and medium enterprises (SMEs) that can go global from day one) (Deloitte 2014)
- Reducing information asymmetries between buyers and sellers and reducing the need for intermediaries (Jensen 2007; Aker 2008)
- Providing economic agents with empowering information and increasing firm efficiency and competitiveness (Yousefi 2011)
- Rejuvenating traditional sectors; 75 per cent of the gains of the internet is captured by non-internet companies (MGI 2011)
- Overcoming infrastructure limitations through new platforms like M-Pesa (KPMG 2012).

Thompson and Garbacz (2011) break down the effects of the internet on economic growth into direct and indirect impacts. Direct impacts include generating investment, increasing employment, increasing two-way information-sharing, cutting transaction costs, and facilitating education and skill development. Indirect impacts include increasing efficiency, and network externalities. Figure 2.2 illustrates these mechanisms.

Figure 2.2 Broadband's direct and indirect impacts on economic growth



Source: Adapted from Thompson and Garbacz (2011).

Digital technologies have enabled the development of new platforms that can transform the way economies function, especially in rural areas. Mobile money has provided a banking alternative for millions of people previously unable to use banking services, has facilitated new business models for organisations operating on top of the platform, and introduced electronic payments in places that previously lacked them (World Bank 2016; KPMG 2012). Mobile money has been widely cited as an M4P (Markets for the Poor) approach because it facilitates 'systemic change' in entire markets making it easier for everyone – especially the poor – to do business (KPMG 2012). Thus, digital innovations have the potential to improve the functioning of markets by overcoming economic constraints and limited infrastructure, and could potentially accelerate leapfrogging and inclusion in other areas if the right platforms are built.

2.3 Leapfrogging

One of the major mechanisms by which digital technologies are expected to lead to economic growth is through leapfrogging. Steinmueller (2001) and others have written about the possibility that digital technologies could provide developing countries with a platform to catch up with developed countries by 'leapfrogging' conventional methods of increasing productivity. However, it is also possible that developing countries could benefit less from ICT investments than developed ones if they are not well prepared to take advantage of the technology (Niebel 2014). Steinmueller (2001) proposes four prerequisites for leapfrogging:

- Absorptive capacities: the ability to produce or use ICTs often acquired through tacit knowledge rather than manuals
- Access to equipment and 'know-how' to make productive use of ICTs
- Availability and linkages with other complementary technologies and sectors
- Downstream integration capabilities: creation of internal markets, logistical capabilities and marketing capabilities to convince users of their utility, reliability and value.

As mentioned earlier, previous studies had found a higher impact of ICT investment in developing countries than developed ones. However, a study of 59 countries categorised as developing, emerging and developed countries finds that although all three country groups showed a positive relationship between economic growth and ICT investment, there are only small differences in the impact of ICTs between the three groups (Niebel 2014). Thus there is no clear evidence that developing countries are disproportionately gaining from ICT investments or 'leapfrogging'.

2.4 Impacts of ICT on poverty

Despite no proof of causality, powerful narratives seeking to expand internet penetration like Internet.org by Facebook – which would benefit economically from more people being online – and other private tech company-led initiatives have cited studies like Deloitte (2014) which projects that expanding internet access in developing countries will lift 160 million people out of poverty (Zuckerberg 2014). Furthermore, Zuckerburg has also claimed that one person is lifted out of poverty for every 10 people gaining internet access and that connecting the 4 billion people who are currently offline can lift 400 million people out of poverty (McFarland 2016). Schradie (2013) challenged Zuckerberg (2013) in an open letter for citing claims by the McKinsey Global Institute (2011) that the internet leads to economic growth based solely on correlations. At the macro level, correlations between ICT and economic growth often get conflated with correlations between economic growth and poverty reduction to argue that ICTs have a significant and positive impact on poverty reduction. The World Economic Forum (2015: 32) says, for example, that the 'impact[s] of ICT on economic growth and poverty alleviation are undeniable, and greater adoption of ICTs in lower-income countries can accelerate income gains at the base of the economic pyramid'; and that although there is a lack of evidence showing that ICTs reduce poverty, decreases in poverty are strongly correlated with ICT adoption at the country level.

Much of the work done on the effect of ICTs on poverty looks at differences between adopters and non-adopters of digital technology despite the potential that they may be inherently different. These studies tend to focus on mobile phones since the internet and computers have not been widely diffused at the bottom of the pyramid. May *et al.* (2014) find that although poverty statuses worsened for non-users of digital technology, adopters experienced a 27 per cent improvement in their poverty status in Kenya, Rwanda and Uganda. However, once again, there is a strong possibility of reverse causality since the chances of gaining access to ICTs doubled with every unit increase in the poverty score.

Klonner and Nolen (2008) find that mobile coverage roll-out is beneficial for people who are extremely poor, but has no significant effect on those in moderate poverty in rural South Africa. May *et al.* (2014) also suggest that mobile access disproportionately benefits the very poor compared to the moderately poor although by a small margin. However, 'even if economic benefits do exceed costs for the poor, the costs are greater and the benefits are lower than for rich users. It is therefore possible that ICTs simultaneously help reduce absolute poverty levels but increase overall income inequalities' (Heeks 2014: 15). This possibility becomes even clearer if you take into account that returns to broadband are higher than returns to mobile phones (Scott 2012). Katz and Callorda (2013) showed that

returns to broadband were disproportionately higher for computer and internet users in Ecuador.

Moreover, mobile phones do not automatically 'economically empower' the poor. In fact, the poor often end up paying more for mobile phone use both in relative and absolute terms. For example, the average cost of operating a mobile phone is 18 per cent of gross national income (GNI) per capita in Africa – and as high as 53 per cent in the Democratic Republic of Congo – but only 1.47 per cent of GNI per capita in Europe (ITU 2015). Thus, Africans spend a relatively high price for mobile phone access. Moreover, the poor don't always choose to use mobile phones for business purposes, even when they have a micro-enterprise (Mpogole, Usanga and Tedre 2008). A survey of 22 rural villages in Tanzania showed that only 7 per cent of respondents purchased a phone for business purposes while 74 per cent of them did so for maintaining social relationships. In the survey, 79.5 per cent of respondents did not agree that owning a mobile phone helps reduce income poverty and about half of them believed that the costs of owning a mobile phone were greater than the benefits. In a survey of mobile-owning women micro-entrepreneurs in rural India, only 10 per cent regularly used their mobile phone to conduct business (Chew *et al.* 2011). In Sri Lanka, a quarter of the poorest people reported that owning and maintaining mobile phones has deteriorated their capacity to save (de Silva and Zainudeen 2006; Mpogole *et al.* 2008). The opportunity costs of owning a mobile device are especially high for those living in off-grid rural areas, forcing them to forgo many productive hours of work to walk long distances – 3 to 7km – to nearby towns or cities several times a week to wait for their phone to charge (*ibid.* 2013). Katengeza *et al.* (2014) found that other things being equal, distance to an electricity source reduces the likelihood that farmers partake in ICT-based projects.

Heeks (2014) conceptualises the effects of ICT on poverty reduction by putting forward three categories of direct ICT application and three perspectives on poverty eradication. Categories of ICT application include other ICT uses, enterprise ICT use and ICT sector use. Other ICT uses include economic or non-economic information flows and transactions to or from users in poor communities. Enterprise ICT is defined by the use of ICTs at work. ICT sector use refers to the use of ICTs to generate income such as selling mobile phones or top-up cards. Perspectives on poverty eradication include: economic, livelihood and capabilities. The economic perspective of poverty reduction aims to tackle poverty eradication through income generation. The livelihoods perspective seeks to facilitate the accumulation of assets including information, skills and health. The capabilities approach seeks to facilitate transitions into new 'roles'. Table 2.3 includes examples of these applications and perspectives. Heeks suggests that the more you move towards the bottom right in this figure, the greater the impact on poverty reduction, but with one caveat: fewer people are affected.

Table 2.3 Summary of Heeks (2014) framework

	Other ICT uses	**Enterprise ICT use**	**ICT sector**
Economic	ICT-enabled journey substitution	ICT-enabled income from market information	ICT-based employment income
Livelihoods	Health information	ICT-enabled customer networks	ICT-based employment assets
Capabilities	ICT-enabled government services	Production of digital content	ICT innovation

Source: Heeks (2014).

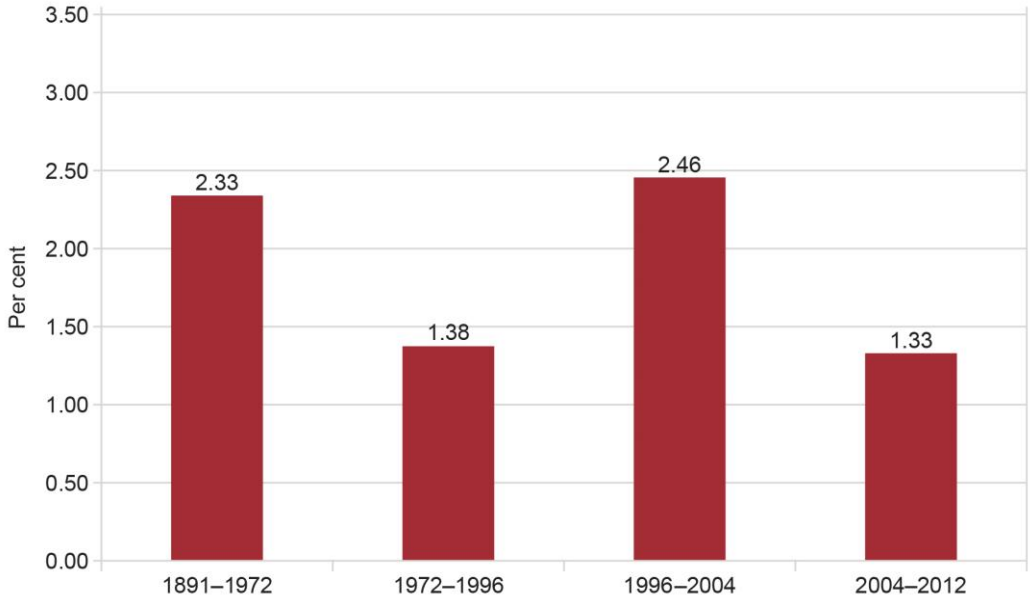
3 Productivity

3.1 Productivity gains from the Digital Revolution

One of the main mechanisms by which technological progress is expected to affect economic prosperity is through increasing productivity. Robert Gordon (2012) divides technological progress since the 1750s into three 'Industrial Revolutions' (IRs) facilitated by General Purpose Technologies (GPTs). The first IR (1750–1830) was powered by the creation of the steam engine, railroads and cotton spinning; the second (1870–1900) included the introduction of electricity, the internal combustion engine and indoor plumbing; the third IR (1972–today) – also known as the 'Digital Revolution' – is the one powered by ICTs, the internet, and other digital technologies.

Gordon (2012), Cowen (2011) and others argue that the Digital Revolution has not spurred as much productivity growth as the previous two industrial revolutions for countries on the technological frontier. Gordon uses the measures of Total Factor Productivity (TFP) throughout the three IRs to make his point. The figure below shows Gordon's results. His analysis suggests that the high levels of TFP gains during the Digital Revolution have been short-lived compared to those of the second IR – eight years compared to 81 years – in the US, and that TFP is back on the decline.

Figure 3.1 Average growth rates of US labour productivity over selected intervals, 1891–2012



Source: Adapted from Gordon (2012).

He further attempts to attribute greater importance to the innovations of the second IR over the Digital Revolution through the following thought experiment in which readers choose between two options:

> With option A you are allowed to keep 2002 electronic technology, including your Windows 98 laptop accessing Amazon, and you can keep running water and indoor toilets; but you can't use anything invented since 2002.

> Option B is that you get everything invented in the past decade right up to Facebook, Twitter, and the iPad, but you have to give up running water and indoor toilets. You have to haul the water into your dwelling and carry out the waste. Even at 3am on a rainy night, your only toilet option is a wet and perhaps muddy walk to the outhouse. Which option do you choose?
> (Gordon 2012: 14)

However, Gordon can be misleading for three reasons. Firstly, it seems speculative and too early to argue that the major technologies driving the Digital Revolution have already been determined and that future digital technologies cannot revive TFP. Gordon acknowledges that it took about a century to see all the benefits of previous industrial revolutions. Kelly (2013) argues that starting the third industrial revolution at the 1960s with the introduction of computational computers does not accurately capture its starting point. To him, the Digital Revolution started in the 1990s with the beginning of the networking of everything – when 'the telephone married the computer' and ordinary people began using the commercial internet. Under Kelly's start date we have 80 more years of potential gains to go. However, these dates are both arbitrary and open to debate. Only time will tell how far along the Digital Revolution we are today and whether it will indeed take 100 years to capture its full gains. As Nobel Laureate Robert Solow said in an interview, projecting future gains from the Digital Revolution may just be 'testing whether you are a [technology] optimist or a pessimist' (EconTalk.org 2014).

Secondly, as Gordon admits, his data only reflects the reality of the United States and other countries on the technological frontier. Although electrification, running water, indoor toilets, and other second IR technologies have diffused widely throughout developed countries, the same is not true for many developing countries. Although digital technologies are also far from ubiquitous, the number of households owning a mobile phone exceeds those with access to improved sanitation, bank accounts or electricity (World Bank 2012). With developing countries projected to continue increasing mobile and internet penetration at faster rates than developed countries, and at a rate faster than they adopt indoor plumbing or electricity, it would be hard to argue that 'IR #2' is more important than the Digital Revolution in regards to raising living standards in developing countries. Given that mobile phones have diffused before technologies that predated them by many decades, Gordon's IRs do not seem to be playing out sequentially in developing countries. The 2016 *World Development Report* argues that a lack of analogue complements – mostly from IR #2 – is what currently prevents developing countries from adopting and benefiting more swiftly from digital technology (World Bank 2016).

Thirdly, Gordon (2012) uncovers six headwinds that are holding the US back from higher productivity gains: an aging population, stagnant education levels, high levels of consumer and government debt, rising inequality, outsourcing and globalisation, and environmental constraints. These 'headwinds' are particular to the US and it is obvious that some of them, such as aging populations, are not an issue in many developing countries. Furthermore, the fact that headwinds are capable of holding a technology back from increasing TFP might mean that there are potentially a lot of other factors affecting its measurement beyond a set of (digital) technologies alone.

3.2 Measurement issues and consumer surplus

Although widely used, growth in TFP and GDP as indicators of productivity and economic growth is contested. There has been a clash between scholars who continue to use these indicators and others who believe them to be outdated. During a streamed academic debate between Erik Brynjolfsson and Tyler Cowen (2011), Brynjolfsson argues that rather than stagnating productivity, countries on the technological frontier are experiencing faster

innovation and productivity growth than ever, but that the average worker is not keeping up with technological change, thus keeping TFP low. The issue with using TFP to measure productivity gains from digital technology is that it subtracts gains from laying people off and replacing them. This is something digital technology does very well through automation.

Brynjolfsson argues that this metric currently does not account for the work that robots and machines do and thus undervalues its effects. Economists in Silicon Valley agree. TFP and measurements used to estimate economic growth – GDP – do not capture the introduction of goods that were previously non-existent, improvements in quality, quicker responses, increased variety, and time lags in productivity payoffs due to the necessity to complement ICTs with other investments (Brynjolfsson 1993).

Furthermore, there are many digital products and services that we enjoy for free but that do not show up in GDP or productivity statistics. Thus, these figures are not capturing all of the ways that technology is advancing productivity, especially on the consumer side. In order for any product or service to be included in GDP statistics they need to have a dollar figure associated with them (Coyle 2014). However, users of the internet are able to access Google, Facebook, Twitter, Instagram, Gmail and many other online services and platforms without paying despite those services providing users with value.[5] Kelly (2013) argues that Gordon and other economists tend to 'fetishize' GDP and productivity statistics and thus only focus on how much 'labour saving' is accomplished. He argues that wealth in the future will not depend on saving labour, but on creating new labour and novel things to do, and that an emphasis on GDP and productivity underplays the human ability and desire to experiment, explore, create art, play and do other fulfilling things that we value. To Kelly, optimisation is something for machines rather than humans.

Furthermore, Kelly (2013) argues that rather than linearly improving things that we already do more efficiently, the Digital Revolution is evolving the economic landscape into an economy with increased complexity, more interdependency, and a decreasing emphasis on ownership, all of which are not necessarily well captured by old metrics. Our current measures are good at capturing traditional activities and how our efficiency in doing those activities has improved. Kelly argues that we don't just want more from less, but we would also like different and new products, ideas and technologies. Moreover, Coyle (2014) argues that the productivity gains in services are very hard to measure. For example, increases in productivity require workers to do more with less, suggesting that a teacher teaching the same number of students would never be able to increase productivity although we value small class sizes. The teaching example highlights one of the biggest critiques of GDP and productivity measures; they fail to fully capture improvements in quality both in services and products.

However, whether current technologies have a bigger consumer surplus than past ones is up for debate. Urban sewage systems and indoor plumbing also had significant consumer surpluses that were not accounted for in GDP. The streets no longer smelled bad and people got sick less often as a result. Furthermore, although it is possible to put a price tag on antibiotics, it is very hard to put a price tag on surviving an illness that was not possible without antibiotics. Nathan Mayer Rothschild, the world's richest man in 1836, died of a tooth ulcer, something he would easily survive today with an antibiotic worth just 10 dollars (Coyle 2014).

[5] Although users do not pay for these services, they are heavily monetised. With these new 'free' web-based services, the user too becomes a product as their data is collated, analysed and sold to third parties.

Box 3.1 Consumer surplus at the base of the pyramid

The benefits that the poor receive from mobile phones are also not purely economic and an emphasis on the economic may overlook their full gains. The fact that poor people are willing to spend a greater share of their income both in relative and absolute terms (Heeks 2014) for connectivity suggests that it provides significant value to them. There is very little work concentrating on consumer surplus at the base of the pyramid.

Kivunike *et al.* (2011) found that users of mobile phones in rural communities in Uganda disproportionately cited social reasons for owning a mobile phone including entertainment and maintaining social relationships rather than economic ones. Although they have not been necessarily labelled as consumer surpluses in the literature, the bottom of the pyramid seems to gain from digital technology in the form of lower prices, greater safety, less time spent on travelling, better communication with migrant relatives, better access to health care and improved resilience to natural disasters (Jensen 2007; Mehta 2013; Rahman *et al.* 2013).

In a study of the fish market in Kerala, India, Jensen (2007) found that mobile phone coverage roll-out was associated with a 4 per cent decrease in the price of fish and a 6 per cent increase in sardine consumption as well as spillover effects to fishermen who did not adopt mobile phones. In a survey in rural Bangladesh, 71 per cent of women said that they felt more secure with mobile phones (Rahman *et al.* 2013). In both India and Bangladesh, mobile phones were found to increase the speed of urban–rural remittances, significantly improving the safety of migrants returning home on trains who had previously been subject to attacks because they were known to be carrying money (Mehta 2013; Rahman *et al.* 2013). Savings in time and increased savings have thus led to greater real returns to migration. This partially explains why members of rural households with at least one migrant worker are more likely to have mobile phones in India although some of those do solely use their mobile phones to receive phone calls from their migrant relative (Mehta 2013).

Access to health information via the internet or through contact with health professionals can lead to improved health outcomes (Mehta 2013). Consumers in rural Bangladesh claim mobile phones and ICT have helped them save money in health care and improved service. Furthermore, almost 80 per cent of respondents in rural Bangladesh said that they used their mobile phones during medical emergencies (Rahman *et al.* 2013). Mobile phone networks have proven to be more resilient during natural disasters and the mobile phone itself has become a major focal point of early warnings, and has accelerated rescue and relief efforts (Rahman *et al.* 2013).

3.3 Evidence of productivity gains

The literature measuring productivity gains from digital technology can be classified into two strands. One measures the impact of investments in ICT on productivity and a more recent strand measures the impact of adopting specific ICT technologies – mobile and broadband – on productivity.

3.3.1 ICT investment and productivity

This sub-section summarises the literature concerning the relationship between ICT investment and productivity. Studies did not find positive relationships between ICT investment and productivity in the 1980s and 1990s. The lack of evidence led the relationship between ICT and productivity to be called the 'Productivity Paradox' or 'Solow's Paradox' named after the Nobel Laureate economist Robert Solow who in 1987 said: 'We see computers everywhere except in productivity statistics' (Brynjolfsson 1993; Solow 1987). This changed near the turn of the century thanks to newly available data and methodologies (Papaioannou and Dimelis 2007).

However, those studies first showed that ICT investments were associated with productivity gains in developed countries but not developing countries, leading some to believe that they would be left out of the productivity gains of ICTs (Dedrick *et al.* 2013; Dewan and Kraemer

2000; Pohjola 2000; Lee *et al.* 2005). Papaioannou and Dimelis (2007) found that developing countries were beginning to benefit from ICT investment between 1993 and 2001, but gains were still much lower for developing countries. In a study of 42 developing and developed countries between 1993 and 2001, Dimelis and Papaioannou (2009) found that there was a positive correlation in both developing and developed countries, with developing countries showing a larger correlation. Dedrick *et al.* (2013) also found a significant and stronger correlation on productivity in developing countries between 1994 and 2007. However, data availability is still an issue. A lack of data on IT capital in low-income countries makes the relationship difficult to study (*ibid.* 2013).

3.3.2 ICT adoption and productivity

This sub-section briefly summarises literature covering the relationship between ICT adoption and productivity. In a sample of 49,610 firms in 117 developing countries between 2006 and 2011, Paunov and Rollo (2015) found widespread productivity gains for firms adopting the internet including firms facing electricity, financial and skill constraints, and dealing with corruption and heavy labour regulations, although to a lesser extent than firms not facing constraints. Productivity and internet adoption were positively correlated in all world regions except for Pacific and South Asia. The McKinsey Global Institute (2011) suggests that firms with online presences grow two times as fast and export twice as much as offline firms. Moreover, businesses allocating 30 per cent of their budget or greater to web technologies increased revenues nine-fold compared to firms spending under 10 per cent. The internet as a GPT seems to have impacts on many sectors. Three-quarters of the value created by the internet is captured by firms that do not consider themselves as tech companies (*ibid.* 2011).

3.3.3 Heterogeneity in productivity gains for firms

The two previous sub-sections looked at productivity gains at aggregate levels. This sub-section covers differences in productivity gains for firms of different types. The use of the internet for productive purposes by firms and the intensity of its use is highly heterogeneous and varies by country, region, within countries, and between sectors and firms. Firms at all country income levels are more likely to use email than have a website, and are more likely to have a website than buy or sell goods online. But firms in high-income countries are more likely to do all those things than those in low-income countries (World Bank 2016). Although most firms in high-income economies have embraced PCs and the internet, other business-related digital technologies have not diffused as ubiquitously. Less than 20 per cent and approximately 15 per cent of firms in developed countries have adopted cloud computing and e-sales on average respectively. A Dalberg (2013b) study showed that businesses across four African countries are more likely to use the internet to conduct research but much less likely to use management applications or to recruit employees on the internet.

Firms within industries also use ICTs differently depending on geographic location, industry and orientation. Dalberg (2013b) finds that in four African countries, international companies were most likely to see web applications as useful followed by national and local companies respectively. Exporting SMEs in the agricultural sector were more likely to use the internet for marketing purposes than non-exporters (*ibid.* 2013b). Although only 25 per cent of Indonesian firms in the textile sector used the internet for communication, nearly 100 per cent of them do in Peru (Paunov and Rollo 2014). A survey of 1,300 businesses in seven sectors across four African countries shows that although the education sector used the internet least to manage customer relationships, supply chains or internal organisations, they instead used it more heavily than other sectors to conduct research, store data and for education/training purposes. Although the financial services sector was the most likely to use the internet to provide a product or service, recruit workers, and manage client relationships and the internal organisation, it was also the least likely sector to use the internet to conduct research (Dalberg 2013b). The figure below breaks down usage of the internet by firms to

perform different tasks by sector. Overall, SMEs were most likely to use the internet to manage customer relationships, conduct research, manage the supply chain, etc., suggesting that the internet does indeed provide SMEs with value. MGI (2015) finds disparities in internet use and gains between sectors in the US and shows that these disparities have been increasing over time between and within industries. This relationship has not been looked at in developing countries.

Table 3.1 Firm use of the internet by sector in four African countries (by percentage)

Sector	Conduct research	Customer relationship	Manage supply chain	Data and information storage	Education and training	Manage internal organisation	Provide product/ service	Recruiting
Agriculture	72	70	53	49	43	38	23	18
Health	67	61	50	58	48	53	38	18
Education	81	45	22	68	84	34	43	24
Financial services	61	74	26	65	40	63	49	39
Energy and transport	65	73	54	57	42	41	42	30
Governance	63	54	22	50	53	56	34	32
SMEs*	99	89	58	86	74	61	62	31

Note: * Calculated using data provided in Dalberg (2013b: 39).
Source: Author's own, based on data from Dalberg (2013b).

Firms in different cities of the same country also experience ICTs differently. Firms in Ireland are more likely to adopt ICT in the capital city (Haller and Siedschlag 2011). Iacovone *et al.* (2015) find that Mexican companies are more likely to effectively adopt digital technologies if they face competition in Mexico or the US from Chinese firms, signalling that competition is a key driver of ICT adoption. MGI (2012) also finds a positive correlation between market competitiveness and higher productivity gains from the internet.

3.4 Spillover effects

This sub-section concerns literature on (positive) externalities of widespread ICT adoption on firms that have not adopted ICTs. Paunov and Rollo (2014) show that widespread adoption of the internet within an industry may have positive spillover effects on firms that don't use the internet in those industries, meaning that the impact of the internet seems to go beyond those that adopt it when uptake is high within an industry. The biggest spillover beneficiaries seem to be firms lacking strong knowledge networks prior to widespread adoption, including single-plant firms, non-exporters and firms operating in remote areas. Firms that export are less likely to benefit from these spillovers because they already have access to external contacts and expertise. There was no evidence that smaller firms disproportionately benefited from knowledge spillovers compared to bigger ones. According to Paunov and Rollo, there are several avenues for knowledge spillovers including recruiting new staff, business association meetings and face-to-face contact with other firms in the industry, competitors and customers. They argue that knowledge spillover could pave the way for

more inclusive innovation but only if firms have the absorptive capacity to make use of the knowledge. At the micro level, Jensen (2007) found that market efficiency gains from mobile phones spilled over to fishermen who didn't use mobile phones in the form of higher earnings.

Box 3.2 Innovation at the bottom of the pyramid

Many mobile innovations have taken root with users in developing countries, including multi-SIM card phones and mobile money (World Bank 2012; Mehta 2013). The missed call (when a caller rings once then ends the call, allowing the person receiving the call to get a predetermined message despite no actual textual or audio communication) has become a common use in developing countries which was not intended by mobile designers (Hamade 2012; Mpogole *et al.* 2008; Mehta 2013). Locally designed applications and platforms that take into account context specificity are more likely to address development challenges (World Bank 2012).

Martin and Abbott (2011) found that farmers in Uganda's Kamuli district came up with unique productive uses for mobile devices tailored to their needs that were not intended by the designers and developers of the phones. Some of these unique uses include using speakerphone for group consultations, documenting demonstrations and lessons through photos and audio recordings, recording market trends in the calendar, documenting contractual agreements in audio, and using the calculator function for pricing decisions (*ibid.* 2011). These uses usually develop over time as users become familiar with the technology. At adoption farmers in rural Uganda engaged in an average of 1.75 different uses for mobile phones but this increased to 5.16 over time as farmers began developing their own innovative uses to deal with changing needs.

There are also examples of the poor taking advantage of mobile technology to develop new business models. For example, micro-entrepreneurs in India have begun charging phones through solar panels and some street-hackers have altered phones to take multiple SIM cards (Mehta 2013). The SIM card innovation was so transformative that manufacturers have begun offering phones with multiple SIM-slots. Moreover, Rutten and Mwangi (2012) suggest that Safaricom and DFID originally intended M-Pesa to be used solely as a payment tool for microfinance and that it was when local people began appropriating it to their own needs that Safaricom noticed it had the potential to be something more. Rather than treating the poor as passive beneficiaries of digital development programmes and policy, more work is needed to understand how they make digital technology work for them.

3.5 Productivity gains of micro-entrepreneurs

3.5.1 Studies focusing on micro-entrepreneurs

While there are few studies that focus on the impact of ICTs on SMEs in developing countries, there are even fewer studies on micro-entrepreneurs (Makoza and Chigona 2012). This sub-section briefly summarises such literature. The literature suggests that in some contexts micro-entrepreneurs benefit from ICTs. Three commonly cited productive uses of mobile phones by micro-entrepreneurs include: accessing information that aids decision-making; increasing efficiency of coordination; and improving social capital and networking opportunities (Martin and Abbott 2011). The use of mobile phones is correlated with the increases in income for potato farmers in India by 19 per cent, grain traders in Niger by 29 per cent, and banana farmers in Uganda by 36 per cent (World Bank 2012). Mobile phones were associated with an 8 per cent increase in profits for fishermen and a 4 per cent decrease in price for consumers plus an increase in sardine consumption of 6 per cent (Jensen 2007). Furthermore, although mostly larger commercial fishermen adopted mobile phones, there were gains by non-users suggesting that mobile phones made the market function better overall.

In a survey of micro-enterprises in rural Kenya, about 90 per cent of respondents believed that mobile phones helped their micro-enterprise grow, and about half of micro-entrepreneurs believed that mobile phones helped them obtain new clients, decreased the time required to make business arrangements, avoid middlemen, get better information about the products and services they sold, and that mobile money has a positive and significant influence on income growth (Mwangi and Acosta 2013). Chew *et al.* (2011) shows that there is a significant but limited positive causal relationship between ICT access and business growth for micro-entrepreneurs. Mobile phones were able to explain only 2 per cent of variance in business growth. However, there is little evidence that computers have a positive impact on micro-entrepreneurs due to low computer and internet diffusion.

Ownership of a mobile device is insufficient in itself for micro-entrepreneurs to reap economic benefits from ICT. ICT use by micro-entrepreneurs is often limited to simple technologies such as mobile phones (Martin and Abbott 2011). Beyond issues of ownership, perceived usefulness, awareness of ICT uses for business activities and a lack of relevant skills tend to be a barrier for micro-enterprises. A lack of awareness can lead micro-entrepreneurs who own ICTs to not use them for business purposes. For example, although hotlines for expert advice are often made available by donors and governments, a lack of knowledge of these services limits their uptake (*ibid.* 2011). A survey of rural India found that only one-fifth of mobile phone users used their phones for economic purposes including accessing market information, seeking employment opportunities, trading and credit. The lack of use of mobile phones for economic activity is especially low for subsistence farmers, who may see less value in using ICTs compared to commercial farmers (Mehta 2013). One widely cited way in which micro-entrepreneurs have benefited from ICTs is through overcoming information asymmetries.

3.5.2 Information asymmetries

This sub-section covers literature concerning the ability of digital technologies to overcome information asymmetries. The literature suggests that overcoming information asymmetries has a greater impact on rural areas where a lack of landlines, reliance on intermediaries and longer distances have traditionally made the flow of information costlier (Klonner and Nolen 2008). In many developing country markets information is often imperfect and limited, with economic agents typically knowing prices in only a few nearby villages or towns. Information asymmetries can make trade slow, costly and risky, constraining the development of markets because gathering information often requires physical interaction, with the potential that economic agents may take journeys only to find empty markets upon arrival. Furthermore, traders with more information are able to engage in opportunistic behaviour when they are aware of their advantage (*ibid.* 2008; Jensen 2007). Markets that operate despite information asymmetries tend to be localised and reliant on intermediaries.

The literature suggests that mobile phones can help overcome information asymmetries before, during and after trades (Jagun *et al.* 2008; Boateng *et al.* 2014). Before trades, mobile phones allow economic agents to access market information. During trades, ICTs allow them to access information vital to negotiation. After trade, economic agents can follow up and maintain relationships with clients. Where mobile phones overcome information asymmetries, the literature suggests that they are capable of increasing market efficiency, reducing intermediaries, reducing price and wage dispersion, cutting costs associated with getting information and saving time and money through journey substitution.

A widely cited Jensen (2007) study found that mobile phone adoption was correlated with significant decreases in price dispersion, nearing the law of one price in Kerala's fish market and the elimination of waste. Jensen argues that mobile phones were commonly used to gather information on price and thus decide where and from whom to buy and sell. Although its findings are contested, Jensen's study is often generalised at a global scale in the ICT4D

(Information and Communication Technologies for Development) literature to advocate for Market Information Systems (MIS) and to argue that mobile phones would provide users around the world with access to price information (Burrell and Oreglia 2015). Metha (2013) also found that mobile phones were associated with a decrease in price dispersion and spoilage for farmers in rural India. Aker (2008) finds that mobile phone roll-out is associated with a 20 per cent decrease in price differentials in Niger's grain markets with greater impacts between markets further away from each other and those connected by substandard roads. Mobile phones were also shown to decrease intra-annual variation, helping stabilise grain prices. Moreover, Mehta (2013) suggests that mobile phones decreased the dispersion of wages between rural Indian markets. Not all studies find that the phone reduced price dispersion or wages. For example, Jagun *et al.* (2008) did not find that mobile phones affected the price of traditional cloth in Nigeria. Thus, price dispersion does not come automatically with the roll-out of mobile coverage.

Moreover, several studies including Burrell and Oreglia (2015), Srinivasan and Burrell (2013), and Steyn and Das (2015) have refuted Jensen's claims about the use of mobile phones to access price information. These studies expanded on Jensen's purely economic study to include ethnographies of fishers and farmers in Kerala (Srinivasan and Burrell 2015; Steyn and Das 2015) and in Uganda and China (Burrell and Oreglia 2015), which shed light on how these economic agents used mobile phones and what capabilities of mobile phones they found to be valuable. None of the fishers interviewed by Steyn and Das (2015) claimed that they used mobile phones to access market price information. Srinivasan and Burrell (2015) and Burrell and Oreglia (2015) also found that their interviewees generally did not access price information via mobile phone. In many instances, mechanisms were already in place to access price information including but not limited to television, radio, extension agents and word of mouth. Moreover, not all economic agents are able to act upon price information equally. In some cases, the cost of fuel and transport is a barrier to accessing better prices in foreign markets. In other cases, relationships with financers and debt collectors hinder fishers and farmers in selling their goods in other markets. Steyn and Das (2015) found that rather than helping fishers determine where to dock, the mobile phone was mostly used to relay messages about when to dock. It is more profitable to dock during busy hours when fishers can demand higher prices in their home landing site. Moreover, economic agents don't always act in an individualistic manner, but are often part of expansive networks of stakeholders with players in many different roles. In many cases, fishers and farmers will choose to stick with the relationships they have built over time and networks that they are familiar with in order to minimise risk and uncertainty (Steyn and Das 2015).

Some argue that mobile phones enable disintermediation (Heeks 2014; Mehta 2013; Rahman *et al.* 2013). Although intermediaries do help overcome information asymmetries in the absence of accessible information, they also tend to have a highly unequal relationship with buyers and sellers that can lead to exploitative or opportunistic behaviour by intermediaries. For example, since traditional Nigerian clothing is only purchased for special occasions and weavers and buyers are unable to find each other on their own, intermediaries commonly overprice garments and use lower-quality materials than promised. Knowledge of such behaviour can further undermine the reputation and trust of entire sectors (Jagun *et al.* 2008). In the Nigerian traditional clothing case, the introduction of mobile phones actually further entrenched intermediaries, exacerbated unequal relationships between intermediaries who had mobile phones and weavers, led to weavers without mobile phones losing orders to weavers with mobile phones, and even engendered a new type of intermediary.

Where phone calls and texts can substitute journeys, they save time and money because phone calls lasting a few minutes tend to be cheaper than transportation, and they also save opportunity costs (Aker 2008; Jagun *et al.* 2008; Mpogole *et al.* 2008; Chew *et al.* 2011;

Katengeza *et al.* 2014; Rahman *et al.* 2013). In Kerala, distances between fishers and markets are often large. Fishers are typically able to travel to one or a few markets a day, making the opportunity cost of arriving at an empty or over-saturated market very high (Jensen 2007). Market inefficiencies are especially apparent when excess supply leads to the spoilage of perishables in one market while excess buyers are unable to purchase anything in nearby markets. Phone calls decrease the likelihood that traders will not find someone to transact with. The introduction of mobile phones in Kerala, India was correlated with a complete elimination of waste (*ibid.* 2007). Although some journeys can be substituted, some journeys still remain important especially when a lack of trust persists, materials or end products need to be picked up, instructions are not easily conveyed over phones, or there is a need to monitor quality (Jagun *et al.* 2008).

In Malawi, ICT-enabled Market Information Services help economic agents perform activities faster, promote competition, reduce transaction costs, improve market performance, and improve agricultural incomes (Katengeza *et al.* 2014). Although donors and governments often establish agencies that provide services related to market information, training and access to experts, many economic agents remain unable to benefit from them because of a lack of awareness that they exist (Makoza and Chingona 2012; Martin and Abbott 2011; Mehta 2013).

Mobile phones have been praised for helping economic agents maintain their business networks (Aker 2008; Jagun *et al.* 2008; Hamade 2012; among others). However, social factors such as gender influence the extent to which mobile phones can improve networks. Martin and Abbott (2011) found that more men were likely to perceive mobile phones as a tool to increase their social network than women in the Kamuli district of Uganda because men tend to be more mobile while women tend to stay at home. This example and the example of the Nigerian traditional cloth sector show that contextual factors have an impact on mobile phones' ability to overcome information asymmetries.

3.6 Complements needed to increase productivity

The literature does not always imply that the productivity gains are automatic. This sub-section covers complementary factors needed to increase productivity. Digital technology can have a negative or no impact on productivity if workers do not have the right skills and if firms do not undergo organisational restructuring processes to make efficient use of the technologies (Brynjolfsson and Hitt 2003; Brynjolfsson and McAfee 2014). Firms in Brazil saw significant productivity increases only after they flattened their organisational structures (Commander *et al.* 2011; World Bank 2016). The flattening of organisations requires allowing workers greater autonomy while also reducing the responsibility of managers and controllers – something that can prove difficult in developed countries and even more difficult in developing countries (Niebel 2014). The World Bank reports that only a quarter of firms that use ICTs have reinvented their organisational structures, meaning most firms are likely to be underusing their digital resources (World Bank 2016). Dedrick *et al.* (2013) argue that productivity gains from ICT investment depend on 'human resources, openness to foreign investment, cost of service, and the quality of infrastructure'. Higher returns to IT investment occurred in firms with greater IT skills and access to good telecommunications infrastructure, cheaper internet prices and greater inflows of foreign direct investment (FDI) from IT-intensive countries. Furthermore, the fact that it took developing countries longer to achieve productivity gains from ICTs suggests that there may be a minimum threshold of adoption to reach network effects, and of experience and learning before countries can expect to see tangible returns to ICT investments (*ibid.* 2013). The minimum threshold has been referred to in multiple studies looking at the relationships between both ICTs and economic growth and ICTs and productivity, meaning that there are potentially network effects to higher penetration rates (Röller and Waverman 2001; Minges 2015).

Furthermore, the literature suggests that there are often lags between ICT adoption and productivity gains. Brynjolfsson and Hitt (2003) found that computerisation investments led to output and productivity growth in the short term, but even larger returns over the long run. It generally takes organisations time – sometimes years – to restructure their organisational structures and make other complementary investments and innovations, such as new management processes and ways to interact with customers and suppliers to take full advantage of ICTs (*ibid.* 2003). Similarly, a study of Italian SMEs showed that broadband adoption can have a negative effect on firm productivity unless they adopt broadband applications relevant to their operations and make appropriate organisational structural changes (Colombo *et al.* 2013). Beyond one-time structural changes, Haltiwanger *et al.* (2003) attributes the greater productivity of foreign American firms operating in Europe to higher levels of experimentation.

However, there seems to be a revolving door as the most productive firms are the ones most likely to have the absorptive capacity to adopt productive technologies, spurring a similar question to the literature on economic growth (Paunov and Rollo 2015). Is digital technology causing productivity gains or are productivity gains causing digital technology diffusion – or neither? According to the World Development Report (2016),

> A positive productivity correlation in the data might simply capture that more productive firms use digital technology more effectively, indicating that other potentially unobservable firm-specific factors explain the positive correlation between digital technologies and firm productivity.
> (World Bank 2016: 56).

It is possible that the internet is most likely adopted in more affluent countries and regions to begin with, thus leading to endogeneity – the possibility that increases in productivity and internet penetration cause each other or that a third variable causes both of them (Czernich *et al.* 2009).

4 Employment

4.1 Current and future trends of employment and technological change

The effects of digital technology on (un)employment has been the topic of much debate. This section reviews such debates and the evidence that underpins it. MGI (2012) suggests that the internet is a net job creator in both developing and developed countries. Furthermore, MGI suggests that it is a disproportionately greater job creator in its list of 30 'aspiring' developing countries than in developed countries, creating 3.2 and 1.6 jobs per job displaced in aspiring and developed countries respectively. In Ecuador, every 1 per cent increase in broadband penetration was shown to correlate with employment rate growth of 0.056 percentage points (pp) and an unemployment rate reduction of 0.105 per cent, suggesting that the internet generated 85,000 jobs in 2012 alone (Katz and Callorda 2013). Klonner and Nolen (2008) found that the expansion of network coverage is associated with a 15 per cent increase in employment in rural South Africa, with the majority of the employment gains experienced by women – every 10pp increase in internet penetration makes women 4.5pp more likely to be formally employed. Although mobile network expansion did not affect male employment rates overall, it led to a sectorial shift away from agriculture making room for women to do those jobs (*ibid.* 2008). Furthermore, Beard *et al.* (2010) show that internet users are less likely to give up on the job search than non-internet users in the US.

However, recent studies warn that automation-facilitated job displacement rates are expected to accelerate over the next decade (World Bank 2016; MGI 2015; Autor 2014; Brynjolfsson and McAfee 2014; among others). These warnings persist for both developed and developing countries as shown in the World Development Report (2016). Fears of technology displacing workers are not novel. The first instance occurred in nineteenth-century England when the Luddites protested, rebelled and rioted against the machines and the low-skilled low-wage labour that replaced them during the second industrial revolution. Electrification spurred similar despair for John Maynard Keynes in 1931 and so did automation for Isaac Asimov in 1964. Some scholars argue that the fear is misplaced due to society's innate ability to correct the social ills of technological progress in the long run (Davenport and Kirby 2015; Autor *et al.* 2003). Others argue that this time is different because contemporary technological advancements are happening at an accelerating rate and while previous technology-led job displacement affected labour in only a few occupations or sectors, this time technology is permeating into almost all sectors and occupations (World Bank 2016; Brynjolfsson and McAfee 2014; Cowen 2013; among others).

Davenport and Kirby (2015) categorise periods of automation into three eras:

- Era 1 [nineteenth century] when machines replaced dirty and dangerous labour
- Era 2 [twentieth century] when machines replaced dull repetitive work
- Era 3 [twenty-first century] where machines are replacing work related to decision-making.

Indeed, today the threat of automation is not one of simply automating routine non-cognitive tasks as it was in the past. Advancements in cognitive computing and artificial intelligence have begun performing tasks that were once believed to be unique to humans. Brynjolfsson and McAfee project:

> Technological progress is going to leave behind some people, perhaps even a lot of people, as it races ahead... There's never been a better time to be a worker with special skills or the right education… However, there's never been a worst time to be a worker with only ordinary skills and abilities to offer because computers, robots, and other digital technologies are acquiring these skills and abilities at an extraordinary rate.
> (Brynjolfsson and McAfee 2014: 11)

Most scholars seem to agree with Brynjolfsson and McAfee that in the short and medium term technological advancements will lead to an unprecedented displacement of workers. Where scholars tend to diverge is in their projections of what employment will look like in the long run. Kelly (2012) and Autor (2014) – probably among the most optimistic – argue that, just as farmers in the 1800s would have a hard time believing that the majority of the workforce is not working in agriculture today or imagining the type of work done in contemporary society, we are currently going through a similar struggle with automation – we can't imagine what kind of work humans will be doing 100 years from now. Other optimists such as Brynjolfsson and McAfee (2014) argue that we can counter these effects if we learn to 'race with the machines' rather than against them. They emphasise that until the foreseeable future, computers will only be good at executing whatever they are programmed to do. Areas where humans are likely to maintain a significant advantage over computers are ideation, creativity and entrepreneurship. Algorithms are currently not capable of telling a good joke or writing beautiful sonnets. Proponents of this view often refer to a historic free-style chess competition between teams consisting of any combination of human and central processing unit (CPU) players. Teams consisting of both humans and computers were always superior to computers or humans on their own. At the end, a team of two novice human players and three weak computers ended up winning the competition, showing that weak humans and weak machines using better processes are superior to expert humans using powerful machines and an inferior process (*ibid.* 2014).

A similar view is held by Davenport and Kirby (2015). To them the way forward is a relay race where teams of humans and computers pass the baton back and forth through a process of 'augmentation' in which both machines and humans add value to each other's work. For this narrative to unfold, many efficiency-minded organisations will have to drop the idea that humans and machines substitute each other depending on costs. They underscore five ways that individuals may augment technology:

- Where machines do lower-level tasks while humans focus on higher order abstract concerns
- Gaining tacit knowledge that cannot be codified and replicated by computers
- Becoming a programmer who can fix mechanical issues and step in when machines go wrong
- Specialising in a very narrow topic that would not be economical to automate; and
- Becoming a designer, constructor, investor and builder of new automation technologies.

One setback of Davenport and Kelly's (2015) augmentation techniques is that they seem to require a high level of skill – and potentially education – that put such techniques and 'racing with the machines' techniques beyond the reach of the poor and marginalised (Cowen 2013). In his book, *Average is Over,* Tyler Cowen (2013) projects a future dominated by a small wealthy elite coexisting with a mass body of poor people. In his projection only a small group of winners – 15 per cent of the population – which he calls the 'hyper-productive', will be able to 'race with the machines' or manage and market people who do. Cowen claims that income polarisation exacerbated by automation will lead to the disappearance of 'the average person' as it had already began to do so in the post-recession job market. Then, the

US and other advanced economies saw a hollowing out of the middle class, with higher earnings going to people able to leverage new technologies, and lower earnings to those unable to adapt to them. Cowen argues that today and increasingly in the future not having the right training or profile will shut people out of employment opportunities.

Similarly, another future of work pessimist, the former US Treasury Secretary Lawrence Summers (2014) says that 'the economic challenge of the future will not be producing enough. It will be providing enough good jobs'. He also compares what is happening today to what happened with agriculture production over the past century but he comes to a different conclusion. Agriculture employed 85 per cent of the global workforce in 1800 but only 33.5 per cent in 2010 and as low as 5 and 2 per cent in the OECD and US/UK respectively. Today, the pace of technological acceleration makes Summers and others sceptical about society's ability to produce good jobs at the rate that they are being displaced. He further warns that while this is happening, 3-D printing, robotics, voice-automated technologies, driverless cars, algorithms that write news stories, etc. are still in their infancy and will likely further disrupt employment. To sum up his fears:

> This time around, change will be faster and affect a much larger share of the economy. Workers leaving agriculture could move into a wide range of jobs in manufacturing or services. Today, however, there are more sectors losing jobs than creating jobs. And the general-purpose aspect of software technology means that even the industries and jobs that it creates are not forever.
> (Summers 2014)

The debate on the implications of technological advance on employment is mostly western-centred. The most recent World Development Report (2016) suggests that there is also reason to be pessimistic about technological advance in developing countries. 'From a technological standpoint, two-thirds of all jobs are susceptible to automation in the developing world, but the effects are moderated by lower wages and slower technology adoption' (World Bank 2016: 129). However, increasing wages and the increasing rate of technology adoption make automation a probable issue in the long run. Although fewer jobs – 50 to 60 per cent – are susceptible to automation in the US, Europe and other advanced economies, the threat there is worse because wages and technological adaptation are higher, making automation more economical and easier (*ibid.* 2016). This gives developing countries more time to put in place policies to mitigate the risks associated with automation and to prepare their people for the future of work. However, this trend is not found in all countries. For example, China has experienced an increase in routine employment due to the mechanisation of agriculture. Many countries in Latin America have also not seen an increase in routine work thanks to a commodity-driven boom that has placed a high demand on low-skilled labour (*ibid.* 2016).

4.2 Employment on the internet

4.2.1 Online outsourcing

The internet has brought with it a new wave of outsourcing which has been identified as a big opportunity for employment in developing countries. Online Outsourcing (OO) is defined as 'the contracting of third party workers and providers – often overseas – to supply services or perform tasks via internet-based marketplaces or platforms' (World Bank 2015: 1). There are two common forms of online outsourcing. Microwork involves tasks requiring basic numeracy, literacy and digital skills that can easily be broken down into smaller tasks and completed within hours or days. Barriers to entry for microwork are low and workers are paid low wages in comparison to online freelancing. Online freelancing is the contracting of individuals with professional or technical skills via the internet to perform large projects over an extended period of time – sometimes months.

Individuals performing microwork and freelancers often find their work on online platforms such as Upwork, Amazon Mechanical Turk and Crowdflower. For both microworkers and freelancers, there are two primary archetypes of platforms to find work. Open services platforms allow employers and employees to negotiate directly. Managed services platforms act as intermediaries between employees and employers, often in a physical location, and provide employees with counselling and training, and quality control for clients. It has been widely noted that workers in the OO sphere often lack the benefits and safety nets that typically come with formal employment – at least in developed countries – including severance pay, unemployment benefits and health insurance (Dalberg 2013a; World Bank 2016, 2015). Furthermore, there are some significant biases and inequalities between users who can and cannot get OO work. Most of the work comes from four anglophone countries, meaning that mostly English speakers can exploit this work. There is also a gender bias, with men more likely to work in OO than women. Furthermore, significant knowledge and skills usually associated with a tertiary education are required for freelancing, which is substantially higher paid than microwork (*ibid.* 2015).

4.2.2 Impact outsourcing

The Rockefeller Foundation, Dalberg (2013a) and the World Bank (2015) have been pushing the idea of impact outsourcing. Impact outsourcing initiatives seek to 'build BPO [Business Process Outsourcing] businesses that target historically disadvantaged individuals for employment' (Dahlberg 2013a: 4). These businesses would fall under the managed services OO platforms because intermediary companies such as Samasource hire, train, console and manage promising disadvantaged youths in-house. According to Dahlberg, these jobs are capable of transforming the lives of marginalised youths and their families because wages are typically 40 to 200 per cent greater than what they could receive elsewhere and these opportunities provide them with the skills and experience necessary to gain future employment and schooling.

Dahlberg (2013a) mentions that youths employed through these schemes are likely to be high school and university graduates from marginalised neighbourhoods or backgrounds who lack the functional and behavioural skills to enter the formal workforce. However, given that these 'marginalised youths' have been able to obtain a formal secondary and/or tertiary education, they are by definition not the most disadvantaged. There are still literacy and educational barriers to participating in the scheme, which leaves out the most disadvantaged and vulnerable. There is also doubt whether these jobs are likely to provide sustainable employment since the jobs created are routine, low-skilled, call-centre type jobs. These kinds of jobs are currently susceptible to automation. Impact outsourcing relies on large multinationals looking to cut costs by hiring low-wage labour and at the same time make an impact on the lives of marginalised youths. However, as Brynjolfsson *et al.* (2014) warn:

> The growing capabilities of automation threaten one of the most reliable strategies that poor countries have used to attract outside investment: offering low wages to compensate for low productivity and skill levels. And the trend will extend beyond manufacturing. Interactive voice response systems, for example, are reducing the requirement for direct person-to-person interaction, spelling trouble for call centers in the developing world… In more and more domains, the most cost-effective source of 'labor' is becoming intelligent and flexible machines as opposed to low-wage humans in other countries.
> (Brynjolfsson *et al.* (2014)

Kelly (2012) also makes similar projections, claiming that offshoring is only the first step to robotisation because over time robots become cheaper than human labour abroad. There is also the potential threat of sequential offshoring common in manufacturing in which as

wages rise in one country, operations are moved to another country with lower wages to keep costs down, creating a 'race to the bottom' where countries compete for limited employment opportunities by lowering wages and taxes (World Bank 2015). Furthermore, it is unlikely that impact outsourcing will help participants develop digital content creation skills given that these job placements mainly focus on using ICTs to service the clients of multinationals. SMEs are more likely to outsource complex functions when they don't have those capabilities in-house through freelancing and they make up 80 per cent of freelance contractors. Multinationals on the other hand, are less likely to outsource complex functions and more likely to outsource lower functions in the value chain through microwork (World Bank 2015). As projected by the future of employment optimists and pessimists alike, the biggest winners in the future are likely to be those able to use the technologies to augment their abilities or who have the capacity to create new ones – not those susceptible to being substituted by automation. Just because an occupation utilises ICT does not make it irreplaceable by ICT. In fact, some tasks that heavily required the use of computers and ICT in the past such as travel agents have nearly disappeared due to automation (Brynjolfsson and McAfee 2014).

Box 4.1 Assessing 'digital job' impact outsourcing using value chain, middle-income trap, and economic complexity literature

Although the middle-income trap literature has mainly focused on the production of physical goods, it may provide some lessons for service jobs based on ICT. Because the Rockefeller Foundation's Digital Jobs Africa initiative focuses mainly on the use of managed services platforms that connect multinationals to local marginalised youths, it is unlikely that these youths will be performing high-value functions, making them unlikely to develop the 'know-how' needed to innovate, design or generate content using ICT. Firms in the Brazilian shoe industry overcame this issue by creating parallel national and regional value chains that do not threaten the foreign lead firm's markets. This allows the local firms to begin experimenting and developing higher-level functions while maintaining their relationship with the foreign firm. Maintaining the relationship with the global lead firm allows them to continue learning from them and provides the local firm with a finance stream for other activities (Navas-Alemán 2011). There seems to be nothing of this nature on the Digital Jobs Africa agenda, but it may be worthwhile seeing how these call centres can become a gateway for local innovation and design capability building.

Economic complexity theory is another potential point of reference for impact outsourcing efforts. This theory has recently gained traction because it has proven to be a far better predictor of economic growth than other predictors including measures of governance and institutional quality, measures of human capital, and the global competitiveness index (Hausmann *et al.* 2014). It suggests that the economic growth of a society is contingent on the amount and diversity of its societal know-how – what it knows how to do – and the ability to bring these capabilities together through firms and 'value networks'. The key to having a large amount of capabilities is to have a very diverse know-how dispersed among many individuals. Thus, it advocates a widespread acquirement of capabilities – as many as possible – and is thus in contradiction to previous economic theories advocating comparative advantage.

The product-space is a centrepiece in complexity theory and maps all the products that an economy is able to produce, giving insight into which products a society may potentially produce based on similarities to products it already produces. Complex products are products that only a few countries are able to produce because they require a rare combination of many capabilities. Ubiquitous products are typically simple products that many countries produce and require very little know-how. Complex economies are those that are able to produce many products including a wide range of complex ones. According to Hidalgo and Hausman (2009), economies are most likely to grow when they have a lot of capabilities relative to their income level. This usually means that all potential capability combinations have not been fully exploited. To my knowledge, no work has been done on the relationship between the internet and economic complexity, or on whether the internet plays a role in adding new capabilities or bringing them together to expand the product space.

Complexity theory suggests that you could not cut and paste an entire industry into a country (Hidalgo and Hausmann 2009). If local digital know-how does not exist, then it is unlikely that a country, city or village will attract a multinational to outsource its digital jobs to it or to have the human resources needed to train employees to perform digital jobs, thus limiting the number of countries that could potentially attract such opportunities. Furthermore, if the prior obstacle is overcome, it is not safe to assume that increasing the service calling industry – a rather ubiquitous and simple industry – will automatically lead to the spurring of new jobs, firms and industries in more complex ICT functions and local content production unless young people are gradually encouraged and supported to develop 'know-how' well beyond that required in their positions.

Having to depend on a multinational that is disconnected from the local setting and keeps its most profitable and higher value-added functions in-house is not likely to induce the development of skills associated with higher value functions. Locally sourced initiatives that seek to place marginalised youths with local tech organisations may be better placed to overcome these obstacles. For example, Laboratoria is a social enterprise that specifically trains the most disadvantaged group of Latin American youths – uneducated young women, many of whom don't know what a web browser is before training – to become computer programmers (MIT Review 2015). They graduate with advanced digital skills, including the ability to create content and platforms and thus higher value skills than those acquired by participants in Digital Jobs Africa. However, it is possible that a big part of Laboratoria's viability is that it currently only operates in cities with booming tech sectors – Santiago, Lima and Mexico City – where they are able to pair their girls with local tech employers after graduation.

5 Inequality

5.1 Inequality between users of digital technology

Although the internet is often heralded as the great equaliser, it has left many behind in both developed and developing countries. More than 4 billion people currently lack access to the internet (World Bank 2016). Looking beyond aggregate numbers of access, digital inequality persists between those who are able to access the internet. In developed countries where digital technologies are near-ubiquitous, digital inequality is prevalent between the 'haves' and 'have-mores' (MGI 2015). The 'haves' have a tough time staying current with digital technologies while individuals, firms and sectors that 'have-more' operate at the frontier of digital technologies, are the first to reap benefits of new technologies and push the boundaries while capturing significant gains relative to the 'haves' in terms of market share and income growth (*ibid.* 2015).

Given that internet penetration levels tend to be much lower in developing countries, developing countries generally confront a double issue. People within developing countries face digital inequality between those who don't have access to digital technology and those who do, as well as inequality between the 'haves' and 'have-mores.' For example, inequality between those who have no phone and those who do; between those with basic phones and owners of smartphones with more productive apps, functions and operating systems; between those who consume content and those who create content or new platforms; between those who have autonomy over their access and those who access digital technology via shared means; between those who live in areas with good signal coverage and those who live beyond the reach of the internet. Furthermore, digital inequalities often mirror analogue ones. This literature review is concerned with economic inequality exacerbated by digital technology. For a quick overview on how users experience digital inequalities see Ramalingam and Hernandez (2016).

5.2 Inequality exacerbated by digital technology in developed countries

Although countries seem to be converging in terms of GDP per capita in the last few decades, within-country inequality has been on the rise (Moore and Justino 2015). Inequality in this literature review refers to within-country inequalities rather than inequalities between countries. In their seminal book *The Second Machine Age*, Brynjolfsson and McAfee (2014) make a compelling case for how advancement in digital technology is the major driver of increasing 'the spread' – inequality – within developed countries today. They uncover four mechanisms driving this phenomenon.

Firstly, the digitalisation of analogue functions can lead to the establishment of companies with a small number of very well paid employees displacing large analogue companies employing many middle-income workers. One extreme case is the one of Instagram compared to Kodak. Instagram – and other social media platforms – have become the major sharing points for photography. Facebook bought Instagram for US$1 billion despite employing only 13 people. Kodak on the other hand was once a key player in photo development but was unable to remain competitive with digital photography because of its better quality and the cost savings associated with not having to buy film or send photos to a lab, and the ability to make and share digital copies of photos at zero marginal cost instantaneously. 'Photography is not an isolated example of this shift. Similar stories have been and will be told… in almost every industry' (Brynjolfsson and McAfee 2014: 137). Developing algorithms and digital products that can replace analogue ones only requires a

small number of designers and can be replicated and distributed to millions of users at almost zero cost.

Secondly, they argue that the Digital Revolution has created a set of disproportionate winners who have accumulated the right non-human and/or human capital. Individuals with the right accumulation of non-human capital include property owners (intellectual, equipment, financial assets, etc.) related to the production of digital technologies. People with the right accumulation of human capital include those with engineering, creative and design skills who have seen their demand increase through 'skill-biased technical change' in which the middle class has been hollowed out through the automation and decrease in demand of middle-skilled jobs while the demand for high-skilled labour has increased (*ibid.* 2014). According to Brynjolfsson and McAfee, the biggest gap has occurred between the best in their fields – superstars – and all other workers. There has been an enormous widening between pay-outs to the top person in a field and the second best. Digital technology has led to both an increase in inequality between people at different ends of the income distribution and increasing inequality between those at the top of the income distribution and those at the very top. Today's superstars are able 'to leverage their talents via digitization and globalization' to reach a massive audience through multiple channels and formats, something that historical superstars were unable to do (Brynjolfsson and McAfee 2014: 151). They argue that we are increasingly moving from skill-biased technological change to superstar-biased technological change in the global economy (Brynjolfsson *et al.* 2014).

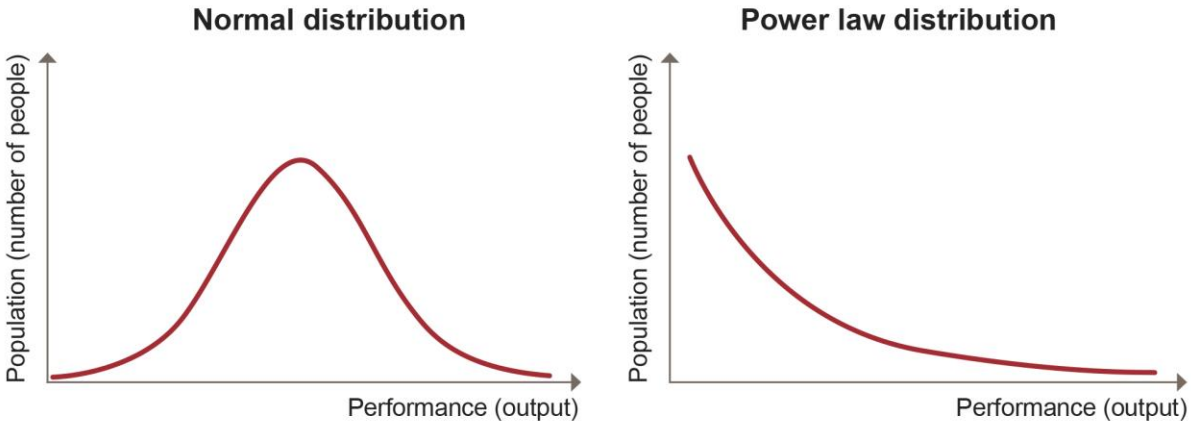
Thirdly, digital technology leads to winner-takes-all – or in some cases winner-takes-most – markets when digital service providers are able to squeeze out the second best and all subsequent providers because consumers will generally choose the top-quality provider, all else being equal, especially if the product is free and available instantly. Today, digital service providers are able to overcome capacity and transportation constraints that limited market-share growth in the past through the use of cheaply replicated digital technology allowing them to deliver services at little or no marginal cost. Improvements in telecommunications and transportation – globalisation – make it easier for winners to increase their market-share and create a global market for their goods. Furthermore, when an app or digital service gains traction in terms of the number of users it has, it can achieve 'network effects' – meaning that the app or digital service becomes more attractive and useful the more its user-base grows, further creating barriers to entry and potential lock-ins (Brynjolfsson and McAfee 2014).

The fourth mechanism uncovered by Brynjolfsson and McAfee (2014) is the evolving skillset that can be automated. The skillset susceptible to automation is dynamic and rapidly increasing, putting evermore employees at risk of being replaced by machines that can perform their jobs better and at lower cost. Automation has most rapidly replaced workers performing routine tasks regardless of whether these are manual or cognitive. Non-routine well-paid cognitive jobs – and even non-routine manual jobs – have held up relatively well. This leads to a polarisation of the workforce in which the demand and wages for workers in non-routine well-paid cognitive jobs are increasing while the demand and wages for workers performing routine tasks are decreasing.

According to Brynjolfsson and McAfee, the aforementioned mechanisms have led to the 'great decoupling' of productivity and median wages that persisted before the Digital Revolution. In the past, median wages and productivity rose accordingly. Today, although productivity and total wealth are increasing, the median workers' income remains stagnant or is actually decreasing, leaving a majority of people worse off than they were before. 'Fewer people are working, and wages for those who are working are lower than before. As a result, while labor compensation and productivity in the past rose in tandem, in recent years a gap has opened' (Brynjolfsson and McAfee 2014: 145). Furthermore, Brynjolfsson *et al.* (2014)

suggest that this phenomenon is leading to a shift from bell-shaped – normal – income distribution to one that resembles a Pareto distribution or power-law distribution (see Figure 5.1).

Figure 5.1 Normal and power-law distributions



Source: Adapted from Brynjolfsson and McAfee (2014).

5.3 Inequality exacerbated by digital technology in developing countries

Most of the literature concerning the effects of advancing digital technology on inequality – including Brynjolfsson and McAfee – tend to focus on developed countries (Autor 2014; Atkinson 2014; Atkinson 2015; Brynjolfsson and McAfee 2014; Cowen 2011; Cowen 2013; Gordon 2012; among others). There have been multiple books written about technology's effect on the skills premium and inequality in developed countries in recent years. Yet literature of the same phenomenon in developing countries is scant. Just as there is reason to be pessimistic about the outlook of employment in developing countries, the World Development Report (World Bank 2016) and other studies give us reason to be pessimistic about the outlook for inequality in developing countries due to technological change. Since 2000, the share of national income earned by workers has decreased in both developed and developing countries, driven primarily by a decreasing share of income earned by workers performing routine codifiable tasks. Thus, polarisation is also occurring in developing countries.

The International Monetary Fund (2007) argued that although technological advancement has contributed to raising the incomes for all population segments in almost every region, it was also the biggest contributor to within-country inequality around the world between 1985 and 2004. The study put technological advancement above other commonly cited inequality-inducing mechanisms including trade and financial globalisation. The study also points to FDI as one of the driving forces behind increasing the skills premium and thus inequality. Inward FDI increases the demand for skilled labour in developing countries while outward FDI decreases the demand for relatively lower-skilled labour in developed countries. The study was carrying a strong narrative that although inequality was rising, most people were better off than before due to rising incomes all around.

Recent literature, however, points in another direction – one in which technology is not lifting most boats and some are sinking. Dabla-Norris *et al.* (2015) find that technological change is increasing the skills premium in both developed and developing countries and suggest that while globalisation further reinforces the skills premium in developed countries, financial deepening does so in developing ones. Karabarbounis and Neiman (2014) show that the

global share of wealth going to labour decreased between 1975 and 2012 in a majority (42) of the 52 countries they studied, including developing countries, despite increases in business earnings and corporate savings. They suggest that at least half of the observed decrease can be attributed to technological advancements lowering the price of investment [of machines] relative to labour, incentivising businesses to switch from human labour to capital. Brynjolfsson *et al.* (2014) use Apple operations in China as an example to illustrate how this is happening. Apple's assembly company in China [Foxconn] heavily relies on low-skilled labour to perform very repetitive tasks – e.g. combining two parts of a keyboard. Foxconn has already begun displacing these workers with robots. Although globalisation brought Apple manufacturing jobs to China due to low labour prices, these jobs are now being squeezed out by machines capable of doing the same work at a lower relative hourly rate without the need to take breaks or go home to sleep. However, how far advances in digital technology affect the skills premium is likely to vary from country to country. It is important to quantify the effects of digital technology on the skills premium in any given country. Knowing the extent of current and potential automation may put us in a better position for the next wave of automation.

5.4 When does job polarisation occur?

Recent evidence suggests that job polarisation may not happen gradually but in cyclical waves during recessions. In the US for example, most of the middle-skilled job loss – 88 per cent – in the last few decades occurred during or within 12 months of a recession (Jaimovich and Siu 2012, 2015). After recessions, aggregate employment has recovered much more slowly for routine middle-skilled jobs and much faster for non-routine low- and high-skilled occupations and aggregate output. The same phenomenon has been observed in western European and other developed countries (*ibid.* 2015; Gaggl and Kaufmann 2015), but has yet to be studied in developing countries. After recessions firms are more likely to seek candidates with more experience and higher levels of educational attainment. Upskilling and jobless recovery are most concentrated in routine jobs susceptible to being replaced by automation (Jaimovich and Siu 2015; Hershbein and Kahn 2016). Furthermore, firms that upskilled during the great recession were also most likely to invest in automation. One plausible explanation for investing in ICT capital for routine tasks during economic downturns is that purchasing ICT is relatively cheaper than re-hiring workers and is seen as a substitute for routine labour. On the other hand, a greater non-routine skill level is needed to complement the newly acquired digital technology, thus incentivising firms to keep and hire workers with non-routine skills (Gaggl and Kaufmann 2015).

Increasing inequality and decreasing shares of labour can be problematic for economies. Dabla-Norris *et al.* (2015) find that in situations where the income share of the top 20 per cent increases by 1pp, GDP tends to decline by 0.08pp; when the income share of the bottom 20 per cent increases by 1pp, GDP tends to increase by 0.38pp. Thus, the economic empowerment of the poor seems to be more important for growth while increasing the share going to the rich stalls or reverses growth. Many others have argued that high inequality is bad for economic growth and the sustainability of growth (*see* section 3.1.2 in Moore and Justino 2015). High levels of inequality can negatively affect human capital, market efficiency and the middle class's demand capacity, thus shrinking internal markets for manufactured and consumer goods. Furthermore, high levels of inequality are associated with many social ills including conflict, political instability, limited individual occupational and educational choices, bad health outcomes for the poor and a lack of social cohesion, limited social mobility and collective action (*ibid.* 2015).

As mentioned in the previous section, skills-biased technological change has not occurred in every country. Where the demand for medium- and low-skilled labour has not increased, however, digital technology tends to have a 'skills bias' in which it increases the work prospects and wages of those with the skills to perform non-routine cognitive work while

replacing workers performing routine tasks. At the moment automation barely affects the work prospects and wages of non-routine low-skilled workers. However, many warn that in the long run as mid-level jobs in services continue to be automated and workers begin to swarm into non-routine low-skilled work – such as carpenters, hairdressers, gardeners, etc. – an oversupply of people willing to do these jobs will lead to a dip in wages for these occupations too (World Bank 2016; Summers 2014; Cowen 2013; Brynjolfsson and McAfee 2014; Autor 2014). The figure below illustrates projections for demand and earnings of different types of work in the future. Apart from being skills-biased, there is also evidence that the technological change is also age-, gender- and education-biased. The young, wealthy people, and men are more likely to be able to adapt to new technologies while the poor, older people and women are most likely to be left behind because they are less likely to have the complementary and ICT skills in demand (World Bank 2016). Furthermore, studies are showing a decrease in return to experience as skills for older – senior – workers are beginning to become obsolete, which will be especially challenging for countries with aging populations.

Table 5.1 Expected impacts of technological change on employment and earnings

Type of occupation (by skills intensity)	Expected impact on	
	Employment	**Earnings**
Non-routine cognitive	Positive	Positive
Routine cognitive and manual	Negative	Negative
Non-routine manual	Positive	Negative

Source: World Bank (2016) based on Autor (2014)

6 Conclusion

This review has summarised the evidence and key debates concerning the effects of digital technology on economic growth, productivity, employment and inequality. Although there are very well-established correlations between economic growth and ICT uptake – especially at the macro level – it remains inconclusive whether the internet causes growth or whether growth causes ICT uptake. The same can be said about the correlations between ICT uptake and productivity. Some reviews and reports claim that others have found a causal link between economic growth in contradiction to the original sources which clearly state that they have not been able to establish a causal relationship. The World Economic Forum (2015: 32) for example cites Minges (2015), Qiang *et al.* (2009) and Scott (2012) as studies 'demonstrating the causal impact of ICTs on growth'. However, the respective studies state the contrary. Qiang *et al.* were not able to prove causality using econometric tests and Scott (2012) did not have time to test causality, leading both studies as well as Minges (2015) to stress that causality is yet to be resolved. They all mention that it is still possible that economic growth causes internet penetration rather than the other way around, that they both cause each other simultaneously, that they may be caused by a third unobserved variable, or that the relationship is sporadic.

Researchers and policymakers must be wary of taking what is said in literature reviews and reports at face value since although they aggregate sources that have been peer-reviewed, they themselves tend to not be peer-reviewed. Moreover, the correlations between economic growth and ICT uptake as well as ICT uptake and productivity tend to be highly heterogeneous, with some countries, regions and sectors showing stronger correlations than others, and some barely showing a correlation at all. Section 2.1.1 shows that the effect seems to be weaker in Panama than it is in Ecuador or China, while the Philippines and Senegal did not show much of a correlation. Moreover the table in 2.1.1 shows that the effect seems to be larger in Latin America and the Caribbean than in the OECD as well as in developing countries when compared with developed ones. Further, the aforementioned Qiang *et al.* (2009) and Scott (2012) studies need to be updated to reflect the ICT technologies available today. There is a lack of studies that measure the impact of switching mobile phone network speeds (from 2G to 3G or from 3G to 4G, for example). Studies measuring the economic impact of ICTs should be updated periodically in order to reflect the array of technologies available at any given moment or at least to help policymakers make a decision about whether the upgrade is worth it.

Moreover, the mechanisms by which ICTs are expected to spur economic growth are mostly mentioned in passing without much effort to quantify if and to what extent they are occurring and/or if they facilitate growth and under what conditions. Although the literature has suggested the potential of countries leapfrogging with digital technology, evidence does not yet support this claim. The evidence is also inconclusive on whether digital technologies lead to poverty reduction. ICTs have been shown to be correlated with poverty reduction in some contexts, but have also been shown to divert spending from essential resources, further placing financial burden on the poor in other contexts; poor people don't always seem to use them for economic purposes. Therefore, it is difficult to argue that ICT uptake automatically leads to poverty reduction. If it does, it is likely to occur under the right circumstances.

We seem to be past the days of Solow's Paradox in which there was no clear relationship between productivity and ICT uptake. ICTs were not showing up in the productivity statistics of developing countries for a long time, but that has now changed and they now tend to show a stronger relationship than developed countries. However, the causality issue emerges here as well. There seems to be a revolving door where more productive firms are

more likely to have the absorptive capacity to adopt productive technologies. As the 2016 World Development Report says:

> A positive productivity correlation in the data might simply capture that more productive firms use digital technology more effectively, indicating that other potentially unobservable firm-specific factors explain the positive correlation between digital technologies and firm productivity.
> (World Bank 2016: 56)

Productivity and ICT adoption correlations tend to be heterogeneous between countries, within countries, between sectors, within sectors, and between firms that do and do not export. There also seems to be a lag between the investment and productivity gains. Firms unable to complement technologies are generally unable to extract as many gains as those that restructure their organisational charts and upgrade their skill levels. Generally, the literature on the impact of ICTs on economic growth and productivity tend to be concentrated at the macro level. However, when these studies are juxtaposed against studies at the micro level, some of their assumptions seem to break down. Although there are examples of micro-entrepreneurs gaining from ICTs, there is also evidence that many micro-entrepreneurs choose not to use mobile phones for business purposes even if they own one. Mobile phones seem to have tackled information asymmetries in some markets and regions, but Jagun *et al.* (2008) provides an example of mobile phones further entrenching intermediation and inequalities between those with and those without information. Thus, although ICTs have the potential to overcome information asymmetries, they cannot be assumed to do so automatically. Deeper understandings of the context receiving ICTs may help policymakers understand whether ICTs alone will overcome information asymmetries and growth barriers or if further steps need to be taken for mobile phones to overcome pre-existing inefficiencies. Moreover, studies on the impact of ICTs on economic growth and productivity overemphasise access over use. Individuals or firms using the technology once in 365 days are typically counted as equal users to those using digital technologies all 365 days of the year. Understanding how increased use of ICTs affects growth and productivity may give us a better understanding of their 'transformative potential' and a better understanding of the digital divide in general.

There is an ongoing and unresolved debate between scholars on the importance of the Digital Revolution in terms of productivity and improvement in living standards. One group of scholars including Eric Cowen and Robert Gordon argue that productivity is on the decline while another group including Erik Brynjolfsson, Andrew McAfee and Kevin Kelly argue that productivity is being underestimated because measurements and workers are unable to keep up with the technology and because we are unlikely to have seen the real productivity gains from the Digital Revolution. This debate remains quite speculative and only time will tell.

Although past anecdotal evidence has shown ICTs to be a net job creator, there are fears of widespread job dislocation in the near future both in developed and developing countries with a majority of jobs in the world susceptible to automation (World Bank 2016). The ability of ICTs to perform new tasks is accelerating at an unprecedented rate and machines are increasingly creeping into tasks that were once seen as 'human'. Here the debate tends not to be about whether there is a threat of automation, computerisation and robotisation, but more about society's ability to recreate good jobs in the long run. On the one hand Tyler Cowen and Lawrence Summers warn of a future of mass unemployment and high inequality. On the other hand, Erik Brynjolfsson, Andrew McAfee and Kevin Kelly project a future in which humankind will be able to race with machines and augment each other's work, performing tasks that will be different from anything we can imagine today. This is once again a speculative debate and only time will tell. However, if digital technology is to continue progressing at the rate it is expected to, policymakers may want to consider

strategies to race with the machines and achieve augmentation. At the moment, these strategies seem constricted to a small fraction of society that is capable of complementing machines, but this need not be the case in the future.

As well as changing the traditional way of work, the internet has given new ways of working and new employer–employee relationships. Remote microwork and freelancing over the internet have been identified as an opportunity for developing countries. However, online outsourcing employment outcomes tend to be heavily unequal. The majority of work comes from anglophone countries, placing a barrier on non-English speakers, and the majority of freelance work requires a high level of expertise which is often only attainable with a tertiary degree. Impact outsourcing for digital jobs is being promoted as a way of bringing marginalised youths into the workforce and providing them with 'ICT jobs'. Although these youths are labelled 'marginalised', there are high barriers to entry for the most marginalised to participate in the programme, including a secondary education and [digital] literacy skills. Moreover, policymakers should be aware that a reliance on call centre outsourcing on its own is unlikely to help youths develop higher-level ICT skills related to innovation, design, programming and content creation. A greater emphasis should be placed on the ability to develop the types of skills that will be in demand in the future of work, those that allow workers to complement machines rather than perform tasks that may soon be automated.

Digital technologies seem to have increased inequality through the digitalisation of analogue functions, the facilitation of disproportionate winners and superstars, the creation of winner-takes-all markets, and an evolving skillset susceptible to automation. These mechanisms have led to a decoupling of wages and productivity and a shift in the distribution of wages in developed countries into the hands of fewer people (Brynjolfsson and McAfee 2014). Although most of the literature concerned with digital technology's effect on income inequality tends to focus on developed countries, evidence is now surfacing showing the same relationship in developing countries. Technological change also seems to be leading to an increasing skills premium and a hollowing out of the middle class in most developing countries studied (Karabarbounis and Neiman 2014). Evidence from developed countries suggests that automation and increasing skills premiums occur in waves during and right after recessions rather than gradually (Jaimovich and Siu 2015; Gaggl and Kaufmann 2015). This relationship has not been studied in developing countries. It would be useful to know if the same phenomenon persists in developing countries. Knowing whether it does could help prepare policymakers for the next and subsequent financial downturns as well as help them avoid implementing policies that have the potential to accelerate the automation of jobs.

References

Accenture (2013) *Defining Digital, Technology's Current Tower of Babel*, Accenture.com, www.accenture.com/us-en/blogs/blogs-defining-digital-technologys-tower-babel (accessed 7 March 2016)

Andreessen, M. (2011) 'Why Software Is Eating the World', *Wall Street Journal*, 20 August, www.wsj.com/articles/SB10001424053111903480904576512250915629460 (accessed 16 March 2016)

Aker, J. (2008) *Does Digital Divide or Provide? The Impact of Cell Phones on Grain Markets in Niger*, Center for Global Development Working Paper 154, Washington DC: Center for Global Development, Tufts University

Atkinson, A. (2015) *Inequality: What Can Be Done?*, Cambridge MA: Harvard University Press

Atkinson, A. (2014) 'After Piketty?', *The British Journal of Sociology* 65.4: 619–38

Autor, D. (2014) 'Skills, Education, and the Rise of Earnings Inequality among the "Other 99 Percent"', *Science* 344.6186: 843–51

Autor, D.; Levy, F. and Murnane, R. (2003) 'The Skill Content of Recent Technological Change: An Empirical Exploration', *The Quarterly Journal of Economics* 118.4: 1279–333

Beard, T.; Ford, G.; Saba, R. and Seals Jr, R. (2010) *Internet Use and Job Search*, Auburn University Department of Economics Working Paper Series 2010(07), Auburn AL: Auburn University

Boateng, R.; Hinson, R.; Galadima, R. and Olumide, L. (2014) 'Preliminary Insights into the Influence of Mobile Phones in Micro-trading Activities of Market Women in Nigeria', *Information Development* 30.1: 32–50

Bresnahan, T. and Trajtenberg, M. (1995) 'General Purpose Technologies "Engines of Growth?"', *Journal of Econometrics* 65: 83–108

Brynjolfsson, E. (1993) 'The Productivity Paradox of Information Technology', *Communications of the ACM* 36.12

Brynjolfsson, E. and Cowen, T. (2011) 'Tyler Cowen vs. Erik Brynjolfsson: Can Technology Be Society's Economic Engine?', Video, Forbes.com, www.forbes.com/sites/techonomy/2011/11/15/tyler-cowen-vs-erik-brynjolfsson-can-technology-be-societys-economic-engine/#6eeb52805120 (accessed 8 March 2016)

Brynjolfsson, E. and Hitt, L. (2003) 'Computing Productivity: Firm-Level Evidence', *Review of Economics and Statistics* 85.4: 793–808

Brynjolfsson, E. and McAfee, A. (2014) *The Second Machine Age*, New York: W.W. Norton & Company Inc.

Brynjolfsson, E.; McAfee, A. and Spence, M. (2014) ‘New World Order: Labor, Capital and Ideas in the Power Law Economy,’ *Foreign Affairs*, from the anthology *The Fourth Industrial Revolution*, www.foreignaffairs.com/articles/united-states/2014-06-04/new-world-order (accessed 7 March 2016)

Burrell, J. and Oreglia, E. (2015) ‘The Myth of Market Price Information: Mobile Phones and the Application of Economic Knowledge in ICTD’, *Economy and Society* 44.2: 271–92

Chew, H.; Levy, M. and Ilavarasan, V. (2011) ‘The Limited Impact of ICTs on Microenterprise Growth: A Study of Businesses Owned by Women in Urban India’, *Information Technologies & International Development* 7.4: 1–16

Clarke, G. and Wallsten, S. (2006) ‘Has the Internet Increased Trade? Developed and Developing Country Evidence’, *Economic Inquiry* 44.3: 465–84

CNET (Computer Network) (2015) *Your Smartphone Will Be Faster in 2016, Just Not Insane 5G Fast*, CNET, www.cnet.com/news/your-smartphone-will-be-faster-in-2016-just-not-insane-5g-fast/ (accessed 7 March 2016)

Colombo, M.; Croce, A. and Grilli, L. (2013) ‘ICT Services and Small Businesses’ Productivity Gains: An Analysis of the Adoption of Broadband Internet Technology’, *Information Economics and Policy* 25.3: 171–89

Commander, S.; Harrison, R. and Menezes-Filho, N. (2011) ‘ICT and Productivity in Developing Countries: New Firm-Level Evidence from Brazil and India’, *Review of Economics and Statistics* 93.2: 528–41

Cowen, T. (2013) *Average is Over*, New York: Penguin Group

Cowen, T. (2011) *The Great Stagnation*, New York: Dutton

Coyle, D. (2014) *GDP*, Princeton: Princeton University Press

Czernich, N.; Falck, O.; Kretschmer, T. and Woessmann, L. (2009) *Broadband Infrastructure and Economic Growth*, CESIFO Working Paper 2861, Center for Economic Studies Information and Forschung (CESIFO), University of Munich

Dabla-Norris, E.; Kochhar, K.; Suphaphiphat, N.; Ricka, F. and Tsounta, E. (2015) ‘Causes and Consequences of Income Inequality: A Global Perspective’, *IMF Staff Discussion Notes* 15.13

Dalberg (2013a) *Digital Jobs in Africa: Catalyzing Inclusive Opportunities for Youth*, www.dalberg.com/documents/Digital_Jobs_in_Africa.pdf (accessed 7 March 2016)

Dalberg (2013b) *Impact of the Internet in Africa*, www.impactoftheinternet.com/pdf/Dalberg_Impact_of_Internet_Africa_Full_Report_April2013_vENG_Final.pdf (accessed 7 March 2016)

Davenport, T. and Kirby, J. (2015) ‘Beyond Automation’, *Harvard Business Review*, June 2015

de Silva, H. and Zainudeen, A. (2006) ‘Perceived Impacts of Access to Telecom at the Bottom of the Pyramid’, Living the Information Society: The Impact of Information and Communication Technologies on People, Work and Communities in Asia, Makati City, Philippines, 23–24 April 2006, http://ssrn.com/abstract=1555616 or http://dx.doi.org/10.2139/ssrn.1555616 (accessed 30 September 2016)

Dedrick, J.; Kraemer, K. and Shih, E. (2013) ‘Information Technology and Productivity in Developed and Developing Countries’, *Journal of Management Information Systems* 30.1: 97–122

Deloitte (2014) *Value of Connectivity: Economic and Social Benefits of Expanding Internet Access*, www2.deloitte.com/content/dam/Deloitte/ie/Documents/TechnologyMediaCommunications/2014_uk_tmt_value_of_connectivity_deloitte_ireland.pdf (accessed 7 March 2016)

Deloitte (2012) *What is the Impact of Mobile Telephony on Economic Growth?*, www.gsma.com/publicpolicy/wp-content/uploads/2012/11/gsma-deloitte-impact-mobile-telephony-economic-growth.pdf (accessed 7 March 2016)

Dewan, S. and Kraemer, K. (2000) ‘Information Technology and Productivity: Evidence from Country-Level Data’, *Management Science* 46.4: 548–62

Dimelis, S. and Papaioannou, S. (2009) ‘FDI and ICT Effects on Productivity Growth: A Comparative Analysis of Developing and Developed Countries’, *Eur J Dev Res* 22.1: 79–96

EconTalk.Org (2014) ‘Robert Solow on Growth and the State of Economics, EconTalk: Library of Economics and Liberty’, Econtalk.org, www.econtalk.org/archives/2014/10/robert_solow_on.html (accessed 8 March 2016)

Ericsson (2013) *Socioeconomic Effects of Broadband Speed,* www.ericsson.com/res/thecompany/docs/corporate-responsibility/2013/ericsson-broadband-final-071013.pdf (accessed 7 March 2016)

Freund, C. and Weinhold, D. (2004) ‘On the Effect of the Internet on International Trade’, *Journal of International Economics* 62: 171–89

Gaggl, P. and Kaufmann, S. (2015) ‘The Cyclical Component of Labor Market Polarization and Jobless Recoveries in the US’, http://ssrn.com/abstract=2638359 (accessed 19 September 2016)

Garcia Zaballos, A. and Lopez-Rivas, R. (2012) *Socioeconomic Impact of Broadband in Latin American and Caribbean Countries*, Inter-American Development Bank Technical Note 471, https://publications.iadb.org/handle/11319/5754?locale-attribute=en (accessed 7 March 2016)

Gordon, R. (2012) *Is U.S. Economic Growth Over? Faltering Innovation Confronts the Six Headwinds*, NBER Working Paper 18315, National Bureau of Economic Research, www.nber.org/papers/w18315 (accessed 7 March 2016)

Haller, S. and Siedschlag, I. (2011) ‘Determinants of ICT Adoption: Evidence from Firm-Level Data’, *Applied Economics* 43.26: 3775–788

Haltiwanger, J.; Jarmin, R. and Schank, T. (2003) *Productivity, Investment in ICT and Market Experimentation: Micro Evidence from Germany and the US*, Friedrich-Alexander-Universität Erlangen-Nürnberg, Lehrstuhl für Arbeitsmarkt- und Regionalpolitik Discussion Paper 19

Hamade, S. (2012) 'The Impact of Mobile Technology on Low-Income Communities in Lebanon', *Digest of Middle East Studies* 21.1: 24–38

Hausmann, R.; Hidalgo, C.; Bustos, S.; Chung, S.; Jimenez, J.; Simoes, A.; Yildirim, M. and Coscia, M. (2014) *The Atlas of Economic Complexity: Mapping Paths to Prosperity*, Cambridge MA: Center for International Development, Harvard University; Harvard Kennedy School; Macro Connections, MIT Media Lab

Heeks, R. (2014) *ICTs and Poverty Eradication: Comparing Economic, Livelihoods and Capabilities Models*, Development Informatics Working Paper Series 58, Centre for Development Informatics

Hershbein, B. and Kahn, L. (2016) 'Is Technological Change Exacerbated in Recessions: Evidence from Vacancy Postings', http://faculty.som.yale.edu/lisakahn/documents/HershbeinKahn_12_2015_draft10.pdf (accessed 7 March 2016)

Hidalgo, C. and Hausmann, R. (2009) *The Building Blocks of Economic Complexity*, CID Working Paper 186, Center for International Development, Harvard University

Iacovone, L.; Pereira-Lopez, M. and Schiffbauer, M. (2015) 'The Complementarity between ICT Use and Competition in Mexico', Background paper for the *World Development Report 2016*, Washington DC: World Bank, http://lacer.lacea.org/handle/123456789/52992?show=full (accessed 7 March 2016)

International Monetary Fund (2007) 'Globalization and Inequality', *World Economic Outlook 2007*, www.imf.org/external/pubs/ft/weo/2007/02/pdf/c4.pdf (accessed 7 March 2016)

ITU (International Telecommunication Union) (2015) *Measuring The Information Society Report 2015*, Geneva: ITU, www.itu.int/en/ITU-D/Statistics/Documents/publications/misr2015/MISR2015-w5.pdf (accessed 11 October 2016)

Jagun, A.; Heeks, R. and Whalley, J. (2008) 'The Impact of Mobile Telephony on Developing Country Micro-Enterprise: A Nigerian Case Study', *Information Technologies and International Development* 4.4: 47–65

Jaimovich, N. and Siu, H. (2015) *Job Polarization and Jobless Recoveries*, http://faculty.arts.ubc.ca/hsiu/work/polar20150503.pdf (accessed 8 March 2016)

Jaimovich, N. and Siu, H. (2012) *The Trend is the Cycle: Job Polarization and Jobless Recoveries*, NBER Working Paper 18334, National Bureau of Economic Research, www.nber.org/papers/w18334 (accessed 8 March 2016)

Jensen, R. (2007) 'The Digital Provide: Information (Technology), Market Performance, and Welfare in the South Indian Fisheries Sector', *The Quarterly Journal of Economics* 122.3: 879–924

Karabarbounis, L. and Neiman, B. (2014) 'The Global Decline of the Labor Share', *The Quarterly Journal of Economics* 129.1: 61–103

Katengeza, S.; Okello, J.; Mensah, E. and Jambo, N. (2014) 'Effect of Participation in ICT-Based Market Information Services on Transaction Costs and Household Income Among Smallholder Farmers in Malawi', in J. Bolay, S. Hostettler and E. Hazboun (eds), *Technologies for Sustainable Development: A Way to Reduce Poverty?*, 1st edition, Springer International Publishing

Katz, R. and Callorda, F. (2013) 'Economic Impact of Broadband Deployment in Ecuador', *Dialogo Regional Sobre Sociedad de la Informacion*, https://idl-bnc.idrc.ca/dspace/bitstream/10625/53797/1/IDL-53797.pdf (accessed 7 March 2016)

Katz, R. and Koutroumpis, P. (2012a) *The Economic Impact of Broadband in the Philippines*, Broadband Series, Broadband Commission for Digital Development, www.itu.int/ITU-D/treg/broadband/BB_MDG_Philippines_BBCOM.pdf (accessed 7 March 2016)

Katz, R. and Koutroumpis, P. (2012b) *The Economic Impact of Broadband in Panama*, Broadband Series, Broadband Commission for Digital Development, www.itu.int/ITU-D/treg/broadband/BB_MDG_Panama_BBCOM.pdf (accessed 7 March 2016)

Katz, R. and Koutroumpis, P. (2012c) 'The Economic Impact of Telecommunications in Senegal', *Communications & Strategies* 86

Kelly, K. (2013) *The Technium: The Post-Productive Economy*, Kk.org, http://kk.org/thetechnium/the-post-produc/ (accessed 7 March 2016)

Kelly, K. (2012) *Better Than Human: Why Robots Will – And Must – Take Our Jobs*, WIRED, www.wired.com/2012/12/ff-robots-will-take-our-jobs/ (accessed 7 March 2016)

Kivunike, F.; Ekenberg, L.; Danielson, M. and Tusubira, F. (2011) 'Perceptions of the Role of ICT on Quality of Life in Rural Communities in Uganda', *Information Technology for Development* 17.1: 61–80

Klonner, S. and Nolen, P. (2008) 'Does ICT Benefit the Poor? Evidence from South Africa', http://privatewww.essex.ac.uk/~pjnolen/KlonnerNolenCellPhonesSouthAfrica.pdf (accessed 7 March 2016)

Koutroumpis, P. (2009) 'The Economic Impact of Broadband on Growth: A Simultaneous Approach', *Telecommunications Policy* 33.9: 471–85

KPMG (2012) *Financial Deepening and M4P: Lessons from Kenya and Rwanda*, Impact Paper 9, www.kpmg.com/eastafrica/en/services/Advisory/Development-Advisory-Services/Thought_Leadership_at_DAS/Documents/Financial%20Deepening%20and%20M4P%20–%20Lessons%20from%20Kenya%20and%20Rwanda.pdf (accessed 7 March 2016)

Lee, S.; Gholami, R. and Tong, T. (2005) 'Time Series Analysis in the Assessment of ICT Impact at the Aggregate Level – Lessons and Implications for the New Economy', *Information & Management* 42.7: 1009–22

Makoza, F. and Chigona, W. (2012) 'The Livelihood Outcomes of ICT Use in Microenterprises: The Case of South Africa', *Electronic Journal of Information Systems in Developing Countries* 53.1: 1–16

Martin, B. and Abbott, E. (2011) 'Mobile Phones and Rural Livelihoods: Diffusion, Uses and Perceived Impacts Among Farmers in Rural Uganda', *Information Technologies & International Development* 7.4

May, J.; Dutton, V. and Munyakazi, L. (2014) 'Information and Communications Technologies as a Pathway from Poverty: Evidence from East Africa', in E. Ofwona Adera, T. Weama, J. May, O. Mascarenhas and K. Diga (eds), *ICT Pathways to Poverty Reduction: Empirical Evidence from East and Southern Africa,* 1st edition, Practical Action Publishing, http://idl-bnc.idrc.ca/dspace/bitstream/10625/52420/1/IDL-52420.pdf (accessed 7 March 2016)

McFarland, M. (2016) 'Why Facebook's Push to End Poverty is Actually Self-serving', *Washington Post*, 16 February, www.washingtonpost.com/news/innovations/wp/2016/02/16/when-facebook-gives-internet-to-the-poor-the-real-winner-isnt-whom-you-think/ (accessed 7 March 2016)

McKinsey Global Institute (MGI) (2015) *Digital America: A Tale of the Haves and Have-Mores*, www.mckinsey.com/industries/high-tech/our-insights/digital-america-a-tale-of-the-haves-and-have-mores (accessed 7 March 2016)

McKinsey Global Institute (2014) *Offline and Falling Behind: Barriers to Internet Adoption*, www.mckinsey.com/~/media/McKinsey/dotcom/client_service/High%20Tech/PDFs/Offline_and_falling_behind_Barriers_to_Internet_adoption.ashx (accessed 30 September 2016)

McKinsey Global Institute (2012) *Online and Upcoming: The Internet's Impact on Aspiring Countries*, www.mckinsey.com/industries/high-tech/our-insights/impact-of-the-internet-on-aspiring-countries (accessed 7 March 2016)

McKinsey Global Institute (2011) *Internet Matters: The Net's Sweeping Impact on Growth, Jobs, and Prosperity*, www.mckinsey.com/industries/high-tech/our-insights/internet-matters (accessed 7 March 2016)

Mehta, B. (2013) *Capabilities, Costs, Networks and Innovations: Impact of Mobile Phones in Rural India*, Institute for Human Development Working Paper 29, New Delhi: Institute for Human Development

Meijers, H. (2012) *Does the Internet Generate Economic Growth, International Trade, or Both?* United Nations University Working Paper Series 2012(050), Maastricht, The Netherlands: United Nations University

Minges, M. (2015) 'Exploring the Relationship between Broadband and Economic Growth,' Background paper for the *World Development Report 2016*, Washington DC: World Bank, www-wds.worldbank.org/external/default/WDSContentServer/WDSP/IB/2016/02/01/090224b084121f4b/1_0/Rendered/PDF/World0developm00and0economic0growth.pdf (accessed 7 March 2016)

MIT Technology Review (2015) *Innovadores Menores De 35: Mariana Costa, 29*, www.technologyreview.es/tr35peru/1590/mariana-costa/ (accessed 7 March 2016)

Moore, M. and Justino, P. (2015) *Inequality: Trends, Harms and New Agendas*, IDS Evidence Report 144, Brighton: IDS

Mpogole, H.; Usanga, H. and Tedre, M. (2008) 'Mobile Phones and Poverty Alleviation: A Survey Study in Rural Tanzania', https://ict4dblog.files.wordpress.com/.../m4d-mpogole-final-paper4.doc (accessed 7 March 2016)

Mwangi, G. and Acosta, F. (2013) 'Mobile Phones and Growth of Microenterprises: A Case Study of Safaricom's "Zidisha Biashara" Customers', *DLSU Business & Economics Review* 23.1: 105–35

Navas-Alemán, L. (2011) 'The Impact of Operating in Multiple Value Chains for Upgrading: The Case of the Brazilian Furniture and Footwear Industries', *World Development* 39.8: 1386–97

Niebel, T. (2014) *ICT and Economic Growth Comparing Developing, Emerging and Developed Countries*, IARIW Working Papers, International Association for Research in Income and Wealth

Ohno, K. (2009) 'Avoiding the Middle-Income Trap: Renovating Industrial Policy Formulation in Vietnam', *ASEAN Economic Bulletin* 26.1: 25–43

Papaioannou, S. and Dimelis, S. (2007) 'Information Technology as a Factor of Economic Development: Evidence from Developed and Developing Countries', *Economics of Innovation and New Technology* 16.3: 179–94

Paunov, C. and Rollo, V. (2015) 'Overcoming Obstacles: The Internet's Contribution to Firm Development', *The World Bank Economic Review* 29. Suppl 1: S192–S204

Paunov, C. and Rollo, V. (2014) *Has the Internet Fostered Inclusive Innovation in the Developing World?*, UNU-MERIT Working Paper Series 2014(084), Maastricht, The Netherlands: United Nations University

Pohjola, M. (2000) 'Information Technology and Economic Growth: A Cross-Country Analysis', *UNU World Institute of Development Economics Research* 173

Qiang, C.; Rossotto, C. and Kimura, K. (2009) 'Economic Impacts of Broadband', in *Information and Communications for Development 2009: Ex-tending Reach and Increasing Impact*, Washington DC: World Bank

Rahman, A.; Abdullah, M.; Haroon, A. and Tooheen, R. (2013) 'ICT Impact on Socio-economic Conditions of Rural Bangladesh', *Journal of World Economic Research* 2.1: 1–8

Ramalingam, B. and Hernandez, K. (2016) 'The Multiple Forms of Digital Inequality', *World Social Science Report 2016,* Paris: ISSC, IDS and UNESCO

Röller, L. and Waverman, L. (2001) 'Telecommunications Infrastructure and Economic Development: A Simultaneous Approach,' *American Economic Review* 91.4: 909–23

Rutten, M. and Mwangi, M. (2012) 'Mobile Cash for Nomadic Livestock Keepers: the Impact of the Mobile Phone Innovation (M-Pesa) on Maasai Pastoralists in Kenya', in J. Gewald, A. Levliveld and I. Pesa (eds), *Transforming Innovations in Africa: Explorative Studies on Appropriation in African Societies (African Dynamics)*, Leiden, The Netherlands: Brill Academic Pub

Schmitz, H. (2007) 'Transitions and Trajectories in the Buildup of Innovation Capabilities: Insights from the Global Value Chain Approach', *Asian Journal of Technology Innovation* 15.2: 151–60

Schradie, J. (2013) *An Open Letter to Mark Zuckerberg: Is Facebook a Human Right?*, Schradie.com, http://schradie.com/an-open-letter-to-mark-zuckerburg-is-facebook-a-human-right/ (accessed 7 March 2016)

Scott, C. (2012) 'Does Broadband Internet Access Actually Spur Economic Growth?', www.eecs.berkeley.edu/~rcs/classes/ictd.pdf (accessed 7 March 2016)

Solow, R. (1987) 'We'd Better Watch Out', *New York Times Book Review,* (July 12) 36

Srinivasan, J. and Burrell, J. (2015) 'On the Importance of Price Information to Fishers and to Economists: Revisiting Mobile Phone Use Among Fishers in Kerala', *Information Technologies & International Development* 11.1: 57–70, http://itidjournal.org/index.php/itid/article/view/1362 (accessed 13 April 2016)

Srinivasan, J. and Burrell, J. (2013) 'Revisiting the Fishers of Kerala, India', in *ICTD '13 Proceedings of the Sixth International Conference on Information and Technologies and Development: Full Papers*, Cape Town, South Africa

Steinmueller, W. (2001) 'ICTs and the Possibilities for Leapfrogging by Developing Countries', *International Labour Review* 140.2: 193–210

Steyn, J. and Das, M. (2015) 'Claims of Mobile Phone Use by Kerala Fishermen Not Supported by Fieldwork', *ICTs for Inclusive Communities in Developing Societies. Proceedings of the 8th International Development Informatics Association Conference*

Stiglitz, J.E. (2011) 'Rethinking Development Economics', *The World Bank Research Observer,* 1 August, 26.2: 230–6

Summers, L. (2014) 'Lawrence H. Summers on the Economic Challenge of the Future: Jobs', *Wall Street Journal,* 7 July, www.wsj.com/articles/lawrence-h-summers-on-the-economic-challenge-of-the-future-jobs-1404762501 (accessed 11 October 2016)

Thompson, H. and Garbacz, C. (2011) 'Economic Impacts of Mobile Versus Fixed Broadband', *Telecommunications Policy* 35.11: 999–1009

Vemuri, V. and Siddiqi, S. (2009) 'Impact of Commercialization of the Internet on International Trade: A Panel Study Using the Extended Gravity Model', *The International Trade Journal* 23.4: 458–84

Vu, K. (2011) 'ICT as a Source of Economic Growth in the Information Age: Empirical Evidence from the 1996–2005 Period', *Telecommunications Policy* 35.4: 357–72

World Bank (2016) *World Development Report 2016: Digital Dividends*, Washington DC: World Bank, www.worldbank.org/en/publication/wdr2016 (accessed 7 March 2016)

World Bank (2015) *The Global Opportunity in Online Outsourcing*, Washington DC: World Bank, www-wds.worldbank.org/external/default/WDSContentServer/WDSP/IB/2015/06/25/090224b082f8922f/1_0/Rendered/PDF/The0global0opp0n0online0outsourcing.pdf (accessed 7 March 2016)

World Bank (2012) *Information and Communications for Development 2012*, Washington DC: World Bank, http://siteresources.worldbank.org/EXTINFORMATIONANDCOMMUNICATIONANDTECHNOLOGIES/Resources/IC4D-2012-Report.pdf (accessed 8 March 2016)

World Economic Forum (2015) 'ICTs, Income Inequality, and Ensuring Inclusive Growth,' *The Global Information Technology Report 2015*: 31–38, http://reports.weforum.org/global-information-technology-report-2015/1-2-icts-income-inequality-and-ensuring-inclusive-growth/ (accessed 8 March 2016)

Yousefi, A. (2011) 'The Impact of Information and Communication Technology on Economic Growth: Evidence from Developed and Developing Countries', *Economics of Innovation and New Technology* 20.6: 581–96

Zuckerberg, M. (2014) ‘Mark Zuckerberg on a Future Where the Internet Is Available to All’, *Wall Street Journal*, 7 July, www.wsj.com/articles/mark-zuckerberg-on-a-future-where-the-internet-is-available-to-all-1404762276 (accessed 7 March 2016)

Zuckerberg, M. (2013) ‘Is Connectivity A Human Right?’, www.facebook.com/isconnectivityahumanright (accessed 7 March 2016)

Brighton BN1 9RE

T +44 (0)1273 606261
F +44 (0)1273 621202
E ids@ids.ac.uk
www.ids.ac.uk