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# Digital Technologies, Trade and Development: Prospects for the Commonwealth

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**Abstract**

Historically, technology has served as a critical driver of globalisation, underpinning the rapid expansion in world trade and driving human progress, raising living standards and welfare, and precipitating transformative improvements in human health, education, and economic and social development. Digital technologies are enabling economy-wide innovation at an unprecedented rate, unleashing new opportunities globally. Members of the Commonwealth are at the forefront of this wave of innovation. Yet the disruption is wide, the implications for sectors are unclear and the threat to comparative advantages is universal. One clear objective is for greater collaboration among members of the Commonwealth to mitigate risks and maximise opportunities to further amplify the 'Commonwealth advantage' in trading relationships.

JEL Classification: O14, L86, F63

Keywords: digital technology, trade, economic development

# Contents

# 1. Introduction

Technological innovation has never moved faster than it does today, driven by a digital economy that is creating new opportunities for trade, investment and innovation among the 53 Commonwealth members. However, a great debate is ongoing about the role of technology-led economic growth. Some argue that this era is behind us, and that the current inventions and innovations are incapable of sparking the robust technology growth of the past. Others argue that technology is a largely passive influence, and that the long tail of the ^008 financial crisis will continue to cast a shadow that keeps margins low and optimism lower. Others bullishly claim that we are on the cusp of the fourth Industrial Revolution, with digital technology in particular providing a lengthened and strengthened backbone to the world economy across economic sectors. Furthermore, digital technologies are predicted to enable recent innovations to be trialled and scaled more quickly in greater numbers. Crucially for the Commonwealth, digital technology embraces maximum malleability both to secure a vibrant economic future for existing digitally mature markets and to transform developing economies, releasing the collective consumer and innovation power of the 50 per cent of the world's citizens and businesses who have no access to banking, the internet or the benefits of a formal economy.

Although optimistic about the transformative economic power of technology-driven prosperity, this Working Paper distances itself from the rhetoric of 'revolution', 'science fiction' and 'shiny gadgets' to provide an evidence-based assessment of the landscape and examine how Commonwealth countries can begin to understand, assess and make decisions that strengthen their economies. This Working Paper helps illustrate what is becoming possible, and how Commonwealth members can align their policies and practices to take fullest advantage.

Section 1 describes the technologies that are driving change. Section 2 describes the economic drivers that are scaling these technologies and their impact on global economic change through international trade. Section 3 details the progress of Commonwealth members in deriving tangible opportunities from technological change, and how these can be harnessed collectively. Section 4 concludes by giving some practical principles to guide decision-making about investments in the face of inescapable technological change with uncertain economic transformation impact.

At the core of this paper is an overarching assessment of the need for Commonwealth countries to identify and adjust to changing technology trends, and to adapt, mitigate and invest to ensure sustainable economic growth. Technology is progressing fast both in isolation and as a complement to and a co-enabler of economic transformation in a variety of sectors and across all countries. The change is clear in developed countries, but in developing countries and small island developing states (SIDS), as well as in the remote parts of some developed countries, the changes are stark, particularly for those communities that have only recently had connections to electricity or the internet.

*Technology optimists* believe that technology will underwrite the economic changes and even transform many Commonwealth countries over the next 5 years.

# 2. Technology

Technology means the ability of humans to create things using hands or machines, applying knowledge to further the practical goals of human life or to alter and manipulate the human environment. For first-mover countries, technological change is typically about innovating at the frontier. For most other countries, technological change is less about innovation and more about adapting existing economic systems, products and processes to achieve higher productivity.

Recent key innovations have resulted in renewable energy, hybrid electric cars, satellite navigation systems and 3D printing.

Table 1. Summary of key emerging technologies by expected timescale for scaling

| 2–5 years | 5–10 years | 10 years+ |
|---|---|---|
| Machine learning<br>Software-defined anything<br>Natural language question answering<br>Servicisation of cars | Virtual reality<br>Cognitive expert advisors<br>Blockchain<br>Connected home<br>Internet of Things platform<br>Micro-data centres | Autonomous vehicles<br>Enterprise taxonomy and ontology management<br>Brain–computer interface<br>Human augmentation<br>4D printing<br>Smart dust |

**Sources:** Gartner, 2016; MGI, 2016; WEF, 2016a.

All technologies evolve, but only a few scale with the market to become integrated and mainstream. New technology is constantly being piloted, occasionally disrupting the mainstream, and becomes assimilated, scaled and, eventually, obsolete. Looking forward, Table 1 summarises the current emerging technologies.

Two closely related and pervasive technological innovations that have altered the fundamentals of (almost) all economic sectors and countries in recent years are the internet and digitisation. Global market penetration has occurred at unprecedented speed – see Table 2 – while providing a cascade of opportunities across economic sectors and countries.

Rapidly decreasing costs are key to maintaining the market penetration of the building blocks of digitisation; costs are declining by over 10 per cent annually (WeAreSocial, 2017).

### *Mobile phones*

Mobile phones are ubiquitous. Two-thirds of the global population – almost 5 billion people – own a mobile phone. This is staggering considering the worldwide disparity in economic, social and geographical profiles.

Somewhat oddly, more people own a data-enabled mobile phone than have access to electricity. As Table 2 shows, mobile devices are increasingly used for broadband and Wi-Fi access, displacing desktop computers as the primary route of internet access – an estimated 90 per cent of social media is streamed on mobile devices. As such, mobiles are a portal to information, news, training, social media and commerce.

### *Internet*

Ten years ago, around 20 per cent of the global population had access to the internet (World Bank, 2007); today, over half has access. The uses for the internet vary by global region, with Europeans using it predominantly for leisure, inspiration and social activities and Africans being more likely to use it for security, safety and finding work (WEF, 2016b; World Bank, 2016).

The speed of the internet is increasing – broadband speed went up by 2.3 per cent to 6.3 Mbps during 2016 (Akamai, 2016) – although it remains a fraction of the perceived speeds (DHL, 2016).

### *Cloud computing*

Cloud or server-based computing improves businesses' agility by enabling them to use information and communication technology (ICT) services provided over the internet. It promises to reduce the costs of software, hardware (including laptops), risks to company data, and document and data storage. In the EU, 97 per cent of enterprises have internet access, and 46 per cent use some level of cloud computing (Eurostat, 2017).

Table 2. Summary of digitisation estimates, 2017

| Factor | Users | Penetration (%) | Change in 2016 |
|---|---|---|---|
| Mobile phone ownership | 4.9 billion | 66 | +5% (222 million) |
| Internet | 3.8 billion | 50 | +10% (354 million) |
| Social media use | 2.8 billion | 37 | +21% (482 million) |
| Social media use by mobile devices | 2.5 billion | 34 | +30% (581 million) |

**Sources:** WeAreSocial, 2017; World Bank, 2017.

*Renewable energy*

Renewable energy is growing globally, with solar photovoltaic (PV) capacity increasing from 6 GW in 2006 to 303 GW in 2016 (REN21, 2017). The basic technology of solar PVs has been around for over 30 years, but three trends in the past 5 years have been transforming the power sector and, crucially, changing who has access. Mass production by Chinese firms has played a key role in making solar PVs available to all, slashing production and retail costs, and enabling new business models of all scales. Compounding this has been the falling cost of oil since 2014, which is simultaneously disrupting global energy markets, disturbing the economic power of incumbent oil and gas companies, and creating a conversation around alternative generation options. Finally, there have been major changes to the storage capacity of batteries, with associated production and retail costs falling by an estimated 65 per cent since 2010 (IRENA, 2017; Worland, 2017).

*Distributed renewable energy*

Alongside these trends, digitisation is disrupting the energy sector. The digitisation of existing centrally planned assets is both improving asset efficiency and creating new opportunities for entrepreneurs (WEF, 2016a). One notable innovation is distributed renewable energy, which is at the heart of evolving business models across rural Africa and Asia that are bringing reliable, cheap and clean electricity to previously off-grid communities. The scalable potential is high, with the United Nations Sustainable Energy for All (SE4ALL) initiative expecting distributed renewable energy to deliver 70 per cent of all new rural electricity connections by 2030 (SE4ALL, 2014).

Current distributed renewable energy packages cost as little as $50, which is paid in monthly instalments following a small deposit (15% of the total installed cost). Furthermore, the energy produced is cheaper than that from alternatives such as kerosene and is typically used to charge lights, radios and mobile phones (CGAP, 2016).

# 3. The economy

## 3.1 Context

Technology is a driver of economic growth. Indeed, the IMF has found consistently over the past decade that over 50 per cent of the fall in the share of global national income from labour is attributable to changes in technology (IMF, 2007; IMF, 2015). Labour income's share of national output is declining in the majority of advanced economies, with technological change accounting for around half of globalisation's impact on income inequality owing to the favouring of highly skilled workers (IMF, 2007; IMF, 2015. However, technology proves economically imbalanced: its economic impact varies across countries and across socioeconomic groups. Indeed, vivid reminders are provided by the persistent structural challenges in the global economy noted by the IMF (2015) – particularly low productivity growth and income inequality. The business case for digitisation producing an economic transformation includes a striking analysis by the McKinsey Global Institute of the underperformance of lagging countries, whose limited participation has been at a real cost to the world economy, which would have seen $10 trillion or 13 per cent higher gross domestic product (GDP) if these nations had kept pace with first-mover countries (MGI, 2016).

The impact that technology can exert on society is starkly illustrated by the way that computer chips and microprocessor power disrupted the dominant blue-chip corporations in the 1970s, which shifted value creation to today's digital economy. Indeed, a high proportion of analysts are heralding a new era of digital globalisation, with no growth in traditional trade and finance, but soaring digital flows. Large investment firms actively discuss the benefits of companies that have embedded digital transformation, and promote and buy stocks in these businesses. This economic revolution can be partially glimpsed in the rapidly falling age of companies on the US Stock Market S&P 500, which are now an average of 15 years old. Furthermore, over half of Fortune 500 firms were new in 2012, and in the UK over 85 per cent of FTSE 100 businesses have changed since the mid-1980s. Some of the changes being witnessed to existing key economic sectors from digitisation are summarised in Table 3.

Table 3. Disruption to economic sectors, and particularly to incumbents

| Company/sector | Original profile | Move into | Technology push |
|---|---|---|---|
| Car companies | Automobiles | 'Bigger business of transportation services' | Servicisation, electric vehicles |
| Finance | Banking, trust | Fintech and range of closely-tailored services | Blockchain |
| Real estate agents | Intermediaries | Disappear | Disintermediation, artificial intelligence |
| Hotels | Accommodation | Experience platforms | Internet, disintermediation |
| Oil and gas | Fuels | Alternative fuels including renewable energy | Solar PV, environmental standards |

A small number of technologies are classified as general purpose technologies (GPTs) owing to the economic growth unlocked through subsequent cascades of complementary innovations across many, sometimes all, economic sectors (Mockyr, 2006). The distinction is important because GPTs have greater potential for economic transformation than an innovation that disrupts in just one sector (Bresnahan and Trajtenberg, 1992), by producing economy-wide productivity gains through declining technology costs, and by facilitating autonomous innovation across a wide range of adopting sectors (Ristuccia and Solumu, 2010).

Digitisation and distributed renewable energy are being viewed as potential GPTs. However, Lipsey et al. (2005) identify fewer than 30 GPTs in the 11,000 years since domestication of plants and animals transformed the human world through the wheel, writing, steam power, cars and, in more modern times, computers. Analysts suggest using total factor productivity (Hulten, 2000) to measure the depth of innovation (Lipsey et al., 2005).

Digitisation shares many attributes with GPTs, and it has a far-reaching economic impact across sectors, enabling:

- **Swift and tailored adoption across sectors**: digitisation enables a wide range of innovative technologies to tunnel through the technology learning curve and achieve technical maturity faster.
- **Scaling**: digitisation enables successful large-scale technologies to be small-scaled by combining its building blocks.
- **Competition**: digitisation offers radically changing comparative advantages, and potentially lower costs.
- **Integrated evidence-based decisions**: these are based on better data offered by availability of digital data and integration of voices of all stakeholders.
- **Trading opportunities**: in principle, anyone with a mobile phone can trade, evidenced by estimates that 400 million Chinese citizens trade internationally through e-commerce.
- **Disintermediation**: broader access to information and service providers could reduce reliance on intermediaries in supply chains (Andersson et al., 2017), in turn increasing returns to primary producers.
- **Productivity gains**: seamless access to information saves people time, which they may invest in other productive activities, such as leisure and entrepreneurship.

### 3.2 Digitisation

The proliferation of computer and digital technology since the 1970s is maturing into a digital ecosystem that is a *general purpose technology*, and its utility is becoming more widespread, enabling change in all economic sectors. The transformative power of digitisation is based on the building blocks of powerful, up-to-date hand-held technology and widespread internet access, lowering the cost of data, efficient cloud storage and emerging powerful data analytics. The economic transformation can already be seen in mobile phone ownership, but, for Commonwealth citizens, also in the new business models that digitisation unleashes.

Furthermore, digitisation is changing the concept of economic transformation owing to the speed of change and the diffusion of technologies. Traditionally, technology's general purpose benefits to an economy could be tracked by either enhancing labour productivity and efficiency (Grossman and Helpman, 1994) or analysing the import of capital goods (Hanlin and Kaplinsky, 2016).

### 3.3 Business models and scaling

New technology requires changes to processes, regulations and operations that, in turn, disrupt accordingly. This disruption continues until the new technology is integrated appropriately. A technology reaches scale when it alters and possibly transforms a business model.

Digitisation leverages these attributes for everyone, and supports scaling new business models to address pressing human needs across a range of economic sectors, including healthcare, transportation, finance, energy and agriculture.

#### *Servicisation*

Some shared assets are relatively expensive for businesses and households, and involve a lot of downtime; for instance, an average family car is used less than 2 per cent of the time. These assets include large agricultural machinery and houses. Digitisation can optimise these shared assets, ensure cheaper costs per use and integrate trust systems. Examples of sectors currently being disrupted are taxis globally by Uber, accommodation by AirBnB, and cars by driverless vehicles.

#### *Trust models, e.g. Blockchain or distributed ledger technology*

Blockchain leverages digitisation and cloud computing networks to promote new models of transparency and trust in economic sectors. By promoting trust through the distributed ledger system, blockchain transactions eradicate the need for independent third parties, such as banks, to be part of the supply chain. This results in shorter supply chains and lower costs, which should result in higher returns for producers and lower prices for consumers. The transformative power of blockchain has been compared to double-entry bookkeeping, which was a key innovative enabler of capitalism in the 1600s.

#### *Equitable economic development*

Arguably, technology has the potential to exert the most disruption on, and bring the greatest benefits to, those with the lowest access to technology, enabling them to tunnel through the expensive and inefficient learning curve. Recent technology innovations are transforming developing economies, with swift access to the latest technology and business models heralding an asset-light development pathway that will be cheaper, cleaner and more equitable than current models. Distributed renewable energy is supplying affordable electricity to those previously off-grid. Mobile phones are enabling connections with distant families as well as trading opportunities.

Realising connectedness in rural areas should produce a dividend for primary producers as disintermediation ensures more value from the supply chain lodges with producers; for example, one intermediary NGO in Kenya facilitates crafts, agriculture and clothes, and reports a 45 per cent increase in value to producers (see Soko, 2017). Higher expected incomes in rural areas will grow trade in primary and secondary commodities, and promote secondary innovations.

It is too early to consider the potential for innovation in rural parts of developing countries to supplant the need for public sector intervention and donor assistance. However, the ability to connect, save time through mechanisation and achieve higher disposable income, merely through one transformative asset – data – is an intriguing proposition. Currently there are limited data on rural areas of developing countries. What will and can local populations do with it?

As technology and economic transformation have an impact on Sustainable Development Goals (SDGs), and change the terms of attaining these important goals, there is a case for better understanding their scale and monitoring their overall effect.

### 3.4 Renewable energy

The World Economic Forum estimates that £1 trillion will be captured over 2016–2025 owing to rapid transformation in the energy sector (WEF, 2016a). This Working Paper concentrates on one aspect of this transformation – renewable energy distributed through solar PVs – and how this is part of evolving business models that are connecting the unconnected to electricity across the Commonwealth. The global proportion of renewable energy use is 15 per cent, and this is expected to rise to 26 per cent by 2020 (IEA, 2015), with many countries beginning to respond to the challenges of grid integration as new installation investments in solar PVs and wind are now cost competitive with new fossil fuel capacity (REN21, 2017). The IEA, in its WEO (2011), estimated that the providing energy access to all will cost US$49 billion annually until 2030 (IEA, 2016). The health effects of poor energy access are significant and include respiratory impacts as well as effects arising from the use of biomass as a fuel.

In the late 19th century, electricity was considered a general purpose technology, when it succeeded in providing reliable energy to factories to fuel the second half of the industrial revolution, enabling an explosion in research and development (R&D) and innovation (which included the invention of the telephone). However, 125 years later, less than half of the world's population and half of the population of the Commonwealth has access to affordable, clean and reliable energy, even though this is enshrined in SDG7 and has long been a policy goal of all world countries. Furthermore, for several other SDGs – agricultural development, education, health and the eradication of extreme poverty – energy access is the missing disruptor. The result is that many governments of developing countries face a large bill when they seek to achieve SDG7 by expanding the electric grid. Yet this bill is dwarfed by the cost of the economic inefficiencies delivered to the population. *The Economist* (2012) sums it up neatly:

> 'This off-grid group is mostly populated by the poor, remote and rural, for who energy is unreliable and costly. Economically, being unconnected stunts opportunity. Unshackling populations from expensive unreliable and often unsustainable energy sources – like kerosene, and fuelwood – should enhance the entire populations' economic opportunities, increasing disposable income, enabling longer operating hours, and powering machinery.'

Electricity sits at the apex of access to other technologies, their optimisation and their trade-offs. It enables children to do homework at night; powers cookers, which are more efficient and have lower emissions than woodfires; allows mobile phones to be charged; and runs refrigerators, which prolong the lifespan of stored produce. It can also change a country's trade needs, reducing the requirement to import expensive fuel oil, natural gas and petroleum to drive the electricity grid and underpin its future expansion.

Evolving business models across the Commonwealth are connecting previously unconnected populations using private- and public-sector-led microgrid solutions based on solar PV and a business model called Pay as You Go (PAYG).

With global energy subsidies accounting for an eye-watering 6.5 per cent of GDP ($4.2 trillion) annually (IMF, 2015), any innovation that can reduce pressure on countries to invest in expensive, vertically integrated public energy infrastructure, and subsidise energy generation, will liberate funds for investment elsewhere.

Energy across the Commonwealth is typically provided centrally; traditionally, decentralised models are coping mechanisms, such as diesel generators. A central energy system is usually the cheapest option for urban populations, as well as being attractive to international finance partners and energy providers (UNIDO, 2017). However, as large proportions of the global population are without electricity, and as costs for SIDS are higher – for example around four times higher for Caribbean Islands (World Bank, 2015) – clearly the current approach of importing fuel for diesel-based electricity grids and vertically integrated energy utilities does not work for poorer people. The displacement of these costs for the government and for energy consumers would see a release of disposable income, which would grow the economy and allow public investments to be redistributed to other worthwhile projects.

### *Business models*

Three broad new business models have emerged that fit with the three economic regions of the Commonwealth:

- Grid complementarity – this uses large numbers of solar PV as complements to the existing grid; these are often connected – e.g. solar parks such as Solar Park in South Africa – and provide between 0.1 MW and 1000 MW. For large, energy-intensive industrial countries, replacing more than 10 per cent of grid electricity is considered unlikely at this time. Solar PVs are used effectively in developed countries.
- Grid replacement – this uses dispersed large numbers of solar PVs as initial complements

to the grid, but with the aim of completely replacing imported fuel (petroleum and liquid natural gas) as the grid power source. It promotes self-sufficiency, balances trade and reduces emissions. This is the model used in many SIDS, e.g. Pacific islands.

- Off-grid small-scale supply – this is a relatively new business model at scale, with Commonwealth countries leading. In 2017, Bangladesh was the world's largest market for solar home systems, and other developing countries in the Commonwealth (including Guyana, India, Kenya, Tanzania and Uganda) are rapidly expanding small-scale renewable systems, including nano-grids and micro-grids, to serve the half of the Commonwealth population currently living off-grid. Two examples of this are decentralised renewable energy and decentralised energy grids.

*Decentralised renewable energy* – solar PV: this uses household and community-based micro- and nano-grids to deliver electricity cleanly and affordably on a small scale. The foundations of this model are digital technology – the ability of the (mostly) unbanked to pay for energy using mobile phones – and private sector investors – to install the PV systems, and devise and manage the contracting. Given the large number of Commonwealth Asian and African citizens who do not have electricity access, this option is intriguing: a 'new model [of renewable energy] that bypasses the government is emerging' (*The Economist*, 2014). This is a plausible opportunity to provide large, tangible change to the economy for rural, remote and poor communities across the Commonwealth. In addition, numerous small-scale renewable options are growing quickly in developed countries, with residential and industrial electricity customers producing their own power, and increasingly becoming prosumers too – that is, they sell excess capacity generated back to the grid. Instead of traditional means of collecting payments (with high transaction costs and losses), electricity bills can now be paid by mobile phone through mobile money services such as M-Pesa (World Bank, 2016). There are examples of pilot systems from Bangladesh, India and Kenya.

*Decentralised electricity grids* – for those countries considering borrowing from multi-lateral banks to fund the multimillion-pound investments in energy infrastructure, the idea of leveraging the market to achieve immediate goals that otherwise would take upwards of 10 years to achieve is attractive (Pérez-Arriaga, 2013). Furthermore, harnessing local entrepreneurs, using existing technology, and learning and developing rural economies will help achieve SDGs and promote national GDP levels.

### 3.5 International trade

Technology differences among nations have always been an important driver of mutually beneficial international trade through comparative and competitive advantage and have shaped the velocity of trade through containerisation, one-window documentation and digitalisation (Grossman and Helpman, 1994). International trade has traditionally driven the globalisation of technologies, which have shaped and defined profiles of production and trade for both exporting sectors and domestic producers. Increasingly, technology is not a physical product that requires import and installation before it can disrupt and shape the economic profile of a country or sector. Today's international trade in services, ideas, business models and approaches is proving a substantial disruptive force that is absent largely from trading accounts, but undoubtedly has extensive indirect impacts on comparative advantage and the profile of a country's international trade.

Indeed, the trade in technologically advanced products and the management of assets and services has always had an unclear economic impact. Some such products are expected to reduce trade, such as 3D printing; some increase trade, such as e-commerce; others are expected to increase unemployment, such as automation; and others create opportunities across entire economies through efficiency savings, such as digitisation. Capturing the direction, scale and timing of any impact frustrates industry analysts, although it often appears simple in hindsight.

Recent technological transformations provide tangible examples of unsettling trade circumstances, rattling entire industrial sectors, disrupting status quo comparative and competitive advantages (EY, 2015) and fundamentally questioning the economic prosperity goals of all Commonwealth members. Drawing on historical experience, emerging insights from recent trade analyses and data, and our focus on distributed renewable energy and digitisation, the following are some expected impacts facing Commonwealth members:

First, international trade will become more diverse, efficient, transparent and competitive, and (potentially) cheaper:

- Diverse – the cost of entering markets is falling, meaning that more people, SMEs and larger firms have access to markets and will trade internationally. As fresh comparative advantages are realised among traders, this will change the profile of trade, with smaller volumes and more instances of goods and services bundled, as well as novel goods from new locations (OECD, 2017).
- Competitive – improved market access will see market incumbents face many small, globally dispersed SMEs competing across an increasing number of sectors.
- Efficient – greater information along supply chains will reduce transaction costs and ensure that production is more closely linked to demand, reducing secondary markets for consumer goods and post-harvest losses for agricultural products.
- Transparent – the twin trends of greater access to information and data across sectors (for instance via blockchain technology) and customer choice (via the internet) will expose companies and sectors that rely on 'closed shops' and proprietary data as a comparative advantage.
- Cheaper – technology leading to an increase in firms' productivity should result in lower prices for intermediate goods in trade, and, potentially, lower prices at retail.

Second, access is ceasing to become a source of comparative advantage. Technology is enabling a level playing field for access to products and services across trade-enabling factors – such as finance, knowledge, networks, IT, energy and automation. International trade has a critical role in facilitating this enhanced global access to enablers.

Third, there are trade-limiting and trade-expanding innovations. Trade-limiting innovations – such as 3D printing and automation – still have weak market penetration, and are not expected to dent international trade flows in the next 5 years (Gartner, 2016), although this could change radically if the right business model were to scale and the costs plummeted. Trade-expanding innovations include blockchain, which is expected to instil cheaper, easier and more transparent trust mechanisms throughout the global trading system. The potential of blockchain technology to cut out intermediaries, particularly those that are expensive, such as financial institutions, while maintaining trust among participants in a supply chain or sovereign countries in trading, hints that a scaled blockchain could prove a huge boon to trade facilitation. For instance, documentary trade using letters of credit issued by banks is being replaced by open-account trade (Dab et al., 2015). The current global trade system is managed by policies – from, for instance, the World Trade Organization or the Trade Facilitation Agreement – but the process of international trade takes a relatively long time. Blockchain could reduce this time, and potentially result in instantaneous transactions, meaning that, in theory at least, more could be traded, and that trade in general would be cheaper and more efficient. For example, export and import declarations could be connected automatically, and finance could be direct business to business rather than involving a financial institution third party as risk-holder and verifier. Several benefits from such efficiency include reduced post-harvest waste when imported goods are held in customs.

Fourth, there will be considerable changes to the secondary and second-hand markets. On one hand, greater efficiencies from immediate digital supply chain information will reduce trade, constraining wastage and overproduction, jeopardising the commerciality of companies that rely on these markets, and potentially pushing up prices for consumers, for instance in fruit juices and chemicals. On the other hand, technology change will mean greater trade in obsolete technologies from more mature markets (e.g. smart phones, cars, analogue machinery), which will be valuable for less mature markets, potentially reducing and/or prolonging the digital divide. For instance, if Elon Musk is correct that TaaS and electric vehicles will lead to 80 per cent fewer cars on US roads by 2030, then millions of petroleum-powered vehicles will be traded during the next 10 years, potentially at very low prices.

Fifth, there are gains for technology-integrated firms. Soaring technology-related and technology-driven trades are a glimpse of a new trend for large investment firms to validate investments made by companies that have embedded digital transformation by actively promoting and buying the stocks of such companies (Capgemini Consulting, 2012). Many of these are younger firms: this trend is partially glimpsed in the rapidly declining age of companies on the US Stock Market S&P 500, which are now an average of 15 years old. Furthermore, over half of Fortune 500 firms were new in 2012, and in the UK over 85 per cent of FTSE 100 companies have changed since the mid-1980s.

Across the Commonwealth there is an identified trade benefit from improvements in ICT/telecommunications infrastructure, with a 1 per cent increase in connectivity resulting in a 0.23 per cent increase in trade (compared with the global average of 0.06 per cent). Furthermore, across the Commonwealth, the leverage from ICT/telecommunications in the supply chain matters more in terms of enhancing global value chain participation than in conventional improvements in trade facilitation and logistics performance indicators. Here, a 1 per cent increase in the Commonwealth logistics performance indicators results in a 0.05 per cent increase in trade (compared with the global average of 0.04 per cent) (Sturgeon et al, 2017).

In the light of these insights, it is clear that technological progress is inevitable and that developing Commonwealth countries need to catch up. The role of international trade in scaling emerging business models is unclear, but what is clear is the need to consider both enabling policy and deploying supportive incentives for the private sector.

# 4. Technology, growth and development in the Commonwealth

Several multicountry studies suggest that each 10 per cent increase in broadband penetration increases GDP growth by 0.9–3.19 per cent, on average (Czernich et al., 2011; Quiang et al., 2009; Scott, 2012; Zaballos and Lopez-Rivas, 2012). When this is applied across the Commonwealth as a whole, the implications are extraordinary.

The GDP of Commonwealth countries adds up to approximately US$10 trillion. Table 4 reveals the expected GDP impact if all Commonwealth countries were to increase their broadband penetration to 50, 75 or 100 per cent, making two assumptions: access is broadband, whether mobile or fixed; and GDP across all countries reacts similarly (i.e., no thresholds exist). To analyse the effect of improvements in broadband penetration, three scenarios are considered:

**Scenario I:** All Commonwealth countries achieve a minimum level of broadband penetration of 50 per cent of the population, equivalent to the world average, which would necessitate some 32 member countries catching up to meet this threshold. This would increase Commonwealth GDP by between US$74 billion and US$263 billion.

**Scenario II:** All Commonwealth members achieve 75 per cent broadband penetration,

Table 4. Implications for Commonwealth GDP from increased broadband coverage (US$ billion)

| % increase in GDP for each 10% broadband (BB) increase | Scenario I: 50% broadband | Scenario II: 75% broadband | Scenario III: 100% broadband | Scenario IV: <50% double broadband, 100% broadband if >50% |
|---|---|---|---|---|
| 0.90 | 74 | 163 | 317 | |
| 1.38 | 114 | 250 | 486 | |
| 3.19 | 263 | 577 | 1,124 | 598 |

**Source:** Author's calculations.

which would require 44 countries catching up to this threshold. This would increase Commonwealth GDP between US$163 billion and US$577 billion.

**Scenario III:** All Commonwealth countries achieve 100 per cent broadband penetration. This would increase Commonwealth GDP between US$317 billion and US$1.1 trillion.

Although Scenario III might be regarded as unrealistic, since no members currently achieve this standard, it provides an important perspective on the gains that can be obtained from digitisation, adding up to US$1 trillion to the GDP of the Commonwealth annually. Scenario I, on the other hand, can be considered a more rational target for developing Commonwealth countries, especially since the international community has committed to striving to provide less developed countries with universal and affordable access to the internet by 2020, although many challenges persist (ITU, 2018). The GDP impact for individual Commonwealth member countries is presented in Annex 1.

From a policy perspective, the most pragmatic approach would be for the 32 Commonwealth countries below the world average to commit to doubling their present broadband coverage, while countries over 50 per cent would work towards full universal broadband penetration. This would contribute around US$600 billion to the GDP of the Commonwealth.

Similarly, there is potential to significantly increase the Commonwealth's collective GDP by achieving higher broadband speed. The average broadband speed among Commonwealth members is 5.7 Mbps, whereas the global average is 6.3 Mbps (Czernich et al., 2011). A study of OECD countries suggests that doubling broadband speed can add 0.3 percentage points to GDP growth, while similar studies for China and Brazil suggest that the impacts on GDP are higher, at 2.2 and 4.7 percentage points, respectively (Rohman and Bohlin, 2012; ITU, 2012). Applied to all Commonwealth countries, this suggests that investments in internet speed could add between US$4 billion and US$444 billion to the GDP of the Commonwealth annually (Table 5). The GDP impact for individual Commonwealth countries is presented in Annex 2.

Table 5. Projected increase in GDP across the Commonwealth from improved broadband speed, 2017 (US$ billion)

| Speed (Mbps) | GDP increase | | |
|---|---|---|---|
| | 0.3% | 2.2% | 4.7% |
| 6.3 | 4 | 30 | 65 |
| 9 | 11 | 80 | 170 |
| 15 | 28 | 208 | 444 |

**Source:** Author's calculations.

Achieving both increased broadband penetration and increased speed can also significantly enhance employment (Kelly and Rossotto, 2012). In the German economy, for example, achieving these goals is estimated to increase employment by 960,000 people and output by more than €170 billion (Katz et al., 2010). A similar study of African countries suggests that improving both broadband penetration and speed can add 1.3 million direct jobs and 2.4 million indirect jobs and contribute 6.7 per cent to African GDP (GSMA, 2016).

# 5. Opportunities and challenges for the Commonwealth

*Technology optimists* believe that the economic transformation of Commonwealth countries over the next 5 years will be tangible, inclusive and profound. Current trends in technology development and adoption are being matched with attendant economic transformations.

Commonwealth countries are among the leading users of distributed renewable energy (for example, Bangladesh, India, Kenya, Tanzania and Uganda all have functioning and growing markets for PAYG solar). Many Commonwealth countries have set national renewable energy targets. Bangladesh has the highest penetration of solar home systems in the world.

In terms of mobile money, M-Pesa has operated in Kenya for over a decade and its evolving business model is being used in a number of other African nations. The principles behind the model are inspiring methods around the world of financial development for the unbanked.

Technology can also be transformative in agriculture. Arguably big data will be of greatest value to those who currently have zero data or analytics. For instance, farmers with only conventional weather forecasting ability have much to gain from digitally enabled weather services, which can downscale appropriately and, coupled with insurance services, can provide services to mitigate the risks from weather. In Kenya, a pilot project, developed by the UK's Department for International Development (DFID) working with farmers, insurance companies and weather providers, is doing exactly this. This digital application of weather insurance helps farmers in East Africa to take preventative measures against episodic shocks (e.g. hailstorms), and will provide financial assistance when problems occur (DFID, 2017).

However, the Commonwealth also faces constraints. Although the populations of developed Commonwealth countries have access to high-speed internet, reliable electricity and a competitive banking sector, this is not the case for most of the developing or small state members. National data do not illustrate the situation for the entire nation, and we expect the incidence of access to be lower for the remote, rural poor in developing countries and for women in developing countries; the digital gender gap is 12 per cent globally, but over 30 per cent in developing countries.

The latest data show that across the Commonwealth there is less connectivity, smaller investments in latest-generation technology and lower investments in attendant infrastructure. There are great differences among countries. Commonwealth countries have lower internet access, at 30 per cent, than the global average of 50 per cent. The internet is slow and investments in faster internet are small, with only 11 members offering ipv6 connectivity to their population, whereas 90 per cent of connections use ipv4 technology and connectedness. Examples of the digital divide across the Commonwealth include the following:

- Outside developed countries and Asia, the Commonwealth is poorly connected to the internet.
- A total of 28 per cent (675 million) of Commonwealth citizens do not have access to electricity.
- Half (1.25 billion) of the Commonwealth citizens are unbanked.
- Most Commonwealth countries do not report on R&D, and almost all that do are below the global average of 2.13 per cent.

The Commonwealth as a collective is equally at the forefront of technology innovation, in the midst of commodification of existing technology, and a straggler. Clearly investments and policy change are needed at country-level if the Commonwealth as a whole is to take full advantage of technology and realise attendant transformative economic potential. Some examples of collaboration among Commonwealth members, leveraged by similar legislation, language, financing and trading systems, are the collaboration among Pacific islands over energy security and the growth of mobile money and PAYG business models in East Africa.

The Commonwealth is a diverse mix of countries, which will require broadly different approaches. When examining decentralised energy technologies across both developed and developing countries, we see a variety of plausible business model solutions on which to focus policy.

## 6. Conclusion

It is clear that there are some key principles from economics, technology development and global experience with evolving business models that converge to underpin those looming decisions for all Commonwealth nations on how to invest for the future. These are set out below:

- **Technology that has the power to transform must transform economically.** Business models to scale innovations, both globally and nationally, require appropriate commercial conditions to be enabled by the public sector, which recognise what entrepreneurs need from assets, access (to finance, skills and opportunity) and regulation. This will require collaboration between the public and private sectors.

- **Private sector as partners in effective transformation.** The clear message from experience in the economic transformations in energy and digitisation across industrial sectors is for the public sector to design in collaboration with the private sector. Partnerships underline the need to co-invest commercially and politically in piloting, scaling, regulation and investment frameworks that can promote inclusive sustainable development.
- **Recognise that some economic disruption is inevitable, and be alert to the potential costs and benefits.** Even if you do not invest in supporting domestic digital-based transformation, it is likely that your trade profile will alter your comparative advantage, since some competitors will be investing in this. There are strong incentives for countries to invest in digital and energy transformation of their economies; the intended outcomes include tipping the balance of their comparative advantage, increasing their share of trade flows and seeking to enhance value through higher quality and higher value retention in the country. Changes abroad will affect transformation globally; for instance, in the USA, the successful development of either the TaaS concept – which aims to reduce by 80 per cent the number of cars on the roads – or the electrification of vehicles – which would similarly render petroleum-dependent vehicles increasingly valueless – could result in a massive increase in trade of petroleum-dependent vehicles to developing countries, which would have implications for ongoing transformation in either electrification or servicisation. Equally, countries may become new competitors.
- **Disruption will occur, particularly to incumbents.** We have seen changes to the largest companies globally over the past 15 years, and we expect this to happen in other countries. For example, risks from decentralised energy provision on incumbent vertically integrated utilities, almost all of which are public companies.
- **Trade is going to change, possibly even transform.** Changes to rural economies, trust in supply chains, easier start-ups and ubiquitous mobile-phone-enabled commerce have the power to disrupt, and possibly transform, trade in terms of ownership, quality, quantity, direction and value. This will alter comparative global advantages.
- **Seek to integrate the most appropriate level of technology.** Clearly, technology cannot be applied to solve all challenges. For instance, the benefits of decentralised grid solutions, as demonstrated in rural areas, will undoubtedly look very different from urban grid solutions. Understanding the appropriate level of supply of a service will require market experimentation, for which private sector and civil society will need to be engaged fully. For government investment decisions, the risks and opportunities of technology adoption or omission will need to be built into cost–benefit analyses and other decision-making frameworks, e.g. as a dashboard for each province or economic sector.
- **Design enabling legislation and policy.** Transformation clearly challenges a government's role, including its capacity to intervene and monitor. Ideally, creating an enabling environment for technological excellence is aided by investment in physical infrastructure, skills, and dedicated policy and regulatory frameworks. For energy, deregulation enables access to the grid and a system of feed-in tariffs for decentralised energy networks and renewable microgeneration. For digital, this will include policies on spectrum, broadband, public access and competition, as well as affordability targets (A4AI, 2017) and investment in enabling infrastructure.
- **Public investments in technology adoption and tailoring will underwrite future economic growth.** A typical list of needs for public investment to take best advantage of looming transformation potential will include electricity, broadband and skills development, particularly for entrepreneurs and public servants. There is a need to develop a 'core digital mindset', update ICT strategies, and incorporate risks and opportunities from digital and energy transformation into inclusive economic change.
- **Data-enabled decisions.** Data capture and transparency are key enablers for stakeholders. They can help governments work towards SDG7, identify electrification

needs, report on renewable energy proportion, monitor private sector performance and track investments in upgrading. Data are needed on where existing resources are, where the unserved are and what the needs of the unserved are.

- **From zero data to trust.** Investments in people, resources and locations around the world would change if there were better data available. A good example is the change from zero data, typical of rural areas of developing countries, into a position of understanding and trust that enables investment. The Kenyan Association of Manufacturers is working with its members and DFID Kenya to obtain data and intelligence to develop a range of service offerings in rural Kenya. One return they get is information on what is demanded, how to establish business and which firms are worthwhile partners.
- **Complementary technologies.** Digital and distributed renewable energy are examples of technologies that complement and catalyse each other in ways that deliver evolving business models that solve complex development challenges (in some contexts). PAYG solar needs mobile money, enabled via digital technology, to establish the payment system for renting solar home systems.

# Annex 1: Projected increase in GDP (US$ million) across Commonwealth (against current data) from increased penetration of broadband to the population (3.19 per cent)

| Commonwealth countries | Population | GDP per capita (US$) | Estimated GDP increase (US$) | | | |
|---|---|---|---|---|---|---|
| | | | Scenario I: 50% BB | Scenario II: 75% BB | Scenario III: 100% BB | Scenario IV: <50% double BB, 100% BB if already >50% |
| Antigua and Barbuda | 92,738 | 15,626 | – | 45 | 161 | 161 |
| Australia | 24,309,330 | 49,554 | – | – | 59,330 | 59,330 |
| The Bahamas | 392,718 | 23,037 | – | – | 635 | 635 |
| Bangladesh | 162,910,864 | 1,359 | 25,145 | 42,803 | 60,461 | 10,171 |
| Barbados | 285,006 | 16,096 | – | – | 350 | 350 |
| Belize | 366,942 | 4,811 | 47 | 188 | 329 | 234 |
| Botswana | 2,303,820 | 6,630 | 1,096 | 2,315 | 3,533 | 1,340 |
| Brunei Darussalam | 428,874 | 26,582 | – | 138 | 1,047 | 1,047 |
| Cameroon | 23,924,407 | 1,012 | 2,264 | 4,194 | 6,124 | 1,597 |
| Canada | 36,286,378 | 42,158 | – | – | 56,266 | 56,266 |
| Cyprus | 1,176,598 | 16,830 | – | 207 | 1,787 | 1,787 |
| Dominica | 73,016 | 7,196 | – | 12 | 54 | 54 |
| Fiji | 897,537 | 5,160 | 54 | 424 | 793 | 685 |
| The Gambia | 2,054,986 | 473 | 102 | 180 | 257 | 53 |
| Ghana | 28,033,375 | 1,523 | 3,612 | 7,016 | 10,421 | 3,197 |
| Grenada | 107,327 | 9,468 | – | 69 | 150 | 150 |
| Guyana | 770,610 | 4,472 | 130 | 405 | 679 | 420 |
| India | 1,326,801,576 | 1,706 | 173,295 | 353,811 | 534,327 | 187,737 |
| Jamaica | 2,803,362 | 5,004 | 348 | 1,467 | 2,585 | 1,889 |
| Kenya | 47,251,449 | 1,493 | 985 | 6,610 | 12,234 | 10,265 |
| Kiribati | 114,405 | 1,449 | 20 | 33 | 46 | 7 |
| Lesotho | 2,160,309 | 1,018 | 238 | 414 | 589 | 113 |
| Malawi | 17,749,826 | 307 | 707 | 1,141 | 1,575 | 161 |
| Malaysia | 30,751,602 | 9,637 | – | 3,721 | 27,356 | 27,356 |
| Malta | 419,615 | 26,093 | – | – | 832 | 832 |
| Mauritius | 1,277,459 | 9,522 | – | 965 | 1,935 | 1,935 |
| Mozambique | 28,751,362 | 383 | 1,441 | 2,319 | 3,198 | 316 |
| Namibia | 2,513,981 | 4,084 | 907 | 1,726 | 2,545 | 731 |
| Nauru | 10,263 | 9,944 | 16 | 24 | 33 | – |
| New Zealand | 4,565,185 | 40,528 | – | – | 6,951 | 6,951 |
| Nigeria | 186,987,563 | 2,166 | 3,305 | 35,610 | 67,915 | 61,306 |
| Pakistan | 192,826,502 | 1,471 | 28,956 | 51,578 | 74,200 | 16,288 |
| Papua New Guinea | 7,776,115 | 2,177 | 2,274 | 3,624 | 4,974 | 427 |
| Rwanda | 11,882,766 | 705 | 855 | 1,523 | 2,191 | 481 |
| Saint Lucia | 186,383 | 7,397 | – | 100 | 210 | 210 |

*(Continued)*

Annex 1 (*Continued*)

| Commonwealth countries | Population | GDP per capita (US$) | Estimated GDP increase (US$) | | | |
|---|---|---|---|---|---|---|
| | | | Scenario I: 50% BB | Scenario II: 75% BB | Scenario III: 100% BB | Scenario IV: <50% double BB, 100% BB if already >50% |
| Samoa | 97,026 | 4,040 | 62 | 124 | 187 | 64 |
| Seychelles | 97,026 | 14,711 | – | 77 | 191 | 191 |
| Sierra Leone | 6,592,102 | 557 | 556 | 849 | 1,141 | 29 |
| Singapore | 5,696,506 | 52,131 | – | – | 16,954 | 16,954 |
| Solomon Islands | 594,934 | 2,021 | 153 | 249 | 345 | 38 |
| South Africa | 54,978,907 | 5,363 | – | 21,709 | 45,222 | 45,222 |
| Sri Lanka | 20,810,816 | 3,908 | 5,191 | 11,677 | 18,162 | 7,780 |
| St Kitts and Nevis | 56,183 | 16,320 | – | – | 71 | 71 |
| St Vincent and the Grenadines | 109,644 | 7,030 | – | 57 | 119 | 119 |
| Swaziland | 1,304,063 | 2,858 | 233 | 531 | 828 | 361 |
| Tanzania | 55,155,473 | 860 | 6,755 | 10,538 | 14,320 | 810 |
| Tonga | 106,915 | 3,696 | 6 | 38 | 69 | 57 |
| Trinidad and Tobago | 1,364,973 | 15,377 | – | 388 | 2,062 | 2,062 |
| Tuvalu | 9,943 | 3,442 | 1 | 4 | 6 | 5 |
| Uganda | 40,322,768 | 633 | 2,506 | 4,542 | 6,578 | 1,565 |
| United Kingdom | 65,111,143 | 40,222 | – | – | 66,831 | 66,831 |
| Vanuatu | 270,470 | 2,860 | 68 | 130 | 192 | 55 |
| Zambia | 16,717,332 | 1,170 | 1,809 | 3,368 | 4,927 | 1,310 |
| **Commonwealth total** | | | **263,137** | **576,938** | **1,124,275** | **598,002** |

# Annex 2: Projected increase in GDP (US$ million) across Commonwealth (against current data) from increased speed of broadband (0.3 per cent per doubling of speed)

| Countries | National speed (Mbps) | Estimated GDP increase (US$million) | | |
|---|---|---|---|---|
| | | 6.3 | 9 | 1.5 |
| Antigua and Barbuda | 2.3 | 7 | 12 | 24 |
| Australia | 10 | – | – | 1,754 |
| The Bahamas | 7.9 | – | 4 | 24 |
| Bangladesh | 4.2 | 325 | 748 | 1,690 |
| Barbados | 5.8 | 1 | 8 | 22 |
| Belize | 2.3 | 10 | 16 | 30 |
| Botswana | 2.2 | 85 | 141 | 265 |
| Brunei Darussalam | 6.5 | – | 13 | 45 |
| Cameroon | 2 | 151 | 247 | 459 |
| Canada | 14.9 | – | – | 45 |
| Cyprus | 7.1 | – | 16 | 66 |
| Dominica | 4 | 1 | 2 | 4 |
| Fiji | 7 | – | 4 | 16 |
| The Gambia | 2.3 | 5 | 8 | 16 |
| Ghana | 3.4 | 112 | 215 | 444 |
| Grenada | 5.2 | 1 | 2 | 6 |
| Guyana | 3.2 | 10 | 18 | 38 |
| India | 5.6 | 902 | 4,199 | 11,526 |
| Jamaica | 6.6 | – | 16 | 54 |
| Kenya | 15 | – | – | 1 |
| Kiribati | 1.2 | 2 | 3 | 6 |
| Lesotho | 9.4 | – | – | 4 |
| Malawi | 1.5 | 55 | 85 | 153 |
| Malaysia | 8.2 | – | 87 | 737 |
| Malta | 12.9 | – | – | 5 |
| Mauritius | 6.4 | – | 15 | 49 |
| Mozambique | 2.7 | 44 | 78 | 151 |
| Namibia | 3 | 33 | 60 | 121 |
| Nauru | 1.9 | 1 | 1 | 2 |
| New Zealand | 12.9 | – | – | 92 |
| Nigeria | 4.1 | 639 | 1,434 | 3,200 |
| Pakistan | 2.4 | 1,350 | 2,293 | 4,389 |
| Papua New Guinea | 8.4 | – | 3 | 40 |
| Rwanda | 8.3 | – | 2 | 20 |
| Saint Lucia | 2.8 | 5 | 9 | 18 |
| Samoa | 2 | 5 | 8 | 15 |

(*Continued*)

Annex 2 (*Continued*)

| Countries | National speed (Mbps) | Estimated GDP increase (US$million) | | |
|---|---|---|---|---|
| | | 6.3 | 9 | 1.5 |
| Seychelles | 3.3 | 4 | 7 | 15 |
| Sierra Leone | 3.4 | 10 | 19 | 38 |
| Singapore | 20 | – | – | – |
| Solomon Islands | 1.6 | 11 | 17 | 30 |
| South Africa | 6.6 | – | 323 | 1,127 |
| Sri Lanka | 7.3 | – | 57 | 257 |
| St Kitts and Nevis | 4.7 | 1 | 3 | 6 |
| St Vincent and the Grenadines | 3.8 | 2 | 3 | 7 |
| Swaziland | 1.6 | 34 | 53 | 96 |
| Tanzania | 3.3 | 128 | 244 | 501 |
| Tonga | 2.4 | 2 | 3 | 6 |
| Trinidad and Tobago | 9.6 | – | – | 36 |
| Tuvalu | 2.9 | 0 | 0 | 0 |
| Uganda | 2.5 | 115 | 197 | 380 |
| United Kingdom | 16 | – | – | – |
| Vanuatu | 1.6 | 7 | 11 | 20 |
| Zambia | 2.3 | 100 | 168 | 320 |
| **Commonwealth total** | | **4,151** | **10,844** | **28,354** |

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