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The Impact of Information and Communication Technologies on Jobs in Africa

A Literature Review

Elvis Melia

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Preface

New digital technologies are expected to have a huge impact on developing countries' prospects for economic development. Digitisation will revolutionise business transactions in many ways: Digital technologies may help provide real-time information to farmers in remote areas; they enable poor people to use mobile banking services financial services; they allow firms in isolated locations to trade with international partners. Generally, they reduce a wide range of transaction costs and they may be used to make economic transactions transparent, reduce the scope for corruption and hold public service providers accountable. At the same time, digitisation enables automation at an unprecedented scale, thereby making millions of routine jobs redundant, and it enables the emergence of oligopolistic platform economies, some of which have led to an unprecedented accumulation of wealth among the super-rich and undermined welfare-oriented societal regulation.

Policymakers thus need to understand the opportunities and threats emerging from the wide range of digital innovations to be able to accelerate and broaden their positive effects while ensuring smart regulations to minimise the negative effects.

The German Development Institute / Deutsches Institut für Entwicklungspolitik (DIE) has initiated a series of research activities to explore some of these impacts on economic development prospects of latecomer economies, especially in Africa. First results have recently been published, and more research findings will be made available throughout 2019. The DIE team thankfully acknowledges financial support as well as expertise from Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ).

- In "Creating wealth without labour? Emerging contours of a new techno-economic landscape" (DIE Discussion Paper 11/2018), Wilfried Lütkenhorst analyses the main digital technology trends and how each of them is likely to affect developing countries' prospects for industrialisation, integration in the world economy and employment.

- Jan Ohnesorge's publication "A primer on blockchain technology and its potential for financial inclusion" (DIE Discussion Paper 2/2018) discusses the development potential of two blockchain uses: to reduce the cost of international remittances; and to improve government services, especially the establishment of transparent and reliable land registries.

- In the present DIE Discussion Paper 3/2019, "The impact of information and communication technologies on jobs in Africa", Elvis Melia reviews the scientific literature on the job effects of digitisation in Africa, differentiating between various technology applications covering information services for farmers and small enterprises and mobile banking, among other widely employed digital innovations.

Two related Discussion Papers are currently under preparation:

- Elvis Melia's second Discussion Paper on the economic effects of digitisation, "African jobs in the digital era: export sectors with a focus on online labour" (forthcoming in the first half of 2019) how digitisation affects African countries' export competitiveness. The study explores global automation, offshoring and reshoring trends through the lens of African opportunities.

- Lütkenhorst et al. (forthcoming in the second half of 2019) explore to which extent China's skyrocketing industrial wages are leading to the relocation of garment and shoe production to Africa. Industry-specific automation trends are studied as well as the strategic behaviour of Chinese investors and the attractiveness of African countries for such investments.

We hope that our ongoing research programme will help to better understand the effects of digitisation on the development of latecomer economies and provide insights for policymakers who want to harness new technological opportunities for inclusive and sustainable development.

Bonn, 25 February 2019 Tilman Altenburg

Programme leader
"Transformation of Economic and Social Systems"

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Elvis Melia

Contents

Abbreviations

4IR	Fourth Industrial Revolution
DHS	Demographic and Health Survey
FSD	Financial Sector Deepening (Financial Access Household surveys)
GDP	gross domestic product
ICTs	information and communication technologies
ISOC	International Standard Classification of Occupations
OLPC	One-Laptop-Per-Child
SIM	subscriber identity module
SMEs	small and medium-sized enterprises
USD	United States dollar

Executive summary

Information and communication technologies (ICTs) could lead to more economic inclusion of emerging market countries, valuable job opportunities for low-income workers, and, overall, higher living standards for all. Alternatively, ICTs could exacerbate the concentration of wealth, as rents are distributed ever more unevenly, leading to greater marginalisation of the peripheral poor. In Sub-Saharan Africa, policymakers tend to see the mobile phone wave and increased internet connectivity as positive. Yet, in the social science literature, various scholars question whether this ICT revolution is really benefitting citizens and workers of the global south. This study takes stock of recent empirical research that could provide evidence for either of these two notions for one particular aspect: ICT impact on African jobs.

The study is divided into four broad empirical categories: ICT-based information services (Section 2); mobile money (Section 3); various direct associations between ICTs and working-age men and women (Section 4); and fast internet (Section 5). This is followed by a discussion on policy options (Section 6), and a conclusion that is forward-looking and points to some future research options (Section 7).

Particularly widespread in Africa are ICT-based extension services and market information services for smallholder farmers. Several programmes for introducing these services have been accompanied by multi-year randomised controlled trials for measuring effectiveness. Results for the impact of ICT-based interventions for farm inputs and productivity are remarkably positive. For ICT-based market information services, results are more varied: but here too, the majority of studies reviewed find either distinctly positive impacts of ICTs on African jobs or points to technical problems that temporarily hinder the expected positive outcomes. Some empirical studies find little or no positive impacts of ICT-based market information services, but none of these studies deem these problems as insurmountable. One study suggests that ICT-induced farm productivity reduces the need for rural farm labour. (This could be interpreted as positive, if it leads to structural transformation of the economy, or as negative, if it leads to a net loss in employment). None of the other studies reviewed in this section point to *negative* results of ICTs on jobs in Africa.

In these quasi-experimental settings, however, some aspects are difficult to control for, and methods are still evolving. Much of this research on various ICT-based information services primarily tests the merits of the services, that is, of the particular *intervention strategies,* not the *direct impact* of the underlying technologies as such. Furthermore, such randomised trials accompanying ICT-based intervention schemes tend to take a narrow focus and may not be adequate for detecting larger structural constraints. Their results can thus not easily be extrapolated to draw conclusions about the *overall* ICT impact on African jobs.

One famous innovation is mobile money. Created in 2007 and spreading across Africa throughout the 2010s, mobile money is seen by policymakers as supporting various types of informal micro-businesses, in agriculture and elsewhere. Here, rigorous research evidence (covered in Section 3) points in a clear direction: mobile money *does* alleviate poverty in Africa, and it creates both rural and urban jobs. Women in particular have benefitted from this innovation. Here it helps to keep in mind, however, that mobile

money is *one distinct* technology. The positive dynamics it creates may be particular to this innovation and not necessarily representative of *all* ICTs.

While the above results were largely derived at via controlled trials, several other methods exist for studying the impact of ICTs on jobs in Africa. Large-number cross-country comparisons, natural experiments, survey analyses, or deep anthropological case studies can complete the picture on whether or not ICTs have had the expected socio-economic impact in Africa, and which nuances exist – for instance, whether or not these impacts are the same for men and women (covered in Section 4). The results of large cross-country comparisons vary. Some studies indicate that ICTs can lead to an increased concentration of wealth by having greater positive effects on countries or firms that are already better off. Several studies thus suggest, in line with the World Bank's (2016) emphasis on "analogue complements," that various other variables – institutional, societal, or cultural – exert influence on whether or not ICTs create jobs in Africa. Applying this method, however, means that causation is difficult to determine (that is, some studies find that ICTs also have *positive* effects on these analogue complements, which blurs our understanding of individual causal relationships).

Case studies on the impact of mobile phones, mostly conducted via randomised trials, find that the introduction of mobile phones *has* had positive effects for African farmers and traders dealing in perishable produce such as bananas, but *not* in more durable produce, such as maize. These findings imply that mobile phones can be more or less helpful via gaining market information, depending especially on how perishable one's goods are. For the former, logistics demand timely communication, whereas the latter can be stored longer and are easier to transport. (However, one study also finds positive effects of mobile phones on urban cloth traders, even though cloth is a non-perishable good).

As far as the empowerment of women is concerned, the picture is more complicated: gender equity and women's income generation can be discussed in absolute or relative terms. When examining women's *absolute* empowerment – that is, when examining whether ICTs have helped women generate incomes irrespective of whether or not men have benefitted more – most empirical analyses point to distinctly positive results. However, when examining the *relative* power distribution between men and women within a given society, there is cause for concern, especially with regard to internet adoption. By one account, Sub-Saharan Africa is currently the only world region in which the digital gap between men and women is not shrinking but *widening*.

This trend is particularly worrying in light of findings that, once connected, the internet seems to have an even greater positive effect for women than mobile phones did. With myriad other responsibilities and operating in patriarchal surroundings (that is, multitasking with children, and mollifying spouses), internet access seems to be a vital tool for women's empowerment. Compared to a phone connection, benefits are far greater because the internet allows African women to communicate subtly, when time permits, via social media instead of having to take phone calls immediately.

This leads the paper to the final empirical section: broadband internet (Section 5). The number of Africans with regular access to fast internet is still miniscule. Thus, compared with the numerous studies on other ICTs reviewed here, much less rigorous evidence exists to date for measuring the impact of broadband internet on jobs in Africa. The

section is structured as a three-step review: i) large-number cross-country comparisons on the internet's statistical relationships with various job-related indicators; ii) critical studies that question the widely assumed benefits of broadband internet connectivity in Africa; and, iii) an extensive recent study on broadband internet impact on African jobs.

Large cross-country comparisons have found that, for developing countries, internet adoption is associated with increases in exports to developed countries; with higher gross domestic product (GDP) per capita growth rates; with higher firm productivity; and with higher labour productivity. But here, too, the assumed causal relationships cannot be entirely verified; and in some of these studies it is unclear whether a fallacy of composition is at play – that is, whether some countries' gains in market share merely come at the expense of other developing countries with worse internet access and diminishing market shares.

Thus, in attempts to unveil hidden structural aspects, several recent studies have taken a more critical stance. They call into question the widely held assumptions on positive causal effects of internet connectivity on African economies, and conclude that the internet *may not* always help African SMEs' positions in global value chains; *may not* cause as much knowledge generation in Africa as is often assumed; and *may not* warrant the general enthusiasm for greater internet connectivity that is often encountered in African policy documents. These findings are tentative and difficult to prove. They are at odds with most of the literature reviewed in the rest of this paper, and, hence, are at odds with this study's policy recommendations (see below). But such critical angles should nevertheless be taken seriously. They point to structural dynamics that are difficult to measure and may exist in parallel with the positive dynamics found in the other studies. Some indications exist that at least one negative dynamic (increased polarisation of wealth and productivity) may surge in the era of Fourth Industrial Revolution (4IR) technologies – that is, in the years ahead, as platform economies, machine learning, big data analytics, and routine task automation increase.

For the time being, however, the evidence for positive impacts of the internet in Africa clearly outweighs existing empirical grounds for scepticism. This is corroborated by one large (forthcoming) study, which enjoys special status in this literature review: Tracing the landings of ten submarine fibre optic cables in 12 African countries between 2006 and 2014, Jonas Hjort and Jonas Poulsen measured the impacts of broadband internet arrivals in these quasi-random locations and found that broadband internet connectivity *has* had significant positive impacts on the number and quality of firms as well as the number and quality of jobs in connected areas. They were able to show that these positive findings were not due to displacement effects (namely, to fewer firms and jobs in nearby unconnected areas due to firm relocation or workers commuting to connected areas). Hence, this study comes close to proving the causal relationship: fast internet connectivity leads to more and better jobs in Africa.

Lastly, policy options are suggested for governments and development partners (Section 6). Some of the review's findings are straightforward: The *quality* of agricultural interventions is important, be they analogue interventions (for instance, delivered in person via an extension officer) or digital interventions (such as those delivered via an ICT-based extension services platform). Digital intervention platforms can be improved in much the same way as analogue interventions are improved: via better feedback

mechanisms and well-planned monitoring and evaluation schemes. Randomised controlled trials should increasingly accompany interventions. Targeting younger farmers may also generate higher returns.

The positive impact of mobile money suggests that amplifying its spread across the subcontinent could spur the creation of jobs. One study found, however, that natural first-mover advantages may be the best predictors for a country's relative success rate in spreading mobile money, and that policy interventions can have negative effects (as seen in Nigeria).

The current speed of technological change can make it difficult for governments and development partners to stay ahead of the curve and to plan for meaningful interventions. The example of the United Kingdom's Department for International Development's (DFID) involvement in the creation of mobile money, however, shows that such forward-looking engagement is possible and worth pursuing. Partner organisations interested in initiating similarly impactful ventures could engage in knowledge generation on blockchain technologies (for instance, GIZ has set up an in-house expertise unit – the Blockchain Lab).

For women empowerment and various other job-creation dynamics, supporting the spread of the internet seems particularly feasible. To date, the evidence base for the internet's positive economic impact on jobs in Africa outweighs the concerns about possible negative effects. Examining different support options for spreading internet adoption across Africa, one study found that adherence to standardised internet inclusion policies, and lowered taxes and import duties on computer hardware are particularly helpful. One option could thus be to utilise the short usage cycles of computer gadgets in high-income countries for carefully monitored import schemes of second-hand devices to lower income countries.

These suggestions are squarely based on the currently available empirical evidence reviewed here. Further research is needed to examine whether such positive claims about ICTs and internet penetration in Sub-Saharan Africa remain warranted going forward. Some of the critical scholars point out that the currently evolving set of Fourth Industrial Revolution technologies hold the risk of reversing this trend: continued commodity exports and technology imports may lead to path-dependence toward ever-diminishing terms of trade for African countries, and platform-based trade may exacerbate wealth inequality rather than mitigate it. Whilst the currently available empirical evidence reviewed in this study is insufficient to support such claims, these concerns need to be engaged with in future research. One example would be to examine which options still exist for African countries to break into productive export sectors.

1 Introduction

There are more mobile phones than adults in most African countries
("Africa calling", 8 August 2016, in The Guardian).

Information and Communication Technology (ICT) increases connections, be it between small farmers and the larger traders who buy their produce, between multinational firms and the smaller manufacturers who build their parts, or between various firms and individuals around the world, linking rich and poor within and across countries. Depending on one's outlook, this should lead to more economic inclusion of emerging market countries, valuable job opportunities for lower income workers, and, overall, higher living standards for all (MGI [McKinsey Global Institute], 2013). Alternatively, it could lead to a further concentration of wealth, as rents are distributed ever-more unevenly within societies and across global regions, leading to greater marginalisation of the peripheral poor within countries and of the global south as a whole (Huws, 2014). In Sub-Saharan Africa (henceforth: "Africa") the past two decades of fast-growing mobile phone usage have led most policymakers to conclude that the mobile phone wave is positive, as the phones save time and bus fares, provide safety, and generate new employment and work opportunities that had hitherto not existed.

Critical literature

In the social science literature, however, various scholars question whether the ICT revolution is really benefitting citizens of the global south. Some have hypothesised the opposite – that ICTs are the latest in a series of technological advancements that buttress the structural forces of inequality and underdevelopment. Murphy and Carmody (2015), for example, make the argument that ICTs can also perpetuate existing modes of extraction and exploitation of the global south. In some instances, mobile phone penetration can force Africa's poor into "negative adoption" of mobile phones (p. 34). This means that to find *any* sort of work in this new, networked society, the poor are *forced* to buy phone credit. Reluctantly, they do so *instead* of paying for their most basic needs and expenditures such as nutritional food or school fees for children. In this view, being disconnected from the network has become so disadvantageous for the poor that they have no choice but to partake. Thus "mobile phones bring poverty" (Murphy & Carmody, 2015, p. 33, citing a Ugandan survey respondent in Diga (2007)).

This paper sets out to take a non-biased account of existing empirical research that could provide evidence for either of these notions: the positive view that ICTs are beneficial for Africa; or the sceptical view that they are not. I limit the scope of this review by focusing on the initial generation of information and communication technologies (ICTs) – entailing mobile phones, text-based services platforms, mobile money, and the internet. These technologies have been around for long enough that a critical mass of empirical studies exists. Not covered in this review are the much newer Fourth Industrial Revolution (4IR) technologies – entailing machine learning, mobile robotics, 3D printing, the blockchain, or platform economies such as ride-hailing apps – because little rigorous research exists on their impact to date (for a discussion of these newer technologies, see Melia, Forthcoming). As per the title of this paper, the dependent variable is also limited to one single outcome – jobs. Jobs are closely related to other economic variables – for example, firm productivity, women's empowerment, skills and educational improvements, economic growth and the

institutional environment – and I thus refer to research that tests for ICT impact on any of these related variables as well. My core focus on jobs, however, is not chosen arbitrarily.

The growing centrality of both "jobs" and "ICT" for Africa

The issue of African job creation is central in development policy circles. This is due to ever-growing numbers of working-age Africans, and perhaps in part also due to Europe's political challenges entailed in absorbing migrants. The International Monetary Fund (IMF) (2015) calculates that due to Africa's demographic changes the number of newly created jobs on the continent will need to be "18 million per year from 2010 to 2035" (p. 30). The United Nations has declared its eighth Sustainable Development Goal to be "employment for all" by the year 2030 (UN [United Nations], 2015, SDG8). In the real world, this challenge coincides with a time where each two-year doubling of global computing power is noticeably more disruptive than the last (Reese, 2018). This moves ICTs to the core of the discussion on African job creation. For Africa, the digital era has begun to progress away from the wave of mobile phones, toward the wave of broadband internet connections. While there is as yet little rigorous research that could be reviewed on the new 4IR technologies, this study provides a foundational overview of the actual effects that narrowband ICTs have so far had on jobs in Africa. I then document the first rigorous findings on the relationship between broadband internet and African jobs.

Exactly how useful ICTs have been for jobs in Africa has long been difficult to measure (be it in jobs directly influenced, or jobs indirectly influenced by new types of economic development, labour or firm productivity levels, or changed institutional environments). Past reviews of the literature have noted that, of the large number of publications on ICTs in Africa, only a small proportion has actually demonstrated rigorous findings on the effects on particular development outcomes (for instance, Duncombe & Boateng, 2009, for ICT in finance). But the body of rigorous research has substantially grown over the past decade, and this study seeks to provide an up-dated review.

Methodology

This literature review is not exhaustive. I focus on empirical research findings published in peer-reviewed journals (and on findings that are still in working paper format but clearly aimed at journal publication). Many more such studies exist, particularly earlier works, as this paper concentrates on findings of the past few years. I also refrain from reviewing theory-based commentaries and related policy reports – some of which are of high quality (for an extensive overview and critique of such reports, see Friederici, Ojanpera, & Graham, 2017). Keeping the main body of this review free of discussing less rigorous publications and free of voicing my own detailed critiques of other researchers' conclusions, is meant to provide a lean text that illuminates the trends in the research. This is, however, closely related to wider policy debates. I have thus made extensive use of footnotes to point to related but less rigorous policy documents, and, in certain instances, to underpin why my conclusions differ from those of other researchers.

I came to this literature by conducting *Google Scholar* searches for various combinations of terms. For independent variables: "ICT," "digital," "internet," "mobile phones," (and more specific terms such as "mobile money," "ICT-based," "text-based," "SMS," "market information services"). For geographic location I used "Africa," "Sub-Saharan Africa," and

various individual country searches. For dependent variables: "jobs," "employment," "income," "work" (and related terms such as "GDP," "productivity," or "inequality;" and gender-related terms). This led me to citation-based snowball searches, starting with articles that were i) published in ranked journals; ii) relatively recent; and, iii) cited most frequently by other peer-reviewed studies. Helpful for cross-referencing this literature review are World Bank (2016); Deichmann, Goyal and Mishra, (2016); and Friederici et al. (2017).

Structure of this literature review

This study divides the literature into four broad categories: ICT-based information services; mobile money; various direct associations between ICTs and working-age men and women; and, finally, fast internet.

The first subset of the literature is dedicated to measuring the effects of mobile phones on various development outcomes, some of which are related to job creation directly (such as productivity, growth, exports), while others can have indirect effects on job creation (for instance, via human development, education, or governance).

Most African workers are still (self-)employed on small farms or in urban microbusinesses. This implies that the biggest potential effects of ICTs (that is, of mobile phones, text-based message services, or the internet) on Sub-Saharan African workers should lie in providing services to small, informal businesses. Particularly widespread among such services are ICT-based extension services and market information services for smallholder farmers. Several of these interventions have been accompanied by multi-year randomised controlled trials for measuring the effectiveness of such interventions. A number of such studies have now been completed and results have recently become available (covered in Section 2).

The innovation of mobile money in 2007 and its spread across Africa throughout the 2010s is seen by policymakers as supporting various types of informal micro-businesses, in agriculture or elsewhere – and here too, rigorous research evidence now exists on whether or not this assumption is true (covered in Section 3).

Apart from randomised controlled trials, researchers have applied other methods to study the impacts of ICTs – from large-number cross-country comparisons, to natural experiments, to survey analyses, and deep anthropological case studies – mainly to find out whether mobile phones, or narrow-band ICTs generally, have had the expected positive socio-economic impact on various aspects of African lives, including those of African women (covered in Section 4).

The paper then reviews the (to date much smaller) body of research on the broadband internet and its impact on African jobs. I begin with large-number cross-country comparisons, which can determine correlations between variables but cannot definitively speak to causal relationships (subsection 5.1). This leads me to introduce and discuss three critical studies that all question the widely assumed *causal* links between broadband internet connectivity and African development outcomes that are closely related to jobs (subsection 5.2). I then close the literature overview by introducing one final paper, a recent and methodologically impressive study (albeit as yet unpublished), which may well become a milestone contribution to the literature on ICTs and jobs in Africa (subsection 5.3).

Lastly, in Section 6, I point to a trend in these results. On the basis of this trend I suggest policy options for governments and development partners interested in the actual role ICTs play in the creation of jobs in Africa. Section 7 gives a short conclusion.

2 Jobs via ICT-based information services for farmers and SMEs?

Several studies have examined the success rates of ICT-based development interventions. Such interventions are often combinations of government- or donor-supported programmes. They mostly provide either particular extension services, that is, tips and tricks on soil, weather, crop types, fertilisers, best practice breeding methods for livestock – or other services that could help farmers become more productive (covered in subsection 2.1); or market information services, that is, lists of real-time prices for certain farm products at local or regional markets (covered in subsection 2.2).

2.1 Information services for productivity enhancement

Globally, the lowest levels of farm productivity are in Sub-Saharan Africa. If smallholder farmers become better informed about their technical options for increasing yields, their productivity usually rises, leading to better working conditions on farms and higher food security (Ragasa & Mazunda, 2018). Supporting analogue agricultural extension services (such as one-time farm visits) with digital tools (such as repeated text messages) can amplify the reach of extension officers exponentially (see, for example, Aker, 2011), can make services more transparent (see, for example, Cole & Fernando 2012), and can give farmers greater agency and trust in accessing the types of input information they need most (see, for example, Ragasa & Mazunda, 2018; Molony, 2008).

Jenny Aker, a leading authority in the field, suggests that ICTs can greatly improve extension services in Sub-Saharan Africa, but only if conducted under the right circumstances (Aker, 2011). After giving an overview of existing ICT-based agricultural extension services,[1] she provides a useful methodological framework for testing the merits

1 For more recent lists of ICT-based intervention strategies see CTA [Technical Centre for Agricultural and Rural Cooperation] (2018), Oestermann, Esselaar and Dymond (2013), or Mramba, Rumanyika, Apiola, and Suhonen (2017). Mramba et al. (2017) compiled and categorised a list of all ICT-based intervention programmes in Sub-Saharan Africa found via internet search. What is noteworthy is that the authors found an exceptionally high proportion of these interventions to be i) agriculture-focused projects, and ii) located in Kenya. The study also claims to have "found several setbacks related to the adoption of ICT among informal workers, such as low uptake level, lack of ICT contextualization, and uneven distribution of ICT solutions among different categories of the informal workers" (Mramba et al., 2017, p. 4). Yet, the study gives no methodological indication for how the authors arrived at this judgment, which led me to omit it from the literature review. Its list of interventions is nonetheless exhaustive and relatively up-to-date (from 2016/2017), and can provide the interested reader with a good baseline compilation of existing initiatives. Oestermann et al. (2013) profiled some 40 companies that use ICT to serve the base of the pyramid markets (that is, consumers who earn on average less than USD 8 per day). The paper's list is global, but many of the cases are from Sub-Saharan Africa. Most recently, CTA (2018) provides more detailed overviews of four ICT-based initiatives that serve East African farmers (three in Uganda – WOUGNET, MUIIS and Ensibuio; and one in Kenya – FarmDrive).

of such interventions (Aker, 2011). Since then, several case studies have undertaken such tests. This section summarises their results.

In northern Ghana, a study found that one ICT-based intervention[2] for rural smallholders did lead to significant increases in the use of pesticides between 2006 and 2009 (Al-Hassan, Egyir, & Abakah et al., 2013). Applying propensity score matching, this study found a 13 per cent higher uptake of improved seeds among treated farmers, leading to an 11 per cent increase in food security (vis-à-vis a control group). The study also found that younger participants were significantly more likely to embrace ICT-based extension service advice, leading the authors to suggest that such interventions should be targeted more at younger generations in future, since this would bring about higher up-take (Al-Hassan et al., 2013).

An extensive study on western Kenyan sugarcane smallholder farmers (conducted between 2011 and 2013), also found that those farmers who received regular advice via SMS text messages earned on average 11.5 per cent more than a control group (Casaburi Mullainathan, Kremer, & Ramrattan, 2013).[3] Furthermore, these were farmers who had not been trained and had no regular contact with their sugarcane company. Making a direct and free hotline available for farmers (to complain if the company had not provided the promised fertiliser) increased the company's input delivery to its smallholder farmers by some 21.6 per cent (Casaburi et al., 2013).

Ogutu, Okello and Otieno (2014) used propensity score matching to test the impact of a different ICT-based intervention for smallholder farmers in three Kenyan Districts (between 2002 and 2010). This intervention, DrumNet (via Pride Africa), was an all-encompassing platform for extension services, market information services, and facilitating access to credit. The study found that "participation in the ICT-based project [had] a positive and significant effect on the usage of purchased seed, fertilizer, labor productivity, and land productivity, but [had] a negative and significant impact on the use of hired, family, and total labor" (Ogutu et al., 2014, p. 319).

In the present literature review on ICT impacts on African *jobs*, the finding that DrumNet actually *reduced* the need for rural farm labour should be a red flag. The causal mechanism behind this seems to be increased land productivity (via non-labour inputs such as seeds and fertiliser) and particularly increased labour *productivity* (via significantly lowered transaction costs in various farm-related search activities). This means that as farmers spend less time on some activities – searching for inputs, negotiating prices for outputs – they can spend more time on tending to their land. This, in turn, frees up hired help and family members to pursue other activities. I will address this seeming conundrum between increased agricultural modernisation and decreased numbers

2 The Sustainable Enterprise Development Foundation, an NGO, used the private market information service platform TradeNet (today Esoko) to deliver targeted information and training to smallholder farmers.

3 Funded by Jamal Poverty Action Lab and four other donors, this intervention was steered directly by the research, and conducted in collaboration with Mumias Sugar Ltd. Results are still preliminary in this (2014) version of the study, but no updated version could be found online. This may or may not be related to Mumias Sugar Ltd having simultaneously been embroiled in gross mismanagement and a grand corruption scandal, from which, after having fired over 50 top-level employees, and a large government bailout, the company has not recovered ("Cash crunch", 22 March 2018, *The Standard*).

of menial jobs in more detail below. For now, the net positive effect of this particular dynamic is corroborated in an earlier study of the same intervention, by Okello (2010), which found that DrumNet's treated farmers and their families were more food secure and had better access to health care than did a control group.

A recent finding from another world region is also positive: Cole & Fernando (2016) studied Avaaj Otalo, a simple mobile-phone-based extension service hotline in India, and traced the effects that this had on cumin and cotton farmers. The study found "dramatic increases in average yield for cumin (26.3 per cent), as well as improvements in cotton yield (3.5 per cent) for a sub-group that received frequent reminders to use the service" (p. 1) and the authors "estimate that a USD 1 investment generates a return of more than USD 10" (p. 21).

These results are all remarkably positive for the impact of ICT-based interventions for farm inputs and productivity. However, this body of literature is still relatively small. A separate body of literature on ICT-based market information services is much larger and its results are more heterogeneous (subsection 2.2).

2.2 ICT-based services for market information

If smallholder farmers are better informed about market prices, various positive effects can ensue: market prices become less volatile and can come down in aggregate (because crop supplies better match demand in a given location, thus reducing gluts and shortages). This is better for consumers, but farm-gate prices (the prices farmers receive for their produce) simultaneously increase, especially for perishable goods (as better market information leads to less wastage). Also, as smallholder farmers are usually poorer than their intermediary traders, increasing their access to information, and hence their bargaining power, can lead to faster poverty reduction.[4] This subsection investigates if empirical evidence supports this theory.

Findings of positive impact on income generation

In Niger, Aker (2008) examined the introduction of mobile phones, and did find a positive impact in the form of *both* higher grain traders' profits (due to lower search costs) *and* overall lower grain consumer prices (due to more evenly available supply). Targeted market information services can also be made more effective if ICTs help spread the services to more smallholder farmers.

This is in line with Svensson and Yanagizawa's (2009) findings that Ugandan maize farmers who had access to a radio-aired market information service were better able to bargain for higher prices for their crops than were their less informed peers. Re-examining this same intervention, Kiiza, Pederson and Lwasa (2011) employed propensity score

4 Mixtures of extension services and market information services, such as the above-mentioned DrumNet, include the Kenya Agricultural Commodity Exchange (KACE), the Regional Agricultural Trade Intelligence Network (RATIN), the National Livestock Market Information System (NLMIS), and the M-farm, all in Kenya. Similar initiatives outside Kenya comprise the Malawi Agricultural Commodity Exchange (MACE), the Busoga Rural Open Source Development Initiative (BROSDI), and then Women of Uganda Network (WOUGNET) (see Ogutu et al., 2014). Refer also to Footnote 2.

matching to check for hidden selection biases, and came to similarly positive results for better-informed farmers.

In Ghana, Nyarko, Hildebrandt, Romagnoli and Soldani (2013), conducting a randomised experiment with 1,000 smallholder farmers between 2011 and 2013, provided their treatment group with free access to Esoko, a private weekly SMS market information service for crop prices. Their preliminary results found a 7 per cent increase in earnings for SMS-recipient yam farmers, presumably due to better bargaining power. A later version of the study by the same authors, Hildebrand, Nyarko, Romagnoli and Soldani (2015), showed 8 to 9 per cent higher farm gate prices and thus substantial improvements in yam farmers' living standards.[5]

These positive results for ICT-based interventions suggest that the underlying information and communication technologies used in these interventions did have some positive impact on jobs in Sub-Saharan Africa. For smallholder farmers, generating higher prices for crops can be translated directly into having higher incomes. But in these quasi-experimental settings some aspects are difficult to control for, and methods are still evolving.[6] Other empirical studies found little or no positive impact of ICT-based market information services. I examine these studies in detail below.

Findings that showed little to no impact

In Botswana, an early study by Duncombe and Heeks (2002) had examined the information needs and information sharing techniques of rural micro-entrepreneurs. Their findings suggest that mobile telephony could benefit these informal businesses, but that other ICTs (such as text, internet, fax [*sic*]) would be more difficult to utilise for individuals. To be useful, these technologies would need to be routed through better-informed intermediary organisations (Duncombe & Heeks, 2002).

One study conducted in Rwanda, by Futch and McIntosh (2009), has been referred to as documenting "no effect of having a mobile phone on prices received by farmers" (Deichmann et al., 2016, p. 12). Futch and McIntosh's study examined the introduction and use of quasi-payphones (where village kiosks had been equipped with a mobile phone for public use, and with car batteries for charging the phones). While this study found that these

5 Interestingly, this same increase of 8 to 9 per cent was found in the control group. The authors attribute this to indirect spillover effects (that is, treatment group farmers' increased information and bargaining power led traders to suspect better informed farmers across the board, and, hence, to offer higher prices to non-informed control group farmers as well). This finding presents an interesting complication to randomised experiments. This study concentrated on yam, but also had data on other crops, for which no discernible impact of the intervention was found.

6 Indirect information spill-over effects are still difficult to detect in these studies (see, for instance, Hildebrandt et al. 2015, above). More broadly, certain counterfactuals cannot be accounted for, for instance, what intervention strategies *would have taken place* in a world in which Africa is experiencing equally rapid development improvements (Radelet, 2015) *without* the existence of ICTs? Also, possible time-lagged *negative effects* of ICTs are unaccounted for, such as cultural and discriminatory clustering, which greater connectivity may bring about. On increasingly polarised opinions in the network age, Ferguson (2017, p. 355) notes that "birds of a feather, in terms of shared interests as well as personality types, flock together as always, and there may be a feedback loop that causes similar users to grow more interconnected through Facebook usage."

"Village Phones" did lead to significantly better transport arrangements for smallholder farmers, the study also found that the phones did *not* lead to higher incomes or higher farm gate prices. This could imply that phone kiosks were of little use to the target population. But the study's authors themselves note that their non-result for the "Village Phones" could well have been due to a similar service, Tuvugane, that had already existed in the area, which entailed that "low-cost access to telephony at the village level had already occurred as of our baseline" (p. 71). Thus, in this case, concluding that phone kiosks led to no positive result, as Deichmann et al.'s quote implies, is inaccurate. Apart from the improved logistics, mobile telephony *did* have overall positive price effects in all tested areas, be it via one provider (Tuvugane) or the other (Village Phones).

But several other studies, particularly for purely text-based services, also showed little to no impact, which somewhat validates Duncombe and Heek's (2002) cautionary predictions. In Ethiopia, Tadesse and Bahiigwa (2015) found that "the effect of village level mobile phone access [was] totally insignificant" (p. 303), and that very few farmers actually used their phones for obtaining market information, and suggested this could be due to a lack of relevant information available (that is, due to the difficulty of accessing existing SMS-based interventions).

Similarly, in Niger, Aker and Fafchamps (2014) found that the introduction of mobile phone coverage had no discernible effects on the average prices that farmers received for any of the study's examined crops (cowpea, sorghum, and millet). For cowpea, mobile phone coverage did have a positive effect on levelling the prices between markets and throughout different times of the year, but this was not the case for either millet or sorghum (which are less perishable crops and can be stored longer).

And Wyche and Steinfield (2015) cite InfoDev which apparently found in 2013 that merely 5 per cent of rural farmers in Kenya and South Africa used their mobile phones for accessing market information services. Wyche and Steinfield followed up on these results with an analysis of some 70 rural Kenyan farmers' use of MFarm. A mobile-phone-based crop-price information service, MFarm, provided daily market prices for 42 crops at Kenya's five large city markets (each SMS costing Ksh1, approx. USD 0.01). In answering their paper's headline question: "Why don't farmers use cell phones to access market prices?" Wyche and Steinfield suggest that rural Kenyan smallholders have several reasons for refraining from text-based services: it is cumbersome to type messages (due to illiteracy, poor eyesight, and inadequate hardware – old handsets with limited backlights, worn-off and broken key pads, and devices that are incompatible with local languages); being off the electricity grid required cost-conscious battery use (most phones were either turned off or placed at far-off charging kiosks); texting costs (even USD 0.01 was expensive in areas where men claimed to have between zero and USD 0.16 of credit on their phones, and where women mostly claimed to have between zero and USD 0.02); and reply text messages received by the service that farmers could often not utilise. This finding suggests that the underlying technology *could be* beneficial to smallholder farmers if they could either access it better (via better equipment), or if the service were improved to match the conditions on the ground (Wyche & Steinfield, 2015).

This notion is in line with Ragasa and Mazunda's (2018) findings of analogue extension services in Malawi: in aggregate, the bulk of extension services had no discernible impact. Yet, when examining solely the impact on the subset of recipients who had deemed their

received advice "very useful," strong and significant effects were found on farm productivity and food security. This leads to a straightforward conclusion: services that are of low quality will be ineffective, regardless of whether they are delivered in person or via ICTs.

So far in this literature review, one study found that ICTs seem to have decreased the need for rural labour by speeding up the process of agricultural modernisation. This could be seen as a negative effect. But it is also a necessary component of improving agricultural productivity and of positive transformation of the economy's structure – leading workers out of less productive, into more productive sectors. All other studies reviewed here have found either distinctly positive impacts of ICTs on African jobs, or technical problems that temporarily hindered these results. None of the authors of the latter studies saw these problems as insurmountable, and none found *negative* results in the sense of Carmody and Murphy's "negative adoption." But such randomised trials, accompanying ICT-based intervention schemes, tend to take a narrow focus and may not be adequate for detecting larger structural constraints.

Problems with ICT-based services could be external, associated with the institutional environment and the limited power of smallholder farmers (or urban micro firms) vis-à-vis their intermediaries and larger trading partners.

An early study by Esselaar, Stork, Ndiwalana and Deen-Swarray (2007) had examined the impact of ICT-based market information services on 3,691 urban (that is, non-farm) SMEs from 13 African countries.[7] This study found that "ICTs are significant input factors for both formal and informal SMEs and contribute positively to revenue generation" and that "ICT use increases labor productivity" (p. 99). But commenting on drawbacks, Esselaar et al.'s recommendations to policymakers included that

> [w]ell-designed phone- or SMS-based business applications may have an impact on the profitability of SMEs. One of the key factors in providing the informal sector access to credit is the lack of co-operation between mobile operators and banks, often as a result of poor regulation. For example, in many countries, mobile operators are not allowed to be banks, but since mobile operators have access to the informal sector they could effectively service this sector. Encouraging innovation and cooperation between mobile phone operators and banks on the mobile platform could deliver SMS based business applications. (Esselaar et al., 2007, p. 99)

This, of course, is precisely what happened in the decade that followed, as the year of their study's publication (2007) was the birth year of mobile money.

7 Botswana, Cameroon, Ethiopia, Ghana, Kenya, Mozambique, Namibia, Nigeria, Rwanda, South Africa, Tanzania, Uganda, and Zimbabwe.

3 Jobs via mobile money?

For small African businesses, the mere access to information can be insufficient for making unconstrained investment decisions. Molony (2008) found that intermediaries in Tanzania had significant power over smallholder farmers: the farmers were forced to accept the prices they were offered, regardless of whether or not their mobile phones provided information on *actual* market prices. This lock-in, Molony found, was due to an asymmetric power relationship, where the intermediaries were also the smallholders' creditors, who could threaten to withhold much-needed financial services to farmers who chose to exit the relationship and sell their crops elsewhere.

For these and other restraints on economic flexibility, the innovation of mobile money is seen as a promising release valve. Mobile money is the most famous ICT-based innovation in Sub-Saharan Africa to date. A form of legal shadow banking, mobile money allows users to store money (usually up to around USD 1,000) on their SIM (subscriber identity module) cards, and send and receive money (usually up to around USD 700 per transaction) to and from other users, businesses, or government agencies. A physical infrastructure of geographically dispersed kiosks and agents also exists, where clients can deposit and receive cash. The most important advantages of mobile money have been found to be distance bridging, security, and shock absorption (Suri, 2017). Several methodologically sophisticated studies have been applied to measuring various impacts of mobile money on Africans. All came to positive results.

In Kenya, Jack and Suri (2011) found that average transaction fees were some 14 times lower than the equivalent bus fares needed to deliver cash in person. In Tanzania, Economides and Jeziorski (2015) found that, due to high crime rates, Tanzanians would rather pay 1 per cent of their money to keep the rest stored digitally than carry all of it in cash for one kilometre outdoors or keep the cash at home over night. Mobile money also seems to have helped low-income Kenyan households to better withstand financial shocks, such as medical emergencies (Suri, 2014), by receiving personal remittances from networks of friends and family (Jack & Suri, 2014; see also Riley (2016) for similar results in Tanzania; and see Suri (2017) for an overview of various findings).[8]

The most famous mobile money service is Kenya's M-Pesa (M stands for mobile, and *pesa* is "money" in Swahili). First tested as a simple microfinance tool, it took off rapidly after its introduction by Safaricom in 2007 (Mas & Radcliff, 2010; Vaughan, Fengler, & Joseph, 2013).

Various versions of the service have emerged in other developing countries, especially across Africa, and by 2015, 82 per cent of banked Sub-Saharan Africans were mobile banked only, making it the world's highest ratio of mobile-to-regular banking (GSMA [Groupe Speciale Mobile Association], 2017).[9] In absolute terms, Sub-Saharan Africa is

8 Such risk pooling has been a core feature of survival for low-income households long before the arrival of mobile money (see, for instance, Collins et al., 2009). But mobile money has significantly reduced the *transaction costs* for such pools (transfers are quicker and easier to perform over long distances and pools increase as more members can contribute smaller amounts).

9 Mobile money versions first existed in South Africa and the Philippines, but Kenya's success story made it known as the pioneer (Suri, 2017).

also the continent with the widest adoption of mobile money. According to Rouse and Verhoef (2017), ten African countries had a mobile-money penetration among survey respondents of above 10 per cent in 2013.

Differences in uptake are large among African countries. In 2014, the proportion of adults with mobile money accounts was 58 per cent in Kenya, 37 per cent in Somalia, and 35 per cent in Uganda (Beck et al., 2016, referencing FinDex data). Nigeria is perhaps the starkest counterexample. As Lepoutre and Oguntoye (2017) note,

> [w]hile Nigeria and Kenya share similar levels of economic development, mobile phone adoption, bank branch penetration and needs for financial inclusion, as of 2016 only 1 per cent of the Nigerian adult population was an active user of mobile money, and only 12 per cent was aware of its existence. (p. 1)

But the overall trend is toward ever-increased adoption across the continent (for causes of these differences, see subsection 6.2 below). Suri (2017, citing GSMA data) notes that by "the end of 2015, there were […] 411 million registered mobile money accounts across the world (all in developing economies, 222.8 million [that is, 52 per cent] in Sub-Saharan Africa)" (Suri, 2017, p. 498).

One year later, by the end of 2016, Sub-Saharan Africa had "nearly 280 million registered accounts and around 1.5 million registered agents. More than 40 per cent of the adult population in seven countries – Gabon, Ghana, Kenya, Namibia, Tanzania, Uganda and Zimbabwe – now use mobile money regularly" (GSMA, 2017, p. 34).[10]

Kenya, along with its pioneer status, also holds a distinct leadership role in the societal penetration of mobile money (continent-wide and worldwide). Usage is nearly twice as high as in Africa's other mobile money leaders – Somalia, Tanzania, Uganda (Rouse & Verhoef, 2017, p. 15). This entails that, thus far, the academic research on mobile money is predominantly concentrated on Kenya. The rest of this subsection summarises the findings of five widely cited studies on mobile money's impact on job creation in Kenya.

Plyler, Haas and Nagarajan (2010) had undertaken a series of inquiries in 2009 in two rural Kenyan settings in Murang'a and Kitui, and in one high-density urban setting, Kibera (in Nairobi). The study found that M-Pesa had primarily led to more money circulation, which in turn led to business expansion of existing SMEs. Some employment increases were also noted by respondents, but mostly only via M-Pesa shops that directly employ agents (Plyler et al., 2010). This form of kiosk employment via ICT may not be deemed as the technology *itself* having increased employment, but the number of direct jobs created by mobile money kiosks is nonetheless significant in Kenya: by late 2015, the

10 These data are somewhat conflicting due to measurement differences. Rouse and Verhoef's measure of "penetration rate" (for example, around 10 per cent for Namibia) is much lower than the GSMA's definition for "adult population … using mobile money regularly" (upward of 40 per cent in Namibia). This may in part be explained, as Rouse and Verhoef note, by the fact that "in Africa, it is common for mobile phones to be shared, and thus more people may be using mobile phones than indicated by these penetration rates" (Rouse & Verhoef, 2017, p. 6).

sector employed some 141,500 mobile money agents across the country (Communications Commission of Kenya (CCK) data, cited in Suri, 2017, p. 506).[11]

Mbiti and Weil (2016) examined FSD Kenya's (Financial Sector Deepening Kenya) FinAccess Survey data for 2006 (that is, before M-Pesa existed), and for 2009 (that is, by which point "over 8.5 million Kenyans had registered on M-Pesa" (p. 247)). They based their survey on a panel of 190 sublocations. Sublocations are the smallest administrative unit in Kenya and consist of 2 to 3 villages in rural areas or a large neighbourhood in a city. This study found (in line with the findings by Plyler et al., 2010) that one-third of respondents claimed to have engaged in increased transactions after the introduction of M-Pesa. More interestingly, regarding employment levels, Mbiti and Weil also found that M-Pesa has led to an increase in the employment rate by 12 percentage points, approximately a 15 percentage increase from the 2006 employment level. This increase was mainly driven by farm employment (their data showed no significant effects of M-Pesa on non-farm employment).[12] This directly contradicts Ogutu et al.'s (2014) finding (discussed above) for an ICT-based information service (DrumNet), having *reduced* farm labour. Mbiti and Weil suggested that M-Pesa's peculiarly positive effect on farm employment could be explained by easier urban-rural remittances. These could have driven the higher demand for labour on remote rural farms (Ogutu et al., 2014, p. 277).

However, Beck, Pamuk, Ramratta and Burak. (2016) examined FSD Kenya's FinAccess Survey data for 2014 of some 1,047 urban city firms (mostly SMEs) in Nairobi, and found that firms of various sizes that used mobile money had easier access to credit, which in turn led to higher levels of output and growth. Particularly, the study found that firms using mobile money had easier access to production inputs from suppliers on credit (Beck et al., 2016).

Gosavi (2017) used the World Bank's 2013 Enterprise Survey Programme data,[13] to examine the benefits of mobile money use by Sub-Saharan African firms. Studying private firms of all sizes in Kenya, Tanzania, Uganda, and Zambia (from all sectors other than agriculture and resource extraction), Gosavi applied various controls and found that firms using mobile money had easier access to credit and also seemed to outperform peers in levels of productivity. Accordingly, the study's conclusion was positive: "adoption of mobile-money services has not only an astounding potential to solve the vexing problem of access to finance, but also an amazing capacity to make firms productive" (p. 13).

Perhaps most impressively, using five rounds of panel data between 2008 and 2014, Suri and Jack (2016) found significant long-term impacts of mobile money on savings and

11 These figures are for both M-Pesa and other mobile money service agents. Safaricom's website reports that "[c]urrently there are over 40,000 [M-Pesa] agents countrywide" (https://www.safaricom.co.ke/personal/m-pesa/getting-started/experience-m-pesa (accessed 2 April 2018)).

12 The authors "use a measure of employment that incorporates farm labor (own-farm and on other's farm), non-farm labor (such as civil service employment), and self-employment (such as owning a shop). Individuals are considered employed if they are actively engaged in any of these activities" (Mbiti & Weil, 2016, p. 277).

13 For an overview of different measurements of financial inclusion, see also the contribution by Nielsen (2014) at https://www.cgap.org/blog/10-useful-data-sources-measuring-financial-inclusion (accessed 2 April 2018).

consumption. Measuring mobile money agent density, Suri and Jack discovered that better access to mobile money services had helped 196,000 households out of extreme poverty, leading to a two-percentage point decrease in poverty at the national level. The authors conclude that their "evidence, and earlier work, suggests that these impacts [of mobile money] derive from a more efficient allocation of labor, savings, and risk" (p. 1292).

These findings are mostly for Kenya, but they suggest that a positive impact in other African countries is likely as well. Thus, the findings that mobile money creates African jobs and alleviates poverty seem to directly refute Murphy and Carmody's notion of "negative adoption." But can this be extrapolated from the particular case of mobile money to the overarching rubric of all ICTs? And if so, do these effects apply equally to both genders?

4 Jobs via ICTs directly – for men and women equally?

Studies on mobile money are helpful for understanding if this particular innovation has had direct impacts on jobs in Africa. By contrast, much of the research cited in Section 2 above (on various ICT-based information services) primarily tested the merits of these services, that is, of the particular intervention strategies, not the direct impact of the interventions' underlying technologies as such. Such studies are important for improving ICT-based interventions, but their results cannot easily be extrapolated to broader conclusions about ICTs' usefulness. An education-sector example makes this point clear: different studies found that One-Laptop-Per-Child (OLPC) initiatives fell short of expectations.[14] But we cannot conclude from this that laptops *per se* are useless for education. It is likely that once the intervention strategy is improved, the same underlying technology will lead to better results. Thus, regarding the question of how the advent of ICTs has been *directly* associated with job creation in Sub-Saharan Africa, some interesting insights can be gained from various methodological angles.

Several studies exist for ICT effects on economic growth, a variable closely related to jobs (see subsection 4.1). Natural experiments can shed light on the direct impact of mobile phone introduction into certain African economic contexts (subsection 4.2). And the interplay between ICTs and various societal factors that influence jobs – health, education, institutions – can help complete the picture (subsection 4.3). Lastly, an extensive review – this subsection is larger than the rest of the section combined – looks at gender differences in access to ICTs, and at findings on African women's (dis)empowerment in the ICT era (subsection 4.4).

14 For a meta-analysis of 15 OLPC studies, see Arias-Ortiz & Cristia (2014). Marandino and Wunava (2014) found that, in Uruguay, the OLPC intervention had led to poor families' increased incomes (by one-third), but that it had not led to the expected uptick in work (see also World Bank, 2016, p. 261).

4.1 Large-number cross-country studies on ICT effects on economic growth

Large-number cross-country studies on ICT impacts on African jobs are rare,[15] but closely related is the impact of ICTs on developing country growth. Discussions around "jobless growth" (for instance, Caballero & Hammour, 1998) suggest that the two variables – "jobs" and "growth" – are not entirely interchangeable. But they seem close enough to warrant a discussion on ICT effects on growth in this subsection.

Lee, Gereffi, and Beauvais (2012) examined the influence of mobile phones on the rate of economic growth across 44 Sub-Saharan African countries. Different regressions of data between 1975 and 2006 showed that the introduction of mobile phones had significant positive effects on growth, especially in areas where landlines were unavailable (namely, in poorer areas). Their method allowed controlling for reverse causality (in other words, for higher growth rates leading to faster mobile phone penetration).[16] The authors note that "an increase in the spread of cellular phones yields a higher growth rate for countries where land-line phones are rare" (pp. 467-468).

Considering the low cost of mobile phones compared to other infrastructure projects, Lee et al. took these results to suggest that extending mobile coverage should be more of a priority for growth-enhancing intervention strategies.

Using 2000-2006 data, Yousefi (2011) compared 62 countries (28 high-income countries; 17 upper-middle-income countries; 15 lower-middle-income countries; and 2 low-income countries). His results confirmed significant positive influence on growth in high- and upper-middle-income countries. But he found no discernible impact on low- and lower-middle-income countries. It should be noted, however, that none of Yousefi's sample countries was in Africa.

Lio and Lui (2006) had also examined the effects of ICTs on agriculture in an early period (1995-2000). In a cross-country analysis of 81 countries from all income groups (of which 41 were low- or lower-middle income), Lio and Lui found that the introduction of ICTs did have positive effects across all income groups, but that the effects in richer countries were twice as large as the effects in poorer countries. The authors attributed this to the differences in pre-existing conditions, such as human capital.

The World Bank (2016) came to similar findings and adopted this line of argument, calling these pre-existing conditions the "analogue complements to digital dividends," a core theme throughout the 2016 World Development Report on Digital Dividends (World Bank, 2016, p. 29). While these large-number cross-country comparisons can point to broad trends, they cannot definitively point out cause-and-effect relationships. This is what we turn to next.

15 For Africa, I only found one such study, which I review in detail in subsection 5.3 below.

16 To control for reverse causality, Lee et al. (2012, p. 465) followed Roodman (2006) in building on the Arellano and Bover (1995) and Blundell and Bond (1998) two-step-difference general method of moments estimator.

4.2 Determining direct causality between ICTs and job-related development outcomes

For direct cause-and-effect, the most famous finding pertains to sardine fisheries in India: Robert Jensen's (2007) study found that Kerala fishermen used mobile phones from their boats to obtain information about which markets had the highest demand for their perishable cargo. This significantly increased the fishermen's incomes and lowered prices for buyers (as leftover sardines were no longer rotting in one town while would-be buyers went hungry in another). This finding is widely cited as proof of a direct and substantial impact of ICTs on poor fishermen's incomes.

But here too, methodological constraints may come into play. A follow-up study found that Jensen's findings were context specific and may not be replicable in regions with greater distances between markets, lower pre-existing credit relationships among traders, or when trading in crops that are more durable than sardines (Srinivasan & Burrell, 2015).

In a similar vein, when studying the spread of mobile phones in Uganda between 2005 and 2009, Muto and Yamano (2009) observed that phones did have positive effects on banana sales (perishable) but not on maize sales (more durable, and hence easier to store and transport). These findings imply that, for gaining market information, mobile phones can be more or less helpful, depending especially on how perishable one's goods are. More evidence could clarify the importance of crop perishability. This is likely to vary in different circumstances, as other factors, such as various societal differences, can change the relationship between ICTs and jobs in Africa.

Somewhat contradictory to this perishable/non-perishable distinction is that the use of mobile phones has also appeared to have a positive market-information-gathering effect in Nigeria's textile trade (that is, in an off-farm sector with non-perishable goods). Jagun, Heeks and Whalley (2008) examined the use of mobile phones by SMEs in Nigeria's cloth weaving sector and found that weavers with phones had a significant advantage over those without (providing a strong incentive for phone adoption by all). At first glance, this dynamic could be seen as supportive of Murphy and Carmody's notion of "negative adoption" – if the traders reluctantly invested in phones to merely keep up with the competition. But Jagun et al. found that the phones were appreciated as tools that helped traders with their logistical constraints. Phones significantly reduced the needs to travel for simple, straightforward communication.

4.3 Societal factors and the relationships between ICTs and jobs

Interestingly, Jagun et al. (2008) also found that even after the introduction of mobile phones, certain interactions between traders still needed to take place face-to-face, due to trust concerns, or for discussing more complex issues (Jagun et al., 2008). Molony (2008) found that such different incentives between the more complex vs. less complex interactions can be difficult to distinguish, especially if researchers are not fully aware of the intricacies of a particular business culture. He notes that "[t]rust and the need for direct, personal interaction through face-to-face contact [is] one of the most pervasive features of African MSE [micro and small enterprises] economies" (p. 639).

This suggests, in line with the World Bank's (2016) emphasis on "analogue complements," (p. 29) that various other variables – institutional, societal, cultural – exert influence on whether or not mobile phones create jobs in Africa.

The flipside of this coin, however, is that the impact of mobile phones is not merely dependent on the analogue compliments for digital-era job creation. Phones can also help *create* these complements. Mobile phones have indeed been found to improve African societies in ways seemingly unrelated to jobs – namely by boosting health, education, good governance, or women's empowerment (see below). This implies that, besides creating jobs directly, the phones seem to create income-generating opportunities indirectly, as healthy, better-educated, better-governed societies can generate more and better jobs.

The various literature strands on ICT-impact on other areas of human wellbeing are beyond the scope of this paper, but the following are recent examples that can be consulted for discussions of further literature in these respective fields.

Asongu and Le Roux (2017) found that, between 2000 and 2012, mobile phones and the internet had positive effects on inclusive development across 49 Sub-Saharan African countries. And Asongu and Nwachukwu (2016) examined the combination of good governance and mobile phone penetration, and found a variety of positive effects of mobile phones on human development in Sub-Saharan Africa.[17]

For Niger, Aker, Ksoll and Lybbert (2010) found in a randomised trial of adult learning programmes that where mobile phone usage was included into the curriculum, students' basic literacy rates improved by 0.19-0.26 standard deviations vis-à-vis the control group.

For women's empowerment, the picture is more complicated, and the topic of gender equity is central to questions of jobs and income generation. Hence, the rest of this section is dedicated to unpacking these issues.

4.4 Income generator for women?

Target 5B of the Sustainable Development Goals is to "[e]nhance the use of enabling technology, in particular information and communications technology, to promote the empowerment of women" (IAEG-SGDI [Inter-agency and Expert Group on SDG Indicators], 2018, p. 7/21). In contrast to this target, strands of feminist perspectives have been sceptical as to whether ICTs can reduce gender discrimination. For Sub-Saharan Africa, Humer (2011) argues that ICTs may help women to become financially independent, but will not change the socio-cultural environment, or even the women's own attitudes toward their oppressive environment. In support for this claim, Humer refers to two qualitative studies: in Mozambique, rural women were found unable to use ICTs, due either to illiteracy or

17 On corruption, Kanyam, Kostanndini and Ferreira (2017) found that "cell phones are powerful tools for reducing corruption" and that "unidirectional causality [exists] from mobile phone penetration to corruption and from internet adoption to corruption." This study also examines and debunks an apparent form of broken windows theory (Wilson & Kelling, 1982). This notion held that, by increasing transparency and thus the overall visibility of pre-existing corruption, ICTs could further normalise corruption and induce more of it (Kanyam et al., 2017, p. 351, referencing Mishra, 2006).

inaccessible content (citing Macueve, Mandlate, Ginger, Gaster, & Macome 2009); and in Uganda, women were found to have become economically empowered and financially independent, but had not attempted to use this power to rectify the on-going disparities between men and women, or even to entertain the idea of female empowerment (citing Kyomuhendo 2009). Thus, Humer argues, technological gadgets cannot *initiate* a shortcut to women's empowerment. Women themselves will need to be the agents in this struggle.

This refers to the *relative* power distribution between men and women within a given society. As we will see below, there is indeed cause for concern, especially with regard to internet adoption, where Sub-Saharan Africa is currently the only world region in which the digital gap between men and women is not shrinking, but *widening* (ITU, 2017).

In rural and urban Ethiopia and in rural and urban Malawi, Geldof (2011) conducted an examination of gender disparity in ICT usage. Having employed a creative combination of interactive methods with some 550 low-literate Ethiopians and Malawians, Geldof found a vast gender divide in usage of, exposure to, and confidence in handling ICTs. Geldof refrained from investigating if the use of ICTs had actually increased or decreased this gender divide (e.g. in education), and took care not to leap to conclusions on causality. But she tentatively suggests that "the gendered domestic responsibilities and time constraints had a limiting effect not only on the use of ICTs, but also on female participation in education" (Geldof, 2011, p. 74).

This apparent correlation between women's use of ICTs and their access to education, relative to men's, seems significant (ITU, 2017).

Absolute women's empowerment via mobile phones?

Contrary to the above *relative* power struggle, however, when examining women's *absolute* empowerment – that is, when examining whether ICTs have helped women generate incomes irrespective of whether or not men have benefitted more – most empirical analyses point to distinctly positive results.

In the mobile money subsection above, I had introduced Suri and Jack's (2016) finding of a two-percentage-point contribution to Kenya's poverty reduction. But I had left out their study's most crucial finding, which is this: most of the 196,000 households that lifted themselves out of extreme poverty via mobile money were female-headed households. The transition took place largely because mobile money helped 184,000 Kenyan women move from less productive subsistence agriculture to more productive petty services, and thus not merely helped the women pull themselves and their children out of poverty, but also helped the country move toward positive structural transformation.

Such promising results are not limited to mobile money. In South Africa, Klonner and Nolen (2010) compared annual household surveys with the specially coded data from the country's leading network provider. The study focuses on rural areas and found significant positive results: the employment rate increased by 15 percentage points when a locality received network coverage, mostly due to greater wage employment of women (the exception were women with small children). They also found that the arrival of the mobile phone network did result in a substantial sectoral shift among the rural employed from agriculture to other sectors, especially among men. This latter finding contradicts Mbiti and

Weil's (2016) finding of mobile money having *increased* agricultural labour, but is in line with Ogutu et al.'s (2014) findings of an ICT-based information service having *decreased* the need for farm labour. With regard to women, however, these positive quantitative findings are in line with the findings of several qualitative studies discussed below.

In Nigeria, Boateng, Hinson, Galadima and Olumide (2013) undertook a qualitative pilot study of 15 small traders and then narrowed their focus to closely observe two female micro-traders (a potato trader and a tomato trader). The researchers found that the more extensive use of mobile phones (that is, not merely for calling and texting, but also for mobile money and other platforms) made the women more effective micro-traders and economically more empowered. The study concluded that "enhancing communication and trading processes through mobile phones directly or indirectly improves revenue and enhances decision making and control, and thereby economically empowers traders" (Boateng et al., p. 44).

For South Africa's urban informal sector, Chair (2014) surveyed five self-employed women on their use of mobile phones for their businesses (two hairdressers, two meat sellers, and one informal pub proprietor). She found that "[a]ll of the respondents valued their phones and were of the opinion that phones really helped … in their business" (p. 13).

At a much larger scale, Bailur and Masiero (2017) – conducting 30 focus group interviews with nearly 200 participants in Kenya, Ghana, and Uganda – studied how poor women (who lived on less than USD 2 per day) used the mobile internet on their phones, and if they were (thinking about) generating an income in this way. The study pointed to a few behavioural patterns that were distinctly different between women and men. Men tended to be more explorative with phones, women more passive; men more possessive of their devices, women more open to sharing with one another. The study's main finding was that earning money via phones was generally something the women had *heard of* but not experienced directly, and that they had few concrete ideas as to how this could be done.[18] Some women reported having heard of general ideas for informal social media advertisements, but "male respondents had more direct experience of income generation" (Bailur & Masiero, 2017, p. 88), and the more particular quotes, for instance for road-side sales, were attributed to men:

> If you want to sell mineral water, you just take a snap and send or share, you can even have groups that you administer yourself, you know, you just send to your group members and say, guys am here selling mineral water. (23-year-old Ugandan man, cited in Bailur & Masiero, 2017, p. 88)

The study found that women saw an overlap between recreational uses of social media and using their mobile internet connections to access information and connections to income generating opportunities:

> I take very long to load airtime to make a call. It is very rare. You are going to find that in most cases, I just load MBs [megabites] and I am going to go to Facebook, I am

18 No timeframe is given for when fieldwork was conducted (as ICT adoption is changing rapidly, this would have been helpful). The article's first date of submission, mid-2016, suggests that the interviews may have been conducted around 2015.

> going to be on WhatsApp and all over. [participants laugh] You are going to be on Facebook as you go to Internet and you are going to find that there are people advertising jobs, you are going to see those groups and may be you like them and may be they help you get the job. Even our own friends, yah. You can chat through WhatsApp like; 'What are you doing? What?' and then they can help you. (19-year-old Ugandan woman, cited in Bailur & Masiero, 2017, p. 89)

This, the authors note, shows the difficulty in separating whether ICTs are used for work or leisure (see also Donner, 2015).

In previous work on India and Uganda, Masika and Bailur (2015) had found that some of the differences between men and women's use of ICTs were due to structural constraints in the family, that is, due to husbands reacting jealously if wives used their phones to communicate with strangers (Masika & Bailur, 2015, cited in Bailur & Masiero, 2017). But in their present study, several female respondents were critical of the patriarchal situation and aware of their own timidity. Some women reportedly noticed a shift in (self-) perception: "the whole society is so much male dominated. Everything is about men. … Women are now coming up gradually. For instance me, I'm now trying to break out of that shell" (Ghanaian woman, no age given, cited on p. 92).

Relative women's empowerment via the internet?

This implies that what may at first glance seem as a banal distinction – being able to communicate more privately, such as not having to take phone calls immediately, but enjoying the freedom to communicate subtly, when time permits, via social media – may be a crucial benefit for many African women. With myriad other responsibilities and operating in patriarchal surroundings (that is, multitasking with children and mollifying spouses), internet access may be a vital tool for empowerment.

This is in line with large cross-country findings by Efobi, Tanankem and Asongu (2018), who examined how ICTs influenced women's economic participation across 48 African countries between 1990 and 2014. Controlling for several other variables,[19] the study apparently found positive impacts across the board: some positive change for women associated with mobile phone penetration, higher positive changes associated with higher regular and mobile internet penetration, and the greatest positive changes associated with fixed broadband subscriptions.[20] The authors tentatively suggest that this could be due to ICTs having led to the substantial growth of the services sectors across Sub-Saharan Africa since 2000 (Efobi et al., 2018, p. 19).

The suggestion that, particularly for African women empowerment, internet access may hold greater potential than basic mobile phones did, is at odds with currently increasing gender disparities among internet users in Africa. According to the latest data available from the International Telecommunications Union (ITU, 2017), in the years 2013 to 2017 the

19 Using ordinary least squares, fixed effects, and generalised method of moments regressions.

20 This study notes that "fixed broadband subscription still maintained a higher effect on female economic participation compared to internet usage and mobile cellular connections. These findings are consistent with a World Bank report that broadband subscription has a higher economic development externality when compared to other ICT indicators like mobile phones" (World Bank, 2016, p. 12).

gender gap in internet usage *decreased in all other world regions*, but *increased in Sub-Saharan Africa:* from 20.7 per cent in 2013 to 25.3 per cent in 2017 (Efobi et al., 2018).[21]

This lack of women's uptake of the internet correlates significantly, according to the ITU, with gender disparities for tertiary education (2017, p. 20). The only world region where women have on average slightly more access to the internet than men, is the Americas, where women also have ample access to tertiary education.[22] This tandem of discrepancies points to an opportunity for priority interventions in both expanding tertiary education for African women and providing greater internet access for African women, especially in view of the coming knowledge economy (see subsection 6.3). For now, the focus on the internet leads over to examining Africa's hitherto miniscule access to broadband internet (see Section 5), and Africa's opportunities for future job creation for all once this access expands.

5 Jobs via broadband internet?

Broadband internet access across Africa varies widely, and data sources and measurement methods differ somewhat. In 2017, some 77.8 mobile phone subscriptions existed for every 100 inhabitants across Sub-Saharan Africa (ITU, 2017 estimates), but hardly anyone had broadband internet via landline. GSMA (2017) estimates the active mobile broadband subscriptions in Sub-Saharan Africa at 26 for every 100. According to ITU (2017), it is 22 per cent of the region's inhabitants who use the internet.[23] Yet, even these figures, if taken at face value (to mean that around a quarter of Africans have unlimited access to broadband internet), are too high, because the way the terms "broadband" and "subscriptions" are used in these statistics can be deceiving. When examining Kenya, one of the continent's best-connected countries, the actual numbers of broadband internet users turn out to be much lower. A leading industry insider in Kenya noted to this author:

> We have 45 million people in Kenya, 39 per cent have smartphones, 18 per cent of those smartphone owners can connect to the internet on a regular basis. Either they have it at home or work or they can pay for a data bundle. And the other 80 per cent [*sic*] who already own the device can't afford it regularly, they may buy a data bundle once this week that is maybe 20MB so they get their sports scores or they send out some Whatsapp messages. (Personal interview, Nairobi, June 2017).

21 However, Asongu & Nwachukwu (2016) cite their earlier work as "recent evidence on the reduction of the gender-divide." And refer to "growing evidence that mobile phones empower women via enhanced channels of financial inclusion. These mechanisms entail improved coordination of female-managed small and medium size enterprises as well as household activities" (p. 3).

22 To my knowledge, a possible causal link between these two factors has not been proven to date.

23 According to Internet World Stats (2018), internet penetration in Africa was 28.7 per cent in June 2016 and 35 per cent in December 2017 (but this includes the North African countries; with higher average incomes, their higher internet usage also drives the overall average usage up).

This leaves some 7 per cent of Kenyans with regular access to broadband internet, but even this access is not unlimited or always fast.[24] Hence, compared with the numerous findings that provided evidence of mobile phones' benefits, (see the sections above), much less rigorous evidence exists for broadband internet's impact on overall job creation in Sub-Saharan Africa.

5.1 Large-number cross country studies on the internet's economic impact

For developing countries, internet adoption has been found to be associated with significant increases in exports (Clarke & Wallsten, 2006); higher GDP per capita growth rates (Qiang & Rossotto, 2009); higher firm productivity (Paunov & Rollo, 2015) and higher labour productivity (World Bank, 2016).

In a sample of 98 countries (22 from Sub-Saharan Africa), Clarke and Wallsten (2006) found that developing countries with more internet[25] access export more to developed countries. The study used data service regulation as one of the controls for reverse causality (that is, for greater exports to rich countries leading to higher internet penetration), and found that

> […] point estimates suggest that a 1 per cent increase in the number of Internet hosts per 100 people would increase total exports as [a percentage] of GDP by 0.05 per cent and exports to high-income countries by 0.08 per cent. (Clarke & Wallsten, 2006, p. 475)[26]

This study does not distinguish what *types* of exports increase with internet connectivity (that is, whether these are productive exports or commodity exports), and does not distinguish whether internet connectivity increases the overall size of trade, or whether more connected developing countries merely gain increased developed-country market share for their exports at the expense of other developing countries (which could end up exporting less).

Qiang and Rossotto (2009) used 1980-2006 data from 120 countries of all income groups to examine the relationship between broadband internet and economic growth.[27] They found that, "*all else being equal* … [t]he growth benefit that broadband provides for developing countries was of similar magnitude as that for developed economies – about a 1.38 percentage point increase for each 10 per cent increase in penetration" (pp. 43-45, emphasis added).

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24 My own research on African online workers involved communicating via Skype with upper-middle class Kenyans who work on online labour platforms or for overseas clients directly. The quality of the internet connection during our interviews was often poor, and interviewees often told me that among their greatest work impediments was unreliable internet (various interviews, 2017 and 2018: see also Melia, Forthcoming).

25 This study does not distinguish between narrowband and broadband internet.

26 Variations of their models with different controls came to slightly different results but all were positive and most were statistically significant.

27 This study was not published as an academic journal article, but as a chapter in a World Bank report. It is not particularly transparent about its methods, and does not disclose which countries made up its sample.

Examining data from 117 developing and emerging countries (39 from Africa) and nearly 50,000 firms (some 13,500 from Africa), Paunov and Rollo (2015) noticed that, between 2006 and 2011, the uptake and use of broadband internet had positive effects on productivity across all productivity levels of firms in Sub-Saharan Africa, and that the effects were highest for firms that were already more productive, and lowest for firms that had been less productive beforehand. This supports the hypothesis that, in spite of the positive overall effects, ICTs contribute to widening the gap between stronger and weaker firms.[28]

In its World Development Report 2016, the World Bank noted that "African firms using the internet[[29]] have on average 3.7 times higher labor productivity than nonusers and 35 percent higher total factor productivity" (World Bank, 2016, p. 52).

The Report refers to an unpublished background paper (Cirera et al., 2015), and does not explain which other variables were controlled for.[30] This leads to a more general problem with these studies: I had emphasised "all else being equal," in Qiang and Rossotto's quote above, because it has been difficult to determine direct *causality* from broadband internet to African jobs. Hence, the next subsection introduces three critiques of the widely held causality assumption, before the subsection after that introduces an extensive 2018 study that seems to have cracked this problem and can actually prove causality.

5.2 Questioning assumed causality between broadband internet and African jobs

In a series of recent studies, scholars associated with the Oxford Internet Institute (OII) have called into question the widely held assumptions on positive causal effects of internet connectivity on African economies, concluding that the internet may not always help African SME's positions in value chains (Foster, Graham, Mann, Waema, & Friederici, 2018); may not cause as much knowledge generation in Africa as is often assumed (Ojanperä, Graham, Straumann, De Sabbata, & Zook, 2017); and may not warrant the general enthusiasm for greater internet connectivity that is often encountered in African policy documents (Friederici et al., 2017). This sub-section summarises these studies and offers short comments thereof in footnotes.

Foster et al. (2018) undertook a qualitative study, examining Kenyan and Rwandan firms in the tea, tourism, and business process outsourcing sectors from a global-value-chains perspective. The study concludes that increased connectivity (that is, internet connection),

28 See Autor, Dorn, Katz, Patterson and Van Reenen (2017), on the growing chasm in firm productivity levels. This is part of the literature on technology's impact on labour's share of GDP. This literature is predominantly focused on high-income countries, and within this, a disproportionately large number of studies is focused on the USA or UK labour markets.

29 Here the World Development Report is vague about whether it is referring to narrowband or broadband internet. The Report's cited background paper, Cirera, Lage and de Oliveria (2015), is not available to the public.

30 A mere correlation is not helpful because similar correlations could be found between productivity levels and any number of infrastructural amenities, such as electricity, indoor plumbing, or air-conditioning. Any indicator of a more established and more productive firm also implies that it is more likely to use the internet.

while leading to increased information availability, can also lead to increased domination, and hence to exploitation by lead firms in a given value chain. Smaller African firms involved in global value chains can lose power to lead players, be they overseas or domestic. The study found, for example, that smaller tea producers could not access the information they needed from bigger players (or did not find it online due to language deficiencies). Foster et al. (2018, p. 80) note that "all firms felt that Internet connectivity had provided efficiency gains and access to more information".

For smaller tourism firms, however, greater connectivity could entail being pushed out of the global value chain, as their intermediary roles became redundant:

> For domestic firms previously heavily involved in local tourism logistics, the presence of online integration was pushing them out of GVCs [global value chains] rather than integrating them. With digitization, international firms can now organize, schedule, or book online from afar […]. (Foster et al., 2018, p. 79)

This finding is in line with Murphy and Carmody's (2015) warnings of forced mobile phone adoption, and with more general warnings of increased openness to globalisation and unfettered markets (Adelman, 1984). While this argument runs counter to most of the advice in the literature reviewed here, it may be a point to bear in mind when pushing for greater market integration of small-scale African SMEs or farmers into (local or global) value chains.[31]

Ojanperä et al. (2017) examined the relationship between broadband internet connectivity and the African knowledge economy, namely how increased access to the internet is associated with i) the region's number of academic journal publications; ii) the region's collaborative coding activity on GitHub[32]; and iii) the number of domain names registered in a given African country. The study controlled for three other influential variables: wealth (measured in GDP); educational attainment (measured in tertiary enrolment and education spending); and innovation capacity (measured via World Economic Forum questionnaire assessments on whether or not respondents thought companies in their respective countries were able to innovate). Their results suggest positive associations across the board: 1 per cent increase in internet connectivity is associated with an increase of 0.11 per cent or 0.28 per cent (depending on the model used) in academic articles published; an increase of 0.51 per cent or 0.75 per cent in collaborative coding; and

31 A Schumpeterian perspective would challenge Foster et al.'s (2018) premise. Notably, the finding that internet connectivity forced individual African SMEs to exit need not be negative for *overall* job creation. It could even generate positive net entry of African SMEs. A Schumpeterian interpretation holds that growth entails initial inequality. If productivity in a sector increases, the destruction of some firms can create opportunities for others. If we assume, however, that the dynamic that Foster et al. point to is solely negative for African SMEs, it remains unclear how large the subset of interviewees was who declared these setbacks in their value chain positions. The number seems small and limited to the tourism sector. Hence, these *negative* findings would need to be weighed against the various *positive* anecdotes for African SMEs who use the internet for *better* value chain integration. Here are two examples of the latter: Oestermann et al. (2013) found that a digital African Cashew Initiative had helped farmers within their value chains in Ghana, Côte d'Ivoire, Burkina Faso, Benin, and Mozambique (p. 52). And MGI (2013) note that a Mozambican firm uses "a smartphone app to connect informal traders with available taxi drivers who can deliver parcels from wholesalers, creating a faster, mobile-based supply chain" (p. 46).

32 GitHub is an online platform, hosting code that can be developed and shared by anyone.

increases of 0.46 per cent or 0.84 per cent in domain registration. This led the authors to note that: "[…] connectivity is clearly an important enabler of digitally mediated content creation […] (Ojanperä et al., 2017, p. 48).

But the study also finds significant increases associated with the control variables: 1 per cent increase in GDP is related to about 0.6 per cent in each of the dependent variables, and, particularly, 1 per cent increase in innovation capacity is associated with much larger increases in the knowledge-economy variables – between 2.3 per cent and 3 per cent.[33] This led the authors to emphasise caution with regard to unbridled optimism about internet connectivity: "In this vein, merely increasing connectivity without supporting GDP growth or increasing innovation capacity might not allow countries to leapfrog to higher levels of digital content creation and has an even smaller effect on production of academic articles" (Ojanperä et al., 2017, p. 46).

Interesting to note, here, is that Ojanperä et al. (2017) *do* find positive relationships between broadband internet and the outcome variables, but frame their conclusion in cautionary terms, since other variables also showed positive relationships with the outcome variables. It is this cautionary framing that is at odds with other studies, more so than the study's statistical findings. For example, Asongu and colleagues (see Asongu & Nwachuku, 2016, or Asongu & Le Roux, 2017) also found positive effects for various other variables, but tend to frame their articles (in headlines, and conclusions) in distinctly positive terms, noting synergy effects between ICTs and other improvements, and suggesting increased investments in ICTs as comparatively cost efficient ways of achieving desirable outcomes.[34]

Friederici et al. (2017) conducted a discourse analysis of seven African ICT policies and 13 reports by international organisations. Investigating these documents' claims about the impact of internet connectivity on economic growth and inequality in Africa, the study found these policy documents and reports to have been: i) overly optimistic; and ii) not based on the findings of rigorous research. Friederici et al. (2017) compare these bullish policy statements with an overview of academic literature, and conclude that

33 Investment in tertiary education and population sizes were also positively associated.

34 This opens questions for Ojanperä et al. (2017): Other studies have found positive relationships between increased broadband internet and variables that bare close resemblance to several of Ojanperä et al.'s control variables. Taking the studies mentioned immediately above: Quian and Rossotto's (2009) dependent variable of "higher GDP per capita growth rates" may or may not be related to Ojanperä et al.'s control variable of "wealth/GDP." But Paunov and Rollo's (2015) outcome variables of "higher firm productivity;" the World Bank's (2016) "higher labour productivity;" and Clarke and Wallsten's (2006) "significant increases in exports" all seem closely related to Ojanperä et al.'s "firm capacity for innovation." This suggests that, if causal relationships exist between broadband internet and any of these related variables, broadband internet may also have an impact on Ojanperä et al.'s control variables. This implies that the internet also has an indirect impact (that is, by influencing these control variables) on Africa's knowledge economy. If, solely relying on Ojanperä et al.'s own statistical results, we assume however that one can adequately control for the internet's impact on any of the other variables, a more straightforward problem emerges with their cautionary conclusion. From a return-on-investment perspective, it could still be more feasible for African governments to invest in broadband internet expansion than to invest in increasing any of the control variables (that is, "higher GDP" is a meta-variable which is difficult to bring about directly, and 1 per cent increase in "tertiary education enrolment rates" could turn out to be more expensive to bring about than a 1 per cent increase in "broadband internet").

> the evidence on growth-enhancing and inequality-reducing impacts of connectivity is inconclusive, especially for low-income contexts. Most evidently, the academic literature has little to offer in support of claims that the Internet causes widespread and inclusive economic impact, thereby tackling inequality. (Friederici et al., p. 6)

Thus, Friederici et al. (2017) rebut these policy documents' claims that expanding broadband internet connectivity is of great importance for African firms and citizens. The study concludes:

> we have shown that the evidence base to support such claims is thin. More worryingly, once we see the techno-determinist and modernist assumptions at the core of many visions, visions of rapid development precipitated through ICTs might not just fail to achieve their goals (even on their own terms), they could actively undermine those very efforts in a world of scarce resources. (p. 19)

But the "evidence base" presented in Friederici et al. (2017) comes in the form of a brief and somewhat problematic overview of the academic literature.[35] This is at odds with the present review of the literature, which, overall, comes to distinctly positive conclusions (and would thus back several of the bullish claims made in the African vision documents). In fairness to Friederici et al. (2017), this positive assessment is in part based on one landmark study that appeared in the interim period between our reviews (namely, Hjort & Poulsen, 2018, see below).

35 Here is why this present literature review diverges from Friederici et al.'s (2017) conclusions: The bulk of Friederici et al.'s (2017) contribution is its thorough review of the policy reports pertaining to Africa. But its critical conclusions are based on findings of their academic literature review, which are at odds with the findings of my literature review here. Of the 27 studies referred to in Friederici et al.'s review of the academic literature, they list more than half (15) as having come to various positive results. Of the remaining 12, one is a short commentary with no original empirical findings (namely, Humer, 2011; see also my review above); four are comparatively old (Dewan & Kraemer, 2000 [using data for 1985-1993]; Pohjola, 2002 [using data for 1985-1999]; Duncombe & Heeks, 2002 [a case study for Botswana; see my review above]; and Lee et al., 2005 [using data for 1980-2000]); four are case studies from other world regions – two of which came to mixed results for South Korea and Iran, respectively (Ju 2014; Rasoulinezhad & Nouri, 2010); one came to no significant result for Ireland (Haller & Lyons, 2015); and one came to tentatively negative results for India (Martinez et al., 2011). This leaves two relevant studies: Skuse and Cousins (2007) which came to mixed results for South Africa; and Yousefi (2011), which came to no positive results for ICT impact in 17 lower-middle-income countries/low-income countries among its sample (there were no African countries in the sample; see also my summary of this study's findings above). Yousefi's non-results for poorer countries could be extrapolated to Africa, but the findings are based on data leading up to 2006, when internet bandwidth was narrow and access much more limited than it is today. There could well have been a tipping point in the meantime (one that had not been reached by Yousefi's sample countries in the early-2000s, but is now being reached in African countries). Most of the recent studies from Africa, reviewed in this present paper, point in that positive direction (see Section 2 and subsection 5.1 above, and especially subsection 5.3 below). Considering that Friederici et al. (2017) focused on Africa, referring to these more recent and Africa-specific studies as their evidence base could have led to a less critical stance toward the various African vision documents.

5.3 First real evidence of causality between broadband internet and African jobs

This recent study has set a new milestone for research on broadband internet impact on African jobs. Hjort and Poulsen (2018) conducted an extensive quasi-natural experiment in tracing the landings of ten submarine fibre optic cables in 12 African countries between 2006 and 2014. These landings marked the arrivals of broadband internet that significantly increased the quality and quantity of bandwidth available in the connected locations. Hjort and Poulsen compared these broadband arrivals with various before-and-after measurements, using the location-specific panel data of six large surveys, as well as time series of night light satellite analyses. The panel data of two household surveys used (Afrobarometer and DHS), covered 9 and 8 countries respectively of their 12-country sample. Location specific firm-level panel data of 7 countries (via World Bank Enterprise Surveys), and a detailed labour force survey from South Africa, as well as before-and-after arrival panel rounds of an extensive manufacturing firm survey for Ethiopia were used to cross-check and build in several robustness checks.

These different outcome measurements unveiled a host of positive results. Wherever the data allowed for measuring an impact, Hjort and Poulsen found substantial positive results. The DHS and Afrobarometer household surveys revealed that

> the probability that an individual is employed increases by 6.9 and 13.2 per cent in the two groups of countries covered […] when fast Internet becomes available [and increases by 3.1 per cent in South Africa]; [that these increases are] not due to displacement of jobs in unconnected areas; [… and that] fast Internet […] appears to shift employment shares towards higher-productivity occupations, [… meaning that] employment inequality if anything falls when fast Internet arrives in Africa. (Hjort & Poulsen, 2018, p. 3)

Specifically, broadband internet arrival led to 23 per cent more firms (that is, net firm entry) in South Africa, particularly in higher value-adding sectors, and to significant increases in productivity levels among Ethiopian manufacturing firms. Their World Bank Enterprise Survey results showed that firms now accessing broadband internet increased their overseas communications by 13 per cent, and had "a decrease in in-country sales, and large increases in both indirect and direct exports" (Hjort & Poulsen, 2018, p. 22); employed some 17 per cent more workers and were *twice* as likely to offer in-house training to staff. Hjort and Poulsen note that these various increases – more firms, more productivity within existing firms, more exports, and more on-the-job training – may explain the mechanism behind their most astonishing finding. Examining which workers, across the education spectrum benefit most from the arrival of fast internet, they found that nearly everyone benefitted (as the following quotations from Hjort & Poulsen, 2018 show):

> In both the DHS countries and South Africa, a relatively large increase in the probability of 'moderately' skilled (ISOC [International Standard Classification of Occupations] level 2) employment appears to contribute most to the overall increase in skilled employment. The point estimates also point towards a sizable increase in 'highly' skilled (ISCO level 4) employment in the DHS countries, when fast Internet becomes available (p. 17).
>
> Remarkably, the estimated increase in the employment rate is of comparable magnitude for those with primary school, those with secondary school, and those with tertiary education in all three samples. Those with primary school in fact see a moderately bigger estimated employment gain than those with secondary school in all three samples,

> though not statistically significantly differentially so. In the Afrobarometer countries – but not in the DHS countries and South Africa – fast Internet also increases the employment rate for those who did not complete primary school significantly (p. 14).
>
> In the DHS countries, those with tertiary education see by far the biggest increase in *skilled* employment. The smaller, but nevertheless noteworthy, estimated increase in skilled employment is of identical magnitude for those with primary and those with secondary education, but more precisely estimated for the latter group. Employment in unskilled occupations increases significantly for those with primary school in both the DHS countries and South Africa (p. 18).

This increased employment for workers across the skills spectrum is taking place in higher value adding firms. Hjort and Poulsen suggest that the arrival of fast internet may thus explain some of the positive structural transformation (from less productive sectors to more productive sectors) found across Africa (see McMillan & Rodrik, 2014).

Lastly, night light density can be used as a proxy for average incomes in a given location. Hjort and Poulsen found a 2.4 per cent or 3.3 per cent (depending on the model used) increase in night light density when fast internet arrives in a given African location.

This was a quasi-natural experiment (that is, the many different arrival times of cables depended on geographic accessibility, not on one of the other variables that tend to interfere with the results of other studies, such as economic trajectory of a given country or city. Various robustness checks (for example, for other infrastructure, and for labour displacement effects via commuting) showed no discernible changes on the positive outcomes. Hence, the arrivals were next to random, and this study comes close to proving that the positive employment effects were actually *caused* by broadband internet connectivity.[36]

6 Discussion and policy options

As in any body of literature, the research reviewed here has shown some inconclusive and partially contradictory results, particularly with regard to ICT-based market information services for smallholder farmers (subsection 2.2). But of the studies reviewed, none provides evidence for "negative adoption" as per Murphy and Carmody's (2015) interpretation,[37] and the overall direction in the evidence reviewed here points to distinctly positive economic effects of mobile phones, mobile money, ICTs more generally, and the internet.

36 This is a review of the January 2018 NBER working paper version. The forthcoming journal article may yet come to revised results. (According to one of the authors, the paper is set to appear in the *American Economic Review*).

37 The exception may be Foster et al.'s (2018) finding that global hotel booking platforms may be pushing some African SMEs out of value chains. This claim should be taken serious, and my own ongoing research into ride-hailing apps (that is, Uber, Taxify, and LittleCab) in Kenya also points to similarly disadvantageous trajectories for Kenyan drivers in the years 2015 to 2018. But these concerns pertain to the newly evolving 4IR technologies (Melia, Forthcoming), on which little rigorous empirical evidence exists to date.

A few policy options can be discussed on the basis of these findings. The following subsections each build on a corresponding section above and flesh out policy ideas for utilising these findings going forward. I also introduce some new empirical evidence, not on whether these technologies are helpful for African jobs (that has been established above), but on how one could best go about spreading them. Spreading, promoting, and utilising ICTs, in the present era, also entails thinking about the changes that these technologies are currently undergoing, and how they interact with newer phenomena, such as the blockchain or platform economies.

6.1 ICT-based information services

For farmers, both advice on farm productivity and market information services for crops can be greatly amplified via ICTs and can thus have significant positive outcomes.[38] But this success of ICT-based services is not automatic. Poorly designed or poorly implemented services fail, regardless of their level of ICT-based amplification.[39]

Feedback mechanisms

Policy recommendations for those interested in improving ICT-based support schemes highlight the importance of feedback mechanisms. The popularity and applicability of support interventions need to be tested regularly by asking recipients what works. If services are inadequate or unreliable, the service provider needs to establish whether the quality of its core service is to be blamed, which could be fixed via generic technical tweaks, or whether the provider is suffering from other institutional, business environmental, or capacity problems, which would demand very different, context-specific remedies. If some recipients find the services useful but others have difficulties deciphering them – for instance, if text-based services prove difficult – the service provider needs to establish whether this is mainly due to poor eyesight, inadequate devices, lack of electricity to receive messages, lack of credit (that is, funds) to send queries, language deficiencies, or a general unfamiliarity with the technology. Each of these problems has been identified in the literature and each demands a different policy solution or service innovation. It can be a mixture of these and other obstacles, and establishing which is most important in a given location and how it is best addressed is an on-going process of trial and error improvement. For finding this right solution, some form of market-based approach (that is, a for-profit, or self-sustaining social business model) may be more suitable than a state-led or donor-driven initiative, as some of these obstacles can be overcome by entrepreneurial providers (that is, voice services can circumvent poor eyesight, illiteracy, or phones with broken backlighting, while solar panels can circumvent being off the electricity grid). But some of the underlying obstacles (such as infrastructure, education, health) can only be fixed by more coordinated efforts that go beyond one single intervention strategy. Such wider initiatives cannot be provided by individual companies, and need to be led by state coordinators or larger partner programmes.

38 See the reviews of Aker (2008); Casaburi et al. (2013); Cole & Fernando (2016); Ogutu et al. (2014); Svensson & Yanagizawa (2009); Kzii et al. (2011); Al-Hassan et al. (2013); and Hildebrand et al. (2015).

39 See the reviews of Ragasa & Mazunda (2018); Wyche & Steinfield (2015); Tadesse & Bahiigwa (2015); and Aker & Fafchamps (2014).

Development partners interested in improving ICT-enabled intervention schemes in Sub-Saharan Africa should consult the results of randomised controlled trials that are most closely related to the anticipated project. Nowadays such trials accompany many of the larger interventions. The results of meta-studies and broad literature reviews of the kind undertaken in Section 2 can only indicate a vague direction; the nuances in the individual cases are significant: interventions fail or succeed depending on unique contextual circumstances, or for reasons that are easily corrected in some fields but not in others. Deciphering such nuances is difficult, even for long-time experts. Development partners who seek to create a successful ICT-based intervention should attempt to do so in partnership with experienced researchers in the field. Before the project begins, guidance should be sought from experienced observers.[40] If possible, a professionally implemented randomised controlled trial should accompany the project for future knowledge generation (see, for instance, Banerjee & Duflo, 2011).

Targeting young farmers

Successful ICT-based interventions can decrease the need for farm labour (Ogutu et al., 2014). This seems to be a conundrum for support measures aimed at rural employment: while technology *increases* farm productivity and output, it *decreases* the need for farm labour, thus decreasing the number of rural jobs. But zooming out to the economy-wide angle may solve this puzzle. The jobs lost on farms are the ones least desirable and least value-adding. If technological upgrading makes agriculture more profitable *and* less labour intensive, good things happen. A green revolution leads to positive structural change of the economy. Farm workers are freed up to pursue education or more desirable work, rural-urban migration ensues, more productive sectors emerge in cities and begin to compete globally. The mechanism is twofold: as agriculture becomes more productive, produce becomes more affordable domestically (allowing urban workers to be more price competitive vis-à-vis overseas workers); alternatively, more produce can be exported (earning the country foreign exchange reserves, which can be invested in production inputs or the needed infrastructure – which makes local companies competitive vis-à-vis overseas firms). The effect is the same: more jobs ensue in more productive sectors.

But options exist for development partners who are interested in using ICTs directly to provide rural employment and slow down the urbanisation process. One suggestion on ICT-based interventions is to specifically target *younger* farmers, as this would lead to higher adoption (Al-Hassan et al., 2013). Younger farmers are more likely to leave the farm to head to a city but they are also more likely to use ICTs. Hence, they could become the most productive farmers. In Kenya, for example, one such approach is that of GreenDreams, using the technology specifically for attracting young Africans to farming (Kahumbu Stephanou, 2017).

40 For selecting such experts, a citation count in the relevant field can serve as a starting point. Among others, this would point to Jenny C. Aker of Tufts University and the Center for Global Development.

6.2 Mobile money

The impressive results for mobile money's impact[41] suggest that it should be a crucial policy objective to help increase the continent-wide spread of this technology, particularly in countries with low adoption rates. Essential to such support would be to know why mobile money spread so fast in some countries (such as in Kenya) and much slower in others (for instance, in Nigeria). Lepoutre and Oguntoye (2017) found that in Kenya, Safaricom's ability to quickly reach a critical mass (as quasi-monopolist), allowed it to reinvest in fortifying its dominant position and extending its ever-growing network of agents around the country. In Nigeria, by contrast, anti-monopoly policies induced negative incentives for potential first movers. The slower uptake problem in Nigeria (and by extension in other "slower" countries) could disappear, they note, once the market-leader reaches a critical mass of users.[42] If such network externalities are the main factor at play, mobile money can be profitable for providers once the business environment is right. This suggests that support could come in the form of macro-level advice to regulators, as well as in the form of specific support for overcoming particular market failures.

For all its glory, however, in times of digital-era changes, mobile money should be seen as a "stop-gap" rather than a final solution to the poor's financial woes. In Kenya, sending Ksh 2,000 (USD 20) via M-Pesa currently costs 69 shillings (USD 0.69) (41sh for the sender, and 28sh withdrawal fees for the recipient).[43] According to one interviewee,

> it's hard enough for people staying in Nairobi, especially the slums, so 40sh is a lot of money for slum dwellers, a whole meal for the day […] Now you need […] 67sh to make transfers. It's actually a lot of money (Whatsapp conversation, January 2018).

The service is immensely useful, but the gains made via mobile money could soon be overtaken by decentralised ledger technologies.[44] The innovations built on the blockchain keep evolving and in some form they could one day upend mobile money providers who currently operate at sizable profit margins, as well as firms specialising in trans-border money transfers, such as Western Union, which can charge as much as 12 per cent for transactions. In the short term, firms like BitPesa in Kenya are interesting. BitPesa seeks to use Bitcoin transactions to bring the price of overseas remittances down to 25 per cent of their current costs (Rossiello, 2017, p. 156).[45] In the medium term, a variant of the technology's underlying crypto currencies could have an effect similar to that seen in the global telephony market throughout the 1990s/2000s: bringing the cost of international transactions down by orders of magnitude, and eventually perhaps to zero.

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41 See the reviews of Suri & Jack (2016); Economides & Jeziorski (2015); Jack & Suri (2011); Suri (2014); Plyler et al. (2010); Mbiti & Weil (2016); and Beck et al. (2016).

42 Other commentators had suggested that the regulator was to blame (Kenya allowed mobile network operators to act as quasi-banks, whereas Nigeria did not); Lepoutre and Oguntoye, (2017) make the convincing point that this had been the decisive difference; mobile money should have failed in Bangladesh where it spread fast, and succeeded in South Africa where it has yet to take off.

43 See also https://www.safaricom.co.ke/personal/m-pesa/getting-started/m-pesa-rates.

44 Blockchains are distributed ledger technologies, meaning that they are based on consensus mechanisms on data shared openly in peer-to-peer networks. Cryptography helps make the legitimacy of new blocks in a blockchain easy to identify but nearly impossible to alter or duplicate once in place (Ohnesorge, 2018, p. 5).

45 For BitPesa, see https://www.bitpesa.co/.

The field of crypto currency may play a critical role in African development over the coming decades. It may well lead to the leapfrogging of an industry as profound as that seen in mobile money. Yet the blockchain-related field is so new and rapidly changing that providing concrete advice as to how and when such a leapfrog would occur seems unwarranted; (it could be related to banking, insurance, legal or other contractual agreements, organisational mechanisms such as voting systems, the sharing economy, the internet of things (IoT), personal identification, direct cash transfers, or some combination of the above).[46] Development partners interested in improving access to financial tools in the narrow sense (that is, the Bitcoin model), and in exploring new tools for mitigating transaction costs for contractual agreements in the wider sense (that is, the Ethereum model), should stay informed of the ever-changing landscape of decentralised ledger technologies.[47] This can be done by i) consulting the relevant literature (for example, Casey & Vigna, 2018); ii) contacting firms and organisations active in the field in Africa, such as BitPesa, for advice and possible collaboration; or iii) setting up an in-house expertise unit, such as GIZ's Blockchain Lab.[48]

Can development partners be pro-active in bringing such monumental changes about? It is a trial and error process, but success stories do exist. Let us revisit the actual birth of the world's first mobile money service, M-Pesa. The Vodafone employee who invented the concept, Nick Hughes, described his experience as follows:

> I was approached by a representative of the UK government who controlled a [Financial Deepening Challenge Fund] project set up by the Department for International Development (DFID). Our discussion centered on the following: Private sector organizations such as Vodafone are legally bound to use their shareholders capital to achieve the best returns. But many organizations use internal competition to allocate funds to their projects, and this competition is based on potential returns on investment. As a result, any initiatives that relate to the development agenda usually get squeezed out. […] I spent a few weeks in mid-2003 putting together a proposal […] and [we] were awarded funding of nearly £1 million, which was matched by Vodafone. A few weeks later, contracts were signed and we set about organizing a series of open workshops in Nairobi and Dar es Salaam. (Hughes & Lonie, 2007, pp. 66-67)

While other factors were certainly important, this account shows that, without donor support, the idea of "mobile money" might never have turned into the real-world service that now pulls millions out of poverty.[49] This is not to suggest that such challenge funds are the best solution. The example is meant to show that well-informed development partners can be proactive in bringing about seismic shifts in digital-era breakthroughs.

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46 Ohnesorge (2018) sees the greatest immediate possibilities in financial services (for instance, remittances) and property rights (that is, land registries). For an example of an existing pilot in blockchain-based development cooperation, see the Kreditanstalt für Wiederaufbau (KfW)'s TruBudget of 2017 available at https://www.kfw.de/KfW-Group/Newsroom/Latest-News/Pressemitteilungen-Details_426112.html.

47 Bitcoin's blockchain is designed purely as a digital currency. Etherium's blockchain is meant to be used more broadly in various other realms beyond finance, such as "smart contracts" with automatically enforced transactions according to previously stipulated rules.

48 GIZ's Blockchain Lab has been testing new applications of decentralised ledger technology in land registries, and decentralised energy markets. See https://www.giz.de/en/worldwide/67045.html.

49 Suri and Jack's (2016) finding that 196,000 Kenyans were pulled out of poverty by mobile money, suggests that similar processes occur in other mobile-money countries – hence our vague claim of "millions."

6.3 Women

Many smallholder farmers across the subcontinent are aging women (Palacios-Lopez, Christiaensen, & Kilic, 2017). Using digital technologies in agriculture thus has a large and immediate impact on women in Sub-Saharan Africa. Services such as HelloTractor in Nigeria, which alerts tractor owners if nearby small plots need ploughing, can help make toiling the land much less arduous for poor rural women and increase their profits (HelloTractor calls itself "the Uber for tractors" (Foote, 2018)).[50] Similarly, in urban areas, motorbike taxi services such as SafeMotos in Rwanda, which closely monitor their drivers, can reduce traffic accidents significantly, thus faring passengers of both sexes safely to and from work, and making women's journeys safer if travelling alone at night.[51] In the same city, Kasha, an e-commerce platform, delivers contraceptives and menstrual health products to women confidentially.[52] And Zipline's SIM-card-steered drones deliver blood supplies to Rwandan clinics when postpartum haemorrhaging occurs (which often causes maternal fatalities).[53] These are all services that i) could not exist without the current state-of-the-art ICTs, and ii) help women either directly in making their work lives easier, or indirectly by increasing safety, health, and dignity.

Particularly helpful for women's empowerment has been the internet (Bailur & Masiero, 2017). But unlike other world regions, the gender gap in African internet usage appears to be widening. An apparent correlation between female tertiary enrolment rates and women's access to the internet (ITU, 2017), suggests that development partners should try to help increase both.

Interesting, as well, is how women could become more involved in more digital work directly. Bailur and Massiero (2017) had found that women were, on average, more reserved and less exploratory when it came to engaging with new technologies.

My own case examples elsewhere (Melia, Forthcoming) show that nudging women towards, or merely showing an opening to working with technology can be extremely beneficial at all levels of the value addition ladder: i) Particularly well suited for helping women in getting started in the most basic type of digital labour – which is currently image tagging – are impact sourcing service providers such as Samasource.[54] ii) Partners interested in promoting women's independent online work could seek out and consult with African women who are themselves at various stages of independent online work. The Rockefeller Foundation has worked in the field of promoting African involvement in online labour platforms over the past years, and could provide helpful insights.[55] iii) Partners interested in promoting women's participation at the top of the value addition ladder, in professional software engineering could concentrate on narrowly targeted

50 For HelloTractor, see https://www.hellotractor.com/home.

51 For SafeMotos, see http://www.safemotos.com/.

52 For Kasha, see https://kasha.co/.

53 For Zipline, see https://www.flyzipline.com/.

54 For Samasource, see https://www.samasource.org/.

55 For the Rockefeller Foundation's "Digital Jobs Africa" initiative, see https://www.rockefellerfoundation.org/our-work/initiatives/digital-jobs-africa/

interventions of linking established female coders to one another. Direct communication with organisations such as Andela or Akirachix could be helpful.[56]

6.4 Internet connectivity

Other observers have been critical of the enthusiasm around connecting Africa to broadband internet.[57] But the evidence in this current literature review indicates that investing in better and more accessible internet connections may be a fast and comparatively cost-effective way towards African private sector development and job creation. Early findings suggested that the internet has positive effects across all levels of wealth and firm productivity, but that it may have the greatest effect for the already better off, hence, increasing the digital divide between more and less productive firms and between more and less wealthy countries.[58] However, I showed above that an extensive new study (Hjort & Poulsen, 2018) found that workers of all income brackets profit from the arrival of broadband internet in African cities.

This implies that better internet connectivity could become the underlying infrastructure for most aspects of economic activity, particularly for exporting to global markets, but for domestic business opportunities as well (because digital platforms and new innovations such as distributed ledger technologies also hold potential for reducing transaction costs in domestic markets).[59]

In spite of this importance of the internet, the data show that mobile phone usage is converging in all world regions, but internet penetration is much lower in South Asia and Sub-Saharan Africa than elsewhere, and that these two regions are currently falling behind; in other words, a global divergence in internet penetration exists (World Bank, 2016, p. 103; but compare ITU, 2017).

Thus, the collective evidence reviewed here indicates that development partners should seek to increase internet access across Africa. How could this best be done? A study by Wentrup et al. (2016) asked which factors had the biggest impact on internet penetration in the region. They hypothesised that four factors would influence internet penetration in Africa: i) authoritarian censorship in the form of firewalls or cyber espionage; ii) internet provider competition (that is, non-monopoly, and hence, presumably, lower prices and better quality). Their study found that these factors actually had *little* influence on whether or not the internet spread in a given country in Africa.

More influential were the other two factors: iii) how actively the standardised Internet inclusion policy, that is, the ITU's Universal Service Fund (USF), is implemented in a given country (USFs are meant to guarantee equal availability, affordability, and accessibility of

56 For Andela, see https://andela.com/. For Akirachix see http://akirachix.com/

57 See the reviews of Foster et al. (2018); Ojanperä et al. (2017) and Friederici et al. (2017).

58 See the reviews of Lio & Louie (2006); Paunov & Rollo (2015).

59 As noted, the World Bank (2016) stresses the importance of "analogue complements to digital dividends," meaning that regulations, skills, and institutions will ultimately determine to what degree ICTs can be utilised in a given country.

the internet).[60] And, iv) the import tariffs and value added tax levels on computer equipment (and whether or not a subsidy exists for hardware). The reasoning is that lack of access to adequate hardware is still a main impediment to using the internet in Africa.

Hence, Wentrup, Xiangxuan, Nakamura and Ström's (2016) findings suggest that, in order to spread the internet across Sub-Saharan Africa, interventions are more effective if aimed at equal access guidelines (that is, the USFs), and at lowering taxes on (or even providing subsidies for) computer hardware.

But intervention strategies need to be country-specific. For example, in Wentrup et al.'s (2016) sample of African countries, total taxation on computer hardware varied significantly – it was nearly 30 per cent in Cameroon (highest), and only 7.5 per cent in Nigeria (lowest). This shows the obvious need for locally tailored interventions: while it may be more important to concentrate on bringing down taxation in one country, in another, improving USF implementation may be more warranted.

Overall, bringing affordable internet and low-cost computing devices to the continent can make a big difference. As one of Nairobi's accomplished online workers told us:

> there are people who did very well in school, especially primary, high school, but sometimes they get stuck, not because they are not smart. Most of the time there are many people [who] get stuck because they don't have the money to proceed. […] I was talking to one guy who is really interested [in online work], but he can't get the money to buy the laptop, he can't get the money to, okay, he got someone to buy him a laptop, then now he has this issue of the internet, he can't afford it, it's too expensive for them. Now, for someone like that, and he's a smart guy, because, he has finished college. So, he can't proceed because of those obstacles. It might seem like very small issues, but they are not, for such a person, internet, laptop, such things. (Personal interview, Nairobi, June 2017)

This quote shows how dire the situation is in some African metropolises, where demographic change and jobs scarcity leads to unemployed university graduates who lack the funds for the most basic inputs needed to become productive in the digital era.

Pushing traditional telecom providers to better adhere to the USF guidelines can be useful. But ambitious initiatives are currently underway for providing globally free broadband internet connections, for instance, by Alphabet's Loon or SpaceX's Starlink.[61] Should these or similar initiatives succeed in bringing free broadband internet to Africa, it would become less urgent for partner interventions to help facilitate the connection, and more important to help Africans acquire the necessary equipment.

Convincing governments to lower import duties and value-added tax for personal computers could be a crucial contribution to job creation. Targeted subsidies, or improved schemes for low-cost imports of second-hand computers could help as well. This runs the risk of

60 Many governments and telecommunication companies promote "Universal Service." It is meant to increase equal access and digital inclusion across various socio-economic chasms, such as income, region, gender, ethnicity, disability, and so on (see Wentrup et al., 2016, pp. 249-250).

61 For Alphabet's Loon, see https://loon.co/, and for SpaceX's Starlink, see https://www.teslarati.com/spacex-starlink-us-military-500-700m-raised/.

becoming environmentally dangerous. Even if a scheme were strictly limited to well-functioning and relatively young devices, the recipient countries' electronic waste management systems could be unable to absorb the e-waste this would entail down the line.

Yet, from the perspective of generating African work in the digital era, the short usage cycles of devices in high-income countries provide an opportunity for bringing Africans online (if second-hand imports are coupled with strict quality oversight, and with support for African waste management systems). However best achieved in practice, increasing African access to fast internet may be among the most effective ways of facilitating jobs in the region.

7 Conclusions

This paper began by pointing to a difference in outlooks: between, on the one hand, global economic consultancies and African policymakers who welcome the ICT revolution in Africa as a trade-increasing and job-creating mechanism; and, on the other hand, critical social scientists who voice scepticism of the presumed merits of information and communication technologies and point to evidence that indicates either no clearly discernible benefits of ICTs in Africa, or even outright negative effects, for instance, in terms of increased exploitation and "negative adoption." The motivation for this literature review was to identify what the actual empirical results of the available, most rigorous scientific studies can tell us about this question. The results are surprisingly clear: none of the methodologically rigorous studies reviewed here find negative effects of ICTs on African jobs, directly or indirectly. A minority of studies show no positive effects. The latter are sometimes cited in support of the critical literature, but on closer inspection, they mostly point to inconclusive results due to particular circumstances that would need tweaking before ICTs could have their expected positive impact.

This positive conclusion does not imply that critical studies of ICTs in Africa are of no value. To the contrary: it is possible that positive biases crept into the various empirical trials cited here, and that, in future, rigorous studies will expose this. But for the time being, these studies provide the best existing evidence, showing various channels of positive effects of ICTs on African jobs.

With the spread of fast internet and the emergence of newer technologies, such as distributed ledgers or platform economies, newly undertaken research will need to establish whether the positive trajectory depicted here will continue in the future, or whether Fourth Industrial Revolution technologies will bring about a different set of challenges. Apart from their argument of "negative adoption," Murphy and Carmody (2015) made a more central claim: they note that, while new technologies *do* lead to greater connectivity to global markets, this entails increased dependence on imports and decreased capacity for productive exports. Murphy and Carmody's case studies show that in Tanzania and South Africa, furniture is increasingly imported from China (squeezing out local furniture producers), while global booking platforms gain ever-more market share (extracting grater revenues from local tourism SMEs). Such structural claims are difficult to verify/falsify – which led me to exclude them from this literature review. But such negative phenomena may indeed exist in parallel with the success stories depicted in the various studies reviewed above. Technology could have positive effects at a micro-

level (for example, saving bus fares) while having negative effects on a macro-level (for instance, making African economies ever-more path dependent on exporting raw commodities and on importing more sophisticated products and services). Hence, in the era of global platforms and ever-greater internet connectivity, future research should explore these questions. One aspect is to ask what possibilities exist for African productive exports in the age of the Fourth Industrial Revolution (Melia, Forthcoming).

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A literature review

Elvis Melia

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Preface

New digital technologies are expected to have a huge impact on developing countries' prospects for economic development. Digitisation will revolutionise business transactions in many ways: Digital technologies may help provide real-time information to farmers in remote areas; they enable poor people to use mobile banking services financial services; they allow firms in isolated locations to trade with international partners. Generally, they reduce a wide range of transaction costs and they may be used to make economic transactions transparent, reduce the scope for corruption and hold public service providers accountable. At the same time, digitisation enables automation at an unprecedented scale, thereby making millions of routine jobs redundant, and it enables the emergence of oligopolistic platform economies, some of which have led to an unprecedented accumulation of wealth among the super-rich and undermined welfare-oriented societal regulation.

Policymakers thus need to understand the opportunities and threats emerging from the wide range of digital innovations to be able to accelerate and broaden their positive effects while ensuring smart regulations to minimise the negative effects.

The German Development Institute / Deutsches Institut für Entwicklungspolitik (DIE) has initiated a series of research activities to explore some of these impacts on economic development prospects of latecomer economies, especially in Africa. First results have recently been published, and more research findings will be made available throughout 2019. The DIE team thankfully acknowledges financial support as well as expertise from Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ).

- In "Creating wealth without labour? Emerging contours of a new techno-economic landscape" (DIE Discussion Paper 11/2018), Wilfried Lütkenhorst analyses the main digital technology trends and how each of them is likely to affect developing countries' prospects for industrialisation, integration in the world economy and employment.

- Jan Ohnesorge's publication "A primer on blockchain technology and its potential for financial inclusion" (DIE Discussion Paper 2/2018) discusses the development potential of two blockchain uses: to reduce the cost of international remittances; and to improve government services, especially the establishment of transparent and reliable land registries.

- In the present DIE Discussion Paper 3/2019, "The impact of information and communication technologies on jobs in Africa", Elvis Melia reviews the scientific literature on the job effects of digitisation in Africa, differentiating between various technology applications covering information services for farmers and small enterprises and mobile banking, among other widely employed digital innovations.

Two related Discussion Papers are currently under preparation:

- Elvis Melia's second Discussion Paper on the economic effects of digitisation, "African jobs in the digital era: export sectors with a focus on online labour" (forthcoming in the first half of 2019) how digitisation affects African countries' export competitiveness. The study explores global automation, offshoring and reshoring trends through the lens of African opportunities.

- Lütkenhorst et al. (forthcoming in the second half of 2019) explore to which extent China's skyrocketing industrial wages are leading to the relocation of garment and shoe production to Africa. Industry-specific automation trends are studied as well as the strategic behaviour of Chinese investors and the attractiveness of African countries for such investments.

We hope that our ongoing research programme will help to better understand the effects of digitisation on the development of latecomer economies and provide insights for policymakers who want to harness new technological opportunities for inclusive and sustainable development.

Bonn, 25 February 2019 Tilman Altenburg

Programme leader
"Transformation of Economic and Social Systems"

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Elvis Melia

Contents

Abbreviations

4IR	Fourth Industrial Revolution
DHS	Demographic and Health Survey
FSD	Financial Sector Deepening (Financial Access Household surveys)
GDP	gross domestic product
ICTs	information and communication technologies
ISOC	International Standard Classification of Occupations
OLPC	One-Laptop-Per-Child
SIM	subscriber identity module
SMEs	small and medium-sized enterprises
USD	United States dollar

Executive summary

Information and communication technologies (ICTs) could lead to more economic inclusion of emerging market countries, valuable job opportunities for low-income workers, and, overall, higher living standards for all. Alternatively, ICTs could exacerbate the concentration of wealth, as rents are distributed ever more unevenly, leading to greater marginalisation of the peripheral poor. In Sub-Saharan Africa, policymakers tend to see the mobile phone wave and increased internet connectivity as positive. Yet, in the social science literature, various scholars question whether this ICT revolution is really benefitting citizens and workers of the global south. This study takes stock of recent empirical research that could provide evidence for either of these two notions for one particular aspect: ICT impact on African jobs.

The study is divided into four broad empirical categories: ICT-based information services (Section 2); mobile money (Section 3); various direct associations between ICTs and working-age men and women (Section 4); and fast internet (Section 5). This is followed by a discussion on policy options (Section 6), and a conclusion that is forward-looking and points to some future research options (Section 7).

Particularly widespread in Africa are ICT-based extension services and market information services for smallholder farmers. Several programmes for introducing these services have been accompanied by multi-year randomised controlled trials for measuring effectiveness. Results for the impact of ICT-based interventions for farm inputs and productivity are remarkably positive. For ICT-based market information services, results are more varied: but here too, the majority of studies reviewed find either distinctly positive impacts of ICTs on African jobs or point to technical problems that temporarily hinder the expected positive outcomes. Some empirical studies find little or no positive impacts of ICT-based market information services, but none of these studies deem these problems as insurmountable. One study suggests that ICT-induced farm productivity reduces the need for rural farm labour. (This could be interpreted as positive, if it leads to structural transformation of the economy, or as negative, if it leads to a net loss in employment). None of the other studies reviewed in this section point to *negative* results of ICTs on jobs in Africa.

In these quasi-experimental settings, however, some aspects are difficult to control for, and methods are still evolving. Much of this research on various ICT-based information services primarily tests the merits of the services, that is, of the particular *intervention strategies,* not the *direct impact* of the underlying technologies as such. Furthermore, such randomised trials accompanying ICT-based intervention schemes tend to take a narrow focus and may not be adequate for detecting larger structural constraints. Their results can thus not easily be extrapolated to draw conclusions about the *overall* ICT impact on African jobs.

One famous innovation is mobile money. Created in 2007 and spreading across Africa throughout the 2010s, mobile money is seen by policymakers as supporting various types of informal micro-businesses, in agriculture and elsewhere. Here, rigorous research evidence (covered in Section 3) points in a clear direction: mobile money *does* alleviate poverty in Africa, and it creates both rural and urban jobs. Women in particular have benefitted from this innovation. Here it helps to keep in mind, however, that mobile

money is *one distinct* technology. The positive dynamics it creates may be particular to this innovation and not necessarily representative of *all* ICTs.

While the above results were largely derived at via controlled trials, several other methods exist for studying the impact of ICTs on jobs in Africa. Large-number cross-country comparisons, natural experiments, survey analyses, or deep anthropological case studies can complete the picture on whether or not ICTs have had the expected socio-economic impact in Africa, and which nuances exist – for instance, whether or not these impacts are the same for men and women (covered in Section 4). The results of large cross-country comparisons vary. Some studies indicate that ICTs can lead to an increased concentration of wealth by having greater positive effects on countries or firms that are already better off. Several studies thus suggest, in line with the World Bank's (2016) emphasis on "analogue complements," that various other variables – institutional, societal, or cultural – exert influence on whether or not ICTs create jobs in Africa. Applying this method, however, means that causation is difficult to determine (that is, some studies find that ICTs also have *positive* effects on these analogue complements, which blurs our understanding of individual causal relationships).

Case studies on the impact of mobile phones, mostly conducted via randomised trials, find that the introduction of mobile phones *has* had positive effects for African farmers and traders dealing in perishable produce such as bananas, but *not* in more durable produce, such as maize. These findings imply that mobile phones can be more or less helpful via gaining market information, depending especially on how perishable one's goods are. For the former, logistics demand timely communication, whereas the latter can be stored longer and are easier to transport. (However, one study also finds positive effects of mobile phones on urban cloth traders, even though cloth is a non-perishable good).

As far as the empowerment of women is concerned, the picture is more complicated: gender equity and women's income generation can be discussed in absolute or relative terms. When examining women's *absolute* empowerment – that is, when examining whether ICTs have helped women generate incomes irrespective of whether or not men have benefitted more – most empirical analyses point to distinctly positive results. However, when examining the *relative* power distribution between men and women within a given society, there is cause for concern, especially with regard to internet adoption. By one account, Sub-Saharan Africa is currently the only world region in which the digital gap between men and women is not shrinking but *widening*.

This trend is particularly worrying in light of findings that, once connected, the internet seems to have an even greater positive effect for women than mobile phones did. With myriad other responsibilities and operating in patriarchal surroundings (that is, multitasking with children, and mollifying spouses), internet access seems to be a vital tool for women's empowerment. Compared to a phone connection, benefits are far greater because the internet allows African women to communicate subtly, when time permits, via social media instead of having to take phone calls immediately.

This leads the paper to the final empirical section: broadband internet (Section 5). The number of Africans with regular access to fast internet is still miniscule. Thus, compared with the numerous studies on other ICTs reviewed here, much less rigorous evidence exists to date for measuring the impact of broadband internet on jobs in Africa. The

section is structured as a three-step review: i) large-number cross-country comparisons on the internet's statistical relationships with various job-related indicators; ii) critical studies that question the widely assumed benefits of broadband internet connectivity in Africa; and, iii) an extensive recent study on broadband internet impact on African jobs.

Large cross-country comparisons have found that, for developing countries, internet adoption is associated with increases in exports to developed countries; with higher gross domestic product (GDP) per capita growth rates; with higher firm productivity; and with higher labour productivity. But here, too, the assumed causal relationships cannot be entirely verified; and in some of these studies it is unclear whether a fallacy of composition is at play – that is, whether some countries' gains in market share merely come at the expense of other developing countries with worse internet access and diminishing market shares.

Thus, in attempts to unveil hidden structural aspects, several recent studies have taken a more critical stance. They call into question the widely held assumptions on positive causal effects of internet connectivity on African economies, and conclude that the internet *may not* always help African SMEs' positions in global value chains; *may not* cause as much knowledge generation in Africa as is often assumed; and *may not* warrant the general enthusiasm for greater internet connectivity that is often encountered in African policy documents. These findings are tentative and difficult to prove. They are at odds with most of the literature reviewed in the rest of this paper, and, hence, are at odds with this study's policy recommendations (see below). But such critical angles should nevertheless be taken seriously. They point to structural dynamics that are difficult to measure and may exist in parallel with the positive dynamics found in the other studies. Some indications exist that at least one negative dynamic (increased polarisation of wealth and productivity) may surge in the era of Fourth Industrial Revolution (4IR) technologies – that is, in the years ahead, as platform economies, machine learning, big data analytics, and routine task automation increase.

For the time being, however, the evidence for positive impacts of the internet in Africa clearly outweighs existing empirical grounds for scepticism. This is corroborated by one large (forthcoming) study, which enjoys special status in this literature review: Tracing the landings of ten submarine fibre optic cables in 12 African countries between 2006 and 2014, Jonas Hjort and Jonas Poulsen measured the impacts of broadband internet arrivals in these quasi-random locations and found that broadband internet connectivity *has* had significant positive impacts on the number and quality of firms as well as the number and quality of jobs in connected areas. They were able to show that these positive findings were not due to displacement effects (namely, to fewer firms and jobs in nearby unconnected areas due to firm relocation or workers commuting to connected areas). Hence, this study comes close to proving the causal relationship: fast internet connectivity leads to more and better jobs in Africa.

Lastly, policy options are suggested for governments and development partners (Section 6). Some of the review's findings are straightforward: The *quality* of agricultural interventions is important, be they analogue interventions (for instance, delivered in person via an extension officer) or digital interventions (such as those delivered via an ICT-based extension services platform). Digital intervention platforms can be improved in much the same way as analogue interventions are improved: via better feedback

mechanisms and well-planned monitoring and evaluation schemes. Randomised controlled trials should increasingly accompany interventions. Targeting younger farmers may also generate higher returns.

The positive impact of mobile money suggests that amplifying its spread across the subcontinent could spur the creation of jobs. One study found, however, that natural first-mover advantages may be the best predictors for a country's relative success rate in spreading mobile money, and that policy interventions can have negative effects (as seen in Nigeria).

The current speed of technological change can make it difficult for governments and development partners to stay ahead of the curve and to plan for meaningful interventions. The example of the United Kingdom's Department for International Development's (DFID) involvement in the creation of mobile money, however, shows that such forward-looking engagement is possible and worth pursuing. Partner organisations interested in initiating similarly impactful ventures could engage in knowledge generation on blockchain technologies (for instance, GIZ has set up an in-house expertise unit – the Blockchain Lab).

For women empowerment and various other job-creation dynamics, supporting the spread of the internet seems particularly feasible. To date, the evidence base for the internet's positive economic impact on jobs in Africa outweighs the concerns about possible negative effects. Examining different support options for spreading internet adoption across Africa, one study found that adherence to standardised internet inclusion policies, and lowered taxes and import duties on computer hardware are particularly helpful. One option could thus be to utilise the short usage cycles of computer gadgets in high-income countries for carefully monitored import schemes of second-hand devices to lower income countries.

These suggestions are squarely based on the currently available empirical evidence reviewed here. Further research is needed to examine whether such positive claims about ICTs and internet penetration in Sub-Saharan Africa remain warranted going forward. Some of the critical scholars point out that the currently evolving set of Fourth Industrial Revolution technologies hold the risk of reversing this trend: continued commodity exports and technology imports may lead to path-dependence toward ever-diminishing terms of trade for African countries, and platform-based trade may exacerbate wealth inequality rather than mitigate it. Whilst the currently available empirical evidence reviewed in this study is insufficient to support such claims, these concerns need to be engaged with in future research. One example would be to examine which options still exist for African countries to break into productive export sectors.

1 Introduction

There are more mobile phones than adults in most African countries
("Africa calling", 8 August 2016, in The Guardian).

Information and Communication Technology (ICT) increases connections, be it between small farmers and the larger traders who buy their produce, between multinational firms and the smaller manufacturers who build their parts, or between various firms and individuals around the world, linking rich and poor within and across countries. Depending on one's outlook, this should lead to more economic inclusion of emerging market countries, valuable job opportunities for lower income workers, and, overall, higher living standards for all (MGI [McKinsey Global Institute], 2013). Alternatively, it could lead to a further concentration of wealth, as rents are distributed ever-more unevenly within societies and across global regions, leading to greater marginalisation of the peripheral poor within countries and of the global south as a whole (Huws, 2014). In Sub-Saharan Africa (henceforth: "Africa") the past two decades of fast-growing mobile phone usage have led most policymakers to conclude that the mobile phone wave is positive, as the phones save time and bus fares, provide safety, and generate new employment and work opportunities that had hitherto not existed.

Critical literature

In the social science literature, however, various scholars question whether the ICT revolution is really benefitting citizens of the global south. Some have hypothesised the opposite – that ICTs are the latest in a series of technological advancements that buttress the structural forces of inequality and underdevelopment. Murphy and Carmody (2015), for example, make the argument that ICTs can also perpetuate existing modes of extraction and exploitation of the global south. In some instances, mobile phone penetration can force Africa's poor into "negative adoption" of mobile phones (p. 34). This means that to find *any* sort of work in this new, networked society, the poor are *forced* to buy phone credit. Reluctantly, they do so *instead* of paying for their most basic needs and expenditures such as nutritional food or school fees for children. In this view, being disconnected from the network has become so disadvantageous for the poor that they have no choice but to partake. Thus "mobile phones bring poverty" (Murphy & Carmody, 2015, p. 33, citing a Ugandan survey respondent in Diga (2007)).

This paper sets out to take a non-biased account of existing empirical research that could provide evidence for either of these notions: the positive view that ICTs are beneficial for Africa; or the sceptical view that they are not. I limit the scope of this review by focusing on the initial generation of information and communication technologies (ICTs) – entailing mobile phones, text-based services platforms, mobile money, and the internet. These technologies have been around for long enough that a critical mass of empirical studies exists. Not covered in this review are the much newer Fourth Industrial Revolution (4IR) technologies – entailing machine learning, mobile robotics, 3D printing, the blockchain, or platform economies such as ride-hailing apps – because little rigorous research exists on their impact to date (for a discussion of these newer technologies, see Melia, Forthcoming). As per the title of this paper, the dependent variable is also limited to one single outcome – jobs. Jobs are closely related to other economic variables – for example, firm productivity, women's empowerment, skills and educational improvements, economic growth and the

institutional environment – and I thus refer to research that tests for ICT impact on any of these related variables as well. My core focus on jobs, however, is not chosen arbitrarily.

The growing centrality of both "jobs" and "ICT" for Africa

The issue of African job creation is central in development policy circles. This is due to ever-growing numbers of working-age Africans, and perhaps in part also due to Europe's political challenges entailed in absorbing migrants. The International Monetary Fund (IMF) (2015) calculates that due to Africa's demographic changes the number of newly created jobs on the continent will need to be "18 million per year from 2010 to 2035" (p. 30). And the United Nations has declared its eighth Sustainable Development Goal to be "employment for all" by the year 2030 (UN [United Nations], 2015, SDG8). In the real world, this challenge coincides with a time where each two-year doubling of global computing power is noticeably more disruptive than the last (Reese, 2018). This moves ICTs to the core of the discussion on African job creation. For Africa, the digital era has begun to progress away from the wave of mobile phones, toward the wave of broadband internet connections. While there is as yet little rigorous research that could be reviewed on the new 4IR technologies, this study provides a foundational overview of the actual effects that narrowband ICTs have so far had on jobs in Africa. I then document the first rigorous findings on the relationship between broadband internet and African jobs.

Exactly how useful ICTs have been for jobs in Africa has long been difficult to measure (be it in jobs directly influenced, or jobs indirectly influenced by new types of economic development, labour or firm productivity levels, or changed institutional environments). Past reviews of the literature have noted that, of the large number of publications on ICTs in Africa, only a small proportion has actually demonstrated rigorous findings on the effects on particular development outcomes (for instance, Duncombe & Boateng, 2009, for ICT in finance). But the body of rigorous research has substantially grown over the past decade, and this study seeks to provide an up-dated review.

Methodology

This literature review is not exhaustive. I focus on empirical research findings published in peer-reviewed journals (and on findings that are still in working paper format but clearly aimed at journal publication). Many more such studies exist, particularly earlier works, as this paper concentrates on findings of the past few years. I also refrain from reviewing theory-based commentaries and related policy reports – some of which are of high quality (for an extensive overview and critique of such reports, see Friederici, Ojanperä, & Graham, 2017). Keeping the main body of this review free of discussing less rigorous publications and free of voicing my own detailed critiques of other researchers' conclusions, is meant to provide a lean text that illuminates the trends in the research. This is, however, closely related to wider policy debates. I have thus made extensive use of footnotes to point to related but less rigorous policy documents, and, in certain instances, to underpin why my conclusions differ from those of other researchers.

I came to this literature by conducting *Google Scholar* searches for various combinations of terms. For independent variables: "ICT," "digital," "internet," "mobile phones," (and more specific terms such as "mobile money," "ICT-based," "text-based," "SMS," "market information services"). For geographic location I used "Africa," "Sub-Saharan Africa," and

various individual country searches. For dependent variables: "jobs," "employment," "income," "work" (and related terms such as "GDP," "productivity," or "inequality;" and gender-related terms). This led me to citation-based snowball searches, starting with articles that were i) published in ranked journals; ii) relatively recent; and, iii) cited most frequently by other peer-reviewed studies. Helpful for cross-referencing this literature review are World Bank (2016); Deichmann, Goyal and Mishra, (2016); and Friederici et al. (2017).

Structure of this literature review

This study divides the literature into four broad categories: ICT-based information services; mobile money; various direct associations between ICTs and working-age men and women; and, finally, fast internet.

The first subset of the literature is dedicated to measuring the effects of mobile phones on various development outcomes, some of which are related to job creation directly (such as productivity, growth, exports), while others can have indirect effects on job creation (for instance, via human development, education, or governance).

Most African workers are still (self-)employed on small farms or in urban microbusinesses. This implies that the biggest potential effects of ICTs (that is, of mobile phones, text-based message services, or the internet) on Sub-Saharan African workers should lie in providing services to small, informal businesses. Particularly widespread among such services are ICT-based extension services and market information services for smallholder farmers. Several of these interventions have been accompanied by multi-year randomised controlled trials for measuring the effectiveness of such interventions. A number of such studies have now been completed and results have recently become available (covered in Section 2).

The innovation of mobile money in 2007 and its spread across Africa throughout the 2010s is seen by policymakers as supporting various types of informal micro-businesses, in agriculture or elsewhere – and here too, rigorous research evidence now exists on whether or not this assumption is true (covered in Section 3).

Apart from randomised controlled trials, researchers have applied other methods to study the impacts of ICTs – from large-number cross-country comparisons, to natural experiments, to survey analyses, and deep anthropological case studies – mainly to find out whether mobile phones, or narrow-band ICTs generally, have had the expected positive socio-economic impact on various aspects of African lives, including those of African women (covered in Section 4).

The paper then reviews the (to date much smaller) body of research on broadband internet and its impact on African jobs. I begin with large-number cross-country comparisons, which can determine correlations between variables but cannot definitively speak to causal relationships (subsection 5.1). This leads me to introduce and discuss three critical studies that all question the widely assumed *causal* links between broadband internet connectivity and African development outcomes that are closely related to jobs (subsection 5.2). I then close the literature overview by introducing one final paper, a recent and methodologically impressive study (albeit as yet unpublished), which may well become a milestone contribution to the literature on ICTs and jobs in Africa (subsection 5.3).

Lastly, in Section 6, I point to a trend in these results. On the basis of this trend I suggest policy options for governments and development partners interested in the actual role ICTs play in the creation of jobs in Africa. Section 7 gives a short conclusion.

2 Jobs via ICT-based information services for farmers and SMEs?

Several studies have examined the success rates of ICT-based development interventions. Such interventions are often combinations of government- or donor-supported programmes. They mostly provide either particular extension services, that is, tips and tricks on soil, weather, crop types, fertilisers, best practice breeding methods for livestock – or other services that could help farmers become more productive (covered in subsection 2.1); or market information services, that is, lists of real-time prices for certain farm products at local or regional markets (covered in subsection 2.2).

2.1 Information services for productivity enhancement

Globally, the lowest levels of farm productivity are in Sub-Saharan Africa. If smallholder farmers become better informed about their technical options for increasing yields, their productivity usually rises, leading to better working conditions on farms and higher food security (Ragasa & Mazunda, 2018). Supporting analogue agricultural extension services (such as one-time farm visits) with digital tools (such as repeated text messages) can amplify the reach of extension officers exponentially (see, for example, Aker, 2011), can make services more transparent (see, for example, Cole & Fernando 2012), and can give farmers greater agency and trust in accessing the types of input information they need most (see, for example, Ragasa & Mazunda, 2018; Molony, 2008).

Jenny Aker, a leading authority in the field, suggests that ICTs can greatly improve extension services in Sub-Saharan Africa, but only if conducted under the right circumstances (Aker, 2011). After giving an overview of existing ICT-based agricultural extension services,[1] she provides a useful methodological framework for testing the merits

1 For more recent lists of ICT-based intervention strategies see CTA [Technical Centre for Agricultural and Rural Cooperation] (2018), Oestermann, Esselaar and Dymond (2013), or Mramba, Rumanyika, Apiola, and Suhonen (2017). Mramba et al. (2017) compiled and categorised a list of all ICT-based intervention programmes in Sub-Saharan Africa found via internet search. What is noteworthy is that the authors found an exceptionally high proportion of these interventions to be i) agriculture-focused projects, and ii) located in Kenya. The study also claims to have "found several setbacks related to the adoption of ICT among informal workers, such as low uptake level, lack of ICT contextualization, and uneven distribution of ICT solutions among different categories of the informal workers" (Mramba et al., 2017, p. 4). Yet, the study gives no methodological indication for how the authors arrived at this judgment, which led me to omit it from the literature review. Its list of interventions is nonetheless exhaustive and relatively up-to-date (from 2016/2017), and can provide the interested reader with a good baseline compilation of existing initiatives. Oestermann et al. (2013) profiled some 40 companies that use ICT to serve the base of the pyramid markets (that is, consumers who earn on average less than USD 8 per day). The paper's list is global, but many of the cases are from Sub-Saharan Africa. Most recently, CTA (2018) provides more detailed overviews of four ICT-based initiatives that serve East African farmers (three in Uganda – WOUGNET, MUIIS and Ensibuio; and one in Kenya – FarmDrive).

of such interventions (Aker, 2011). Since then, several case studies have undertaken such tests. This section summarises their results.

In northern Ghana, a study found that one ICT-based intervention[2] for rural smallholders did lead to significant increases in the use of pesticides between 2006 and 2009 (Al-Hassan, Egyir, & Abakah et al., 2013). Applying propensity score matching, this study found a 13 per cent higher uptake of improved seeds among treated farmers, leading to an 11 per cent increase in food security (vis-à-vis a control group). The study also found that younger participants were significantly more likely to embrace ICT-based extension service advice, leading the authors to suggest that such interventions should be targeted more at younger generations in future, since this would bring about higher up-take (Al-Hassan et al., 2013).

An extensive study on western Kenyan sugarcane smallholder farmers (conducted between 2011 and 2013), also found that those farmers who received regular advice via SMS text messages earned on average 11.5 per cent more than a control group (Casaburi Mullainathan, Kremer, & Ramrattan, 2013).[3] Furthermore, these were farmers who had not been trained and had no regular contact with their sugarcane company. Making a direct and free hotline available for farmers (to complain if the company had not provided the promised fertiliser) increased the company's input delivery to its smallholder farmers by some 21.6 per cent (Casaburi et al., 2013).

Ogutu, Okello and Otieno (2014) used propensity score matching to test the impact of a different ICT-based intervention for smallholder farmers in three Kenyan Districts (between 2002 and 2010). This intervention, DrumNet (via Pride Africa), was an all-encompassing platform for extension services, market information services, and facilitating access to credit. The study found that "participation in the ICT-based project [had] a positive and significant effect on the usage of purchased seed, fertilizer, labor productivity, and land productivity, but [had] a negative and significant impact on the use of hired, family, and total labor" (Ogutu et al., 2014, p. 319).

In the present literature review on ICT impacts on African *jobs*, the finding that DrumNet actually *reduced* the need for rural farm labour should be a red flag. The causal mechanism behind this seems to be increased land productivity (via non-labour inputs such as seeds and fertiliser) and particularly increased labour *productivity* (via significantly lowered transaction costs in various farm-related search activities). This means that as farmers spend less time on some activities – searching for inputs, negotiating prices for outputs – they can spend more time on tending to their land. This, in turn, frees up hired help and family members to pursue other activities. I will address this seeming conundrum between increased agricultural modernisation and decreased numbers

2 The Sustainable Enterprise Development Foundation, an NGO, used the private market information service platform TradeNet (today Esoko) to deliver targeted information and training to smallholder farmers.

3 Funded by Jamal Poverty Action Lab and four other donors, this intervention was steered directly by the research, and conducted in collaboration with Mumias Sugar Ltd. Results are still preliminary in this (2014) version of the study, but no updated version could be found online. This may or may not be related to Mumias Sugar Ltd having simultaneously been embroiled in gross mismanagement and a grand corruption scandal, from which, after having fired over 50 top-level employees, and a large government bailout, the company has not recovered ("Cash crunch", 22 March 2018, *The Standard*).

of menial jobs in more detail below. For now, the net positive effect of this particular dynamic is corroborated in an earlier study of the same intervention, by Okello (2010), which found that DrumNet's treated farmers and their families were more food secure and had better access to health care than did a control group.

A recent finding from another world region is also positive: Cole & Fernando (2016) studied Avaaj Otalo, a simple mobile-phone-based extension service hotline in India, and traced the effects that this had on cumin and cotton farmers. The study found "dramatic increases in average yield for cumin (26.3 per cent), as well as improvements in cotton yield (3.5 per cent) for a sub-group that received frequent reminders to use the service" (p. 1) and the authors "estimate that a USD 1 investment generates a return of more than USD 10" (p. 21).

These results are all remarkably positive for the impact of ICT-based interventions for farm inputs and productivity. However, this body of literature is still relatively small. A separate body of literature on ICT-based market information services is much larger and its results are more heterogeneous (subsection 2.2).

2.2 ICT-based services for market information

If smallholder farmers are better informed about market prices, various positive effects can ensue: market prices become less volatile and can come down in aggregate (because crop supplies better match demand in a given location, thus reducing gluts and shortages). This is better for consumers, but farm-gate prices (the prices farmers receive for their produce) simultaneously increase, especially for perishable goods (as better market information leads to less wastage). Also, as smallholder farmers are usually poorer than their intermediary traders, increasing their access to information, and hence their bargaining power, can lead to faster poverty reduction.[4] This subsection investigates if empirical evidence supports this theory.

Findings of positive impact on income generation

In Niger, Aker (2008) examined the introduction of mobile phones, and did find a positive impact in the form of *both* higher grain traders' profits (due to lower search costs) *and* overall lower grain consumer prices (due to more evenly available supply). Targeted market information services can also be made more effective if ICTs help spread the services to more smallholder farmers.

This is in line with Svensson and Yanagizawa's (2009) findings that Ugandan maize farmers who had access to a radio-aired market information service were better able to bargain for higher prices for their crops than were their less informed peers. Re-examining this same intervention, Kiiza, Pederson and Lwasa (2011) employed propensity score

4 Mixtures of extension services and market information services, such as the above-mentioned DrumNet, include the Kenya Agricultural Commodity Exchange (KACE), the Regional Agricultural Trade Intelligence Network (RATIN), the National Livestock Market Information System (NLMIS), and the M-farm, all in Kenya. Similar initiatives outside Kenya comprise the Malawi Agricultural Commodity Exchange (MACE), the Busoga Rural Open Source Development Initiative (BROSDI), and then Women of Uganda Network (WOUGNET) (see Ogutu et al., 2014). Refer also to Footnote 2.

matching to check for hidden selection biases, and came to similarly positive results for better-informed farmers.

In Ghana, Nyarko, Hildebrandt, Romagnoli and Soldani (2013), conducting a randomised experiment with 1,000 smallholder farmers between 2011 and 2013, provided their treatment group with free access to Esoko, a private weekly SMS market information service for crop prices. Their preliminary results found a 7 per cent increase in earnings for SMS-recipient yam farmers, presumably due to better bargaining power. A later version of the study by the same authors, Hildebrand, Nyarko, Romagnoli and Soldani (2015), showed 8 to 9 per cent higher farm gate prices and thus substantial improvements in yam farmers' living standards.[5]

These positive results for ICT-based interventions suggest that the underlying information and communication technologies used in these interventions did have some positive impact on jobs in Sub-Saharan Africa. For smallholder farmers, generating higher prices for crops can be translated directly into having higher incomes. But in these quasi-experimental settings some aspects are difficult to control for, and methods are still evolving.[6] Other empirical studies found little or no positive impact of ICT-based market information services. I examine these studies in detail below.

Findings that showed little to no impact

In Botswana, an early study by Duncombe and Heeks (2002) had examined the information needs and information sharing techniques of rural micro-entrepreneurs. Their findings suggest that mobile telephony could benefit these informal businesses, but that other ICTs (such as text, internet, fax [*sic*]) would be more difficult to utilise for individuals. To be useful, these technologies would need to be routed through better-informed intermediary organisations (Duncombe & Heeks, 2002).

One study conducted in Rwanda, by Futch and McIntosh (2009), has been referred to as documenting "no effect of having a mobile phone on prices received by farmers" (Deichmann et al., 2016, p. 12). Futch and McIntosh's study examined the introduction and use of quasi-payphones (where village kiosks had been equipped with a mobile phone for public use, and with car batteries for charging the phones). While this study found that these

5 Interestingly, this same increase of 8 to 9 per cent was found in the control group. The authors attribute this to indirect spillover effects (that is, treatment group farmers' increased information and bargaining power led traders to suspect better informed farmers across the board, and, hence, to offer higher prices to non-informed control group farmers as well). This finding presents an interesting complication to randomised experiments. This study concentrated on yam, but also had data on other crops, for which no discernible impact of the intervention was found.

6 Indirect information spill-over effects are still difficult to detect in these studies (see, for instance, Hildebrandt et al. 2015, above). More broadly, certain counterfactuals cannot be accounted for, for instance, what intervention strategies *would have taken place* in a world in which Africa is experiencing equally rapid development improvements (Radelet, 2015) *without* the existence of ICTs? Also, possible time-lagged *negative effects* of ICTs are unaccounted for, such as cultural and discriminatory clustering, which greater connectivity may bring about. On increasingly polarised opinions in the network age, Ferguson (2017, p. 355) notes that "birds of a feather, in terms of shared interests as well as personality types, flock together as always, and there may be a feedback loop that causes similar users to grow more interconnected through Facebook usage."

"Village Phones" did lead to significantly better transport arrangements for smallholder farmers, the study also found that the phones did *not* lead to higher incomes or higher farm gate prices. This could imply that phone kiosks were of little use to the target population. But the study's authors themselves note that their non-result for the "Village Phones" could well have been due to a similar service, Tuvugane, that had already existed in the area, which entailed that "low-cost access to telephony at the village level had already occurred as of our baseline" (p. 71). Thus, in this case, concluding that phone kiosks led to no positive result, as Deichmann et al.'s quote implies, is inaccurate. Apart from the improved logistics, mobile telephony *did* have overall positive price effects in all tested areas, be it via one provider (Tuvugane) or the other (Village Phones).

But several other studies, particularly for purely text-based services, also showed little to no impact, which somewhat validates Duncombe and Heek's (2002) cautionary predictions. In Ethiopia, Tadesse and Bahiigwa (2015) found that "the effect of village level mobile phone access [was] totally insignificant" (p. 303), and that very few farmers actually used their phones for obtaining market information, and suggested this could be due to a lack of relevant information available (that is, due to the difficulty of accessing existing SMS-based interventions).

Similarly, in Niger, Aker and Fafchamps (2014) found that the introduction of mobile phone coverage had no discernible effects on the average prices that farmers received for any of the study's examined crops (cowpea, sorghum, and millet). For cowpea, mobile phone coverage did have a positive effect on levelling the prices between markets and throughout different times of the year, but this was not the case for either millet or sorghum (which are less perishable crops and can be stored longer).

And Wyche and Steinfield (2015) cite InfoDev which apparently found in 2013 that merely 5 per cent of rural farmers in Kenya and South Africa used their mobile phones for accessing market information services. Wyche and Steinfield followed up on these results with an analysis of some 70 rural Kenyan farmers' use of MFarm, a mobile-phone-based crop-price information service. MFarm provided daily market prices for 42 crops at Kenya's five large city markets (each SMS costing Ksh1, approx. USD 0.01). In answering their paper's headline question: "Why don't farmers use cell phones to access market prices?" Wyche and Steinfield suggest that rural Kenyan smallholders have several reasons for refraining from text-based services: it is cumbersome to type messages (due to illiteracy, poor eyesight, and inadequate hardware – old handsets with limited backlights, worn-off and broken key pads, and devices that are incompatible with local languages); being off the electricity grid required cost-conscious battery use (most phones were either turned off or placed at far-off charging kiosks); texting costs (even USD 0.01 was expensive in areas where men claimed to have between zero and USD 0.16 of credit on their phones, and where women mostly claimed to have between zero and USD 0.02); and reply text messages received by the service that farmers could often not utilise. This finding suggests that the underlying technology *could be* beneficial to smallholder farmers if they could either access it better (via better equipment), or if the service were improved to match the conditions on the ground (Wyche & Steinfield, 2015).

This notion is in line with Ragasa and Mazunda's (2018) findings of analogue extension services in Malawi: in aggregate, the bulk of extension services had no discernible impact. Yet, when examining solely the impact on the subset of recipients who had deemed their

received advice "very useful," strong and significant effects were found on farm productivity and food security. This leads to a straightforward conclusion: services that are of low quality will be ineffective, regardless of whether they are delivered in person or via ICTs.

So far in this literature review, one study found that ICTs seem to have decreased the need for rural labour by speeding up the process of agricultural modernisation. This could be seen as a negative effect. But it is also a necessary component of improving agricultural productivity and of positive transformation of the economy's structure – leading workers out of less productive, into more productive sectors. All other studies reviewed here have found either distinctly positive impacts of ICTs on African jobs, or technical problems that temporarily hindered these results. None of the authors of the latter studies saw these problems as insurmountable, and none found *negative* results in the sense of Carmody and Murphy's "negative adoption." But such randomised trials, accompanying ICT-based intervention schemes, tend to take a narrow focus and may not be adequate for detecting larger structural constraints.

Problems with ICT-based services could be external, associated with the institutional environment and the limited power of smallholder farmers (or urban micro firms) vis-à-vis their intermediaries and larger trading partners.

An early study by Esselaar, Stork, Ndiwalana and Deen-Swarray (2007) had examined the impact of ICT-based market information services on 3,691 urban (that is, non-farm) SMEs from 13 African countries.[7] This study found that "ICTs are significant input factors for both formal and informal SMEs and contribute positively to revenue generation" and that "ICT use increases labor productivity" (p. 99). But commenting on drawbacks, Esselaar et al.'s recommendations to policymakers included that

> [w]ell-designed phone- or SMS-based business applications may have an impact on the profitability of SMEs. One of the key factors in providing the informal sector access to credit is the lack of co-operation between mobile operators and banks, often as a result of poor regulation. For example, in many countries, mobile operators are not allowed to be banks, but since mobile operators have access to the informal sector they could effectively service this sector. Encouraging innovation and cooperation between mobile phone operators and banks on the mobile platform could deliver SMS based business applications. (Esselaar et al., 2007, p. 99)

This, of course, is precisely what happened in the decade that followed, as the year of their study's publication (2007) was the birth year of mobile money.

7 Botswana, Cameroon, Ethiopia, Ghana, Kenya, Mozambique, Namibia, Nigeria, Rwanda, South Africa, Tanzania, Uganda, and Zimbabwe.

3 Jobs via mobile money?

For small African businesses, the mere access to information can be insufficient for making unconstrained investment decisions. Molony (2008) found that intermediaries in Tanzania had significant power over smallholder farmers: the farmers were forced to accept the prices they were offered, regardless of whether or not their mobile phones provided information on *actual* market prices. This lock-in, Molony found, was due to an asymmetric power relationship, where the intermediaries were also the smallholders' creditors, who could threaten to withhold much-needed financial services to farmers who chose to exit the relationship and sell their crops elsewhere.

For these and other restraints on economic flexibility, the innovation of mobile money is seen as a promising release valve. Mobile money is the most famous ICT-based innovation in Sub-Saharan Africa to date. A form of legal shadow banking, mobile money allows users to store money (usually up to around USD 1,000) on their SIM (subscriber identity module) cards, and send and receive money (usually up to around USD 700 per transaction) to and from other users, businesses, or government agencies. A physical infrastructure of geographically dispersed kiosks and agents also exists, where clients can deposit and receive cash. The most important advantages of mobile money have been found to be distance bridging, security, and shock absorption (Suri, 2017). Several methodologically sophisticated studies have been applied to measuring various impacts of mobile money on Africans. All came to positive results.

In Kenya, Jack and Suri (2011) found that average transaction fees were some 14 times lower than the equivalent bus fares needed to deliver cash in person. In Tanzania, Economides and Jeziorski (2015) found that, due to high crime rates, Tanzanians would rather pay 1 per cent of their money to keep the rest stored digitally than carry all of it in cash for one kilometre outdoors or keep the cash at home over night. Mobile money also seems to have helped low-income Kenyan households to better withstand financial shocks, such as medical emergencies (Suri, 2014), by receiving personal remittances from networks of friends and family (Jack & Suri, 2014; see also Riley (2016) for similar results in Tanzania; and see Suri (2017) for an overview of various findings).[8]

The most famous mobile money service is Kenya's M-Pesa (M stands for mobile, and *pesa* is "money" in Swahili). First tested as a simple microfinance tool, it took off rapidly after its introduction by Safaricom in 2007 (Mas & Radcliff, 2010; Vaughan, Fengler, & Joseph, 2013).

Various versions of the service have emerged in other developing countries, especially across Africa, and by 2015, 82 per cent of banked Sub-Saharan Africans were mobile banked only, making it the world's highest ratio of mobile-to-regular banking (GSMA [Groupe Speciale Mobile Association], 2017).[9] In absolute terms, Sub-Saharan Africa is

8 Such risk pooling has been a core feature of survival for low-income households long before the arrival of mobile money (see, for instance, Collins et al., 2009). But mobile money has significantly reduced the *transaction costs* for such pools (transfers are quicker and easier to perform over long distances and pools increase as more members can contribute smaller amounts).

9 Mobile money versions first existed in South Africa and the Philippines, but Kenya's success story made it known as the pioneer (Suri, 2017).

also the continent with the widest adoption of mobile money. According to Rouse and Verhoef (2017), ten African countries had a mobile-money penetration among survey respondents of above 10 per cent in 2013.

Differences in uptake are large among African countries. In 2014, the proportion of adults with mobile money accounts was 58 per cent in Kenya, 37 per cent in Somalia, and 35 per cent in Uganda (Beck et al., 2016, referencing FinDex data). Nigeria is perhaps the starkest counterexample. As Lepoutre and Oguntoye (2017) note,

> [w]hile Nigeria and Kenya share similar levels of economic development, mobile phone adoption, bank branch penetration and needs for financial inclusion, as of 2016 only 1 per cent of the Nigerian adult population was an active user of mobile money, and only 12 per cent was aware of its existence. (p. 1)

But the overall trend is toward ever-increased adoption across the continent (for causes of these differences, see subsection 6.2 below). Suri (2017, citing GSMA data) notes that by "the end of 2015, there were […] 411 million registered mobile money accounts across the world (all in developing economies, 222.8 million [that is, 52 per cent] in Sub-Saharan Africa)" (Suri, 2017, p. 498).

One year later, by the end of 2016, Sub-Saharan Africa had "nearly 280 million registered accounts and around 1.5 million registered agents. More than 40 per cent of the adult population in seven countries – Gabon, Ghana, Kenya, Namibia, Tanzania, Uganda and Zimbabwe – now use mobile money regularly" (GSMA, 2017, p. 34).[10]

Kenya, along with its pioneer status, also holds a distinct leadership role in the societal penetration of mobile money (continent-wide and worldwide). Usage is nearly twice as high as in Africa's other mobile money leaders – Somalia, Tanzania, Uganda (Rouse & Verhoef, 2017, p. 15). This entails that, thus far, the academic research on mobile money is predominantly concentrated on Kenya. The rest of this subsection summarises the findings of five widely cited studies on mobile money's impact on job creation in Kenya.

Plyler, Haas and Nagarajan (2010) had undertaken a series of inquiries in 2009 in two rural Kenyan settings in Murang'a and Kitui, and in one high-density urban setting, Kibera (in Nairobi). The study found that M-Pesa had primarily led to more money circulation, which in turn led to business expansion of existing SMEs. Some employment increases were also noted by respondents, but mostly only via M-Pesa shops that directly employ agents (Plyler et al., 2010). This form of kiosk employment via ICT may not be deemed as the technology *itself* having increased employment, but the number of direct jobs created by mobile money kiosks is nonetheless significant in Kenya: by late 2015, the

10 These data are somewhat conflicting due to measurement differences. Rouse and Verhoef's measure of "penetration rate" (for example, around 10 per cent for Namibia) is much lower than the GSMA's definition for "adult population … using mobile money regularly" (upward of 40 per cent in Namibia). This may in part be explained, as Rouse and Verhoef note, by the fact that "in Africa, it is common for mobile phones to be shared, and thus more people may be using mobile phones than indicated by these penetration rates" (Rouse & Verhoef, 2017, p. 6).

sector employed some 141,500 mobile money agents across the country (Communications Commission of Kenya (CCK) data, cited in Suri, 2017, p. 506).[11]

Mbiti and Weil (2016) examined FSD Kenya's (Financial Sector Deepening Kenya) FinAccess Survey data for 2006 (that is, before M-Pesa existed), and for 2009 (that is, by which point "over 8.5 million Kenyans had registered on M-Pesa" (p. 247)). They based their survey on a panel of 190 sublocations. Sublocations are the smallest administrative unit in Kenya and consist of 2 to 3 villages in rural areas or a large neighbourhood in a city. This study found (in line with the findings by Plyler et al., 2010) that one-third of respondents claimed to have engaged in increased transactions after the introduction of M-Pesa. More interestingly, regarding employment levels, Mbiti and Weil also found that M-Pesa has led to an increase in the employment rate by 12 percentage points, approximately a 15 percentage increase from the 2006 employment level. This increase was mainly driven by farm employment (their data showed no significant effects of M-Pesa on non-farm employment).[12] This directly contradicts Ogutu et al.'s (2014) finding (discussed above) for an ICT-based information service (DrumNet), having *reduced* farm labour. Mbiti and Weil suggested that M-Pesa's peculiarly positive effect on farm employment could be explained by easier urban-rural remittances. These could have driven the higher demand for labour on remote rural farms (Ogutu et al., 2014, p. 277).

However, Beck, Pamuk, Ramratta and Burak. (2016) examined FSD Kenya's FinAccess Survey data for 2014 of some 1,047 urban city firms (mostly SMEs) in Nairobi, and found that firms of various sizes that used mobile money had easier access to credit, which in turn led to higher levels of output and growth. Particularly, the study found that firms using mobile money had easier access to production inputs from suppliers on credit (Beck et al., 2016).

Gosavi (2017) used the World Bank's 2013 Enterprise Survey Programme data,[13] to examine the benefits of mobile money use by Sub-Saharan African firms. Studying private firms of all sizes in Kenya, Tanzania, Uganda, and Zambia (from all sectors other than agriculture and resource extraction), Gosavi applied various controls and found that firms using mobile money had easier access to credit and also seemed to outperform peers in levels of productivity. Accordingly, the study's conclusion was positive: "adoption of mobile-money services has not only an astounding potential to solve the vexing problem of access to finance, but also an amazing capacity to make firms productive" (p. 13).

Perhaps most impressively, using five rounds of panel data between 2008 and 2014, Suri and Jack (2016) found significant long-term impacts of mobile money on savings and

11 These figures are for both M-Pesa and other mobile money service agents. Safaricom's website reports that "[c]urrently there are over 40,000 [M-Pesa] agents countrywide" (https://www.safaricom.co.ke/personal/m-pesa/getting-started/experience-m-pesa (accessed 2 April 2018)).

12 The authors "use a measure of employment that incorporates farm labor (own-farm and on other's farm), non-farm labor (such as civil service employment), and self-employment (such as owning a shop). Individuals are considered employed if they are actively engaged in any of these activities" (Mbiti & Weil, 2016, p. 277).

13 For an overview of different measurements of financial inclusion, see also the contribution by Nielsen (2014) at https://www.cgap.org/blog/10-useful-data-sources-measuring-financial-inclusion (accessed 2 April 2018).

consumption. Measuring mobile money agent density, Suri and Jack discovered that better access to mobile money services had helped 196,000 households out of extreme poverty, leading to a two-percentage point decrease in poverty at the national level. The authors conclude that their "evidence, and earlier work, suggests that these impacts [of mobile money] derive from a more efficient allocation of labor, savings, and risk" (p. 1292).

These findings are mostly for Kenya, but they suggest that a positive impact in other African countries is likely as well. Thus, the findings that mobile money creates African jobs and alleviates poverty seem to directly refute Murphy and Carmody's notion of "negative adoption." But can this be extrapolated from the particular case of mobile money to the overarching rubric of all ICTs? And if so, do these effects apply equally to both genders?

4 Jobs via ICTs directly – for men and women equally?

Studies on mobile money are helpful for understanding if this particular innovation has had direct impacts on jobs in Africa. By contrast, much of the research cited in Section 2 above (on various ICT-based information services) primarily tested the merits of these services, that is, of the particular intervention strategies, not the direct impact of the interventions' underlying technologies as such. Such studies are important for improving ICT-based interventions, but their results cannot easily be extrapolated to broader conclusions about ICTs' usefulness. An education-sector example makes this point clear: different studies found that One-Laptop-Per-Child (OLPC) initiatives fell short of expectations.[14] But we cannot conclude from this that laptops *per se* are useless for education. It is likely that once the intervention strategy is improved, the same underlying technology will lead to better results. Thus, regarding the question of how the advent of ICTs has been *directly* associated with job creation in Sub-Saharan Africa, some interesting insights can be gained from various methodological angles.

Several studies exist for ICT effects on economic growth, a variable closely related to jobs (see subsection 4.1). Natural experiments can shed light on the direct impact of mobile phone introduction into certain African economic contexts (subsection 4.2). And the interplay between ICTs and various societal factors that influence jobs – health, education, institutions – can help complete the picture (subsection 4.3). Lastly, an extensive review – this subsection is larger than the rest of the section combined – looks at gender differences in access to ICTs, and at findings on African women's (dis)empowerment in the ICT era (subsection 4.4).

14 For a meta-analysis of 15 OLPC studies, see Arias-Ortiz & Cristia (2014). Marandino and Wunava (2014) found that, in Uruguay, the OLPC intervention had led to poor families' increased incomes (by one-third), but that it had not led to the expected uptick in work (see also World Bank, 2016, p. 261).

4.1 Large-number cross-country studies on ICT effects on economic growth

Large-number cross-country studies on ICT impacts on African jobs are rare,[15] but closely related is the impact of ICTs on developing country growth. Discussions around "jobless growth" (for instance, Caballero & Hammour, 1998) suggest that the two variables – "jobs" and "growth" – are not entirely interchangeable. But they seem close enough to warrant a discussion on ICT effects on growth in this subsection.

Lee, Gereffi, and Beauvais (2012) examined the influence of mobile phones on the rate of economic growth across 44 Sub-Saharan African countries. Different regressions of data between 1975 and 2006 showed that the introduction of mobile phones had significant positive effects on growth, especially in areas where landlines were unavailable (namely, in poorer areas). Their method allowed controlling for reverse causality (in other words, for higher growth rates leading to faster mobile phone penetration).[16] The authors note that "an increase in the spread of cellular phones yields a higher growth rate for countries where land-line phones are rare" (pp. 467-468).

Considering the low cost of mobile phones compared to other infrastructure projects, Lee et al. took these results to suggest that extending mobile coverage should be more of a priority for growth-enhancing intervention strategies.

Using 2000-2006 data, Yousefi (2011) compared 62 countries (28 high-income countries; 17 upper-middle-income countries; 15 lower-middle-income countries; and 2 low-income countries). His results confirmed significant positive influence on growth in high- and upper-middle-income countries. But he found no discernible impact on low- and lower-middle-income countries. It should be noted, however, that none of Yousefi's sample countries was in Africa.

Lio and Lui (2006) had also examined the effects of ICTs on agriculture in an early period (1995-2000). In a cross-country analysis of 81 countries from all income groups (of which 41 were low- or lower-middle income), Lio and Lui found that the introduction of ICTs did have positive effects across all income groups, but that the effects in richer countries were twice as large as the effects in poorer countries. The authors attributed this to the differences in pre-existing conditions, such as human capital.

The World Bank (2016) came to similar findings and adopted this line of argument, calling these pre-existing conditions the "analogue complements to digital dividends," a core theme throughout the 2016 World Development Report on Digital Dividends (World Bank, 2016, p. 29). While these large-number cross-country comparisons can point to broad trends, they cannot definitively point out cause-and-effect relationships. This is what we turn to next.

15 For Africa, I only found one such study, which I review in detail in subsection 5.3 below.

16 To control for reverse causality, Lee et al. (2012, p. 465) followed Roodman (2006) in building on the Arellano and Bover (1995) and Blundell and Bond (1998) two-step-difference general method of moments estimator.

4.2 Determining direct causality between ICTs and job-related development outcomes

For direct cause-and-effect, the most famous finding pertains to sardine fisheries in India: Robert Jensen's (2007) study found that Kerala fishermen used mobile phones from their boats to obtain information about which markets had the highest demand for their perishable cargo. This significantly increased the fishermen's incomes and lowered prices for buyers (as leftover sardines were no longer rotting in one town while would-be buyers went hungry in another). This finding is widely cited as proof of a direct and substantial impact of ICTs on poor fishermen's incomes.

But here too, methodological constraints may come into play. A follow-up study found that Jensen's findings were context specific and may not be replicable in regions with greater distances between markets, lower pre-existing credit relationships among traders, or when trading in crops that are more durable than sardines (Srinivasan & Burrell, 2015).

In a similar vein, when studying the spread of mobile phones in Uganda between 2005 and 2009, Muto and Yamano (2009) observed that phones did have positive effects on banana sales (perishable) but not on maize sales (more durable, and hence easier to store and transport). These findings imply that, for gaining market information, mobile phones can be more or less helpful, depending especially on how perishable one's goods are. More evidence could clarify the importance of crop perishability. This is likely to vary in different circumstances, as other factors, such as various societal differences, can change the relationship between ICTs and jobs in Africa.

Somewhat contradictory to this perishable/non-perishable distinction is that the use of mobile phones has also appeared to have a positive market-information-gathering effect in Nigeria's textile trade (that is, in an off-farm sector with non-perishable goods). Jagun, Heeks and Whalley (2008) examined the use of mobile phones by SMEs in Nigeria's cloth weaving sector and found that weavers with phones had a significant advantage over those without (providing a strong incentive for phone adoption by all). At first glance, this dynamic could be seen as supportive of Murphy and Carmody's notion of "negative adoption" – if the traders reluctantly invested in phones to merely keep up with the competition. But Jagun et al. found that the phones were appreciated as tools that helped traders with their logistical constraints. Phones significantly reduced the needs to travel for simple, straightforward communication.

4.3 Societal factors and the relationships between ICTs and jobs

Interestingly, Jagun et al. (2008) also found that even after the introduction of mobile phones, certain interactions between traders still needed to take place face-to-face, due to trust concerns, or for discussing more complex issues (Jagun et al., 2008). Molony (2008) found that such different incentives between the more complex vs. less complex interactions can be difficult to distinguish, especially if researchers are not fully aware of the intricacies of a particular business culture. He notes that "[t]rust and the need for direct, personal interaction through face-to-face contact [is] one of the most pervasive features of African MSE [micro and small enterprises] economies" (p. 639).

This suggests, in line with the World Bank's (2016) emphasis on "analogue complements," (p. 29) that various other variables – institutional, societal, cultural – exert influence on whether or not mobile phones create jobs in Africa.

The flipside of this coin, however, is that the impact of mobile phones is not merely dependent on the analogue compliments for digital-era job creation. Phones can also help *create* these complements. Mobile phones have indeed been found to improve African societies in ways seemingly unrelated to jobs – namely by boosting health, education, good governance, or women's empowerment (see below). This implies that, besides creating jobs directly, the phones seem to create income-generating opportunities indirectly, as healthy, better-educated, better-governed societies can generate more and better jobs.

The various literature strands on ICT-impact on other areas of human wellbeing are beyond the scope of this paper, but the following are recent examples that can be consulted for discussions of further literature in these respective fields.

Asongu and Le Roux (2017) found that, between 2000 and 2012, mobile phones and the internet had positive effects on inclusive development across 49 Sub-Saharan African countries. And Asongu and Nwachukwu (2016) examined the combination of good governance and mobile phone penetration, and found a variety of positive effects of mobile phones on human development in Sub-Saharan Africa.[17]

For Niger, Aker, Ksoll and Lybbert (2010) found in a randomised trial of adult learning programmes that, where mobile phone usage was included into the curriculum, students' basic literacy rates improved by 0.19-0.26 standard deviations vis-à-vis the control group.

For women's empowerment, the picture is more complicated, and the topic of gender equity is central to questions of jobs and income generation. Hence, the rest of this section is dedicated to unpacking these issues.

4.4 Income generator for women?

Target 5B of the Sustainable Development Goals is to "[e]nhance the use of enabling technology, in particular information and communications technology, to promote the empowerment of women" (IAEG-SGDI [Inter-agency and Expert Group on SDG Indicators], 2018, p. 7/21). In contrast to this target, strands of feminist perspectives have been sceptical as to whether ICTs can reduce gender discrimination. For Sub-Saharan Africa, Humer (2011) argues that ICTs may help women to become financially independent, but will not change the socio-cultural environment, or even the women's own attitudes toward their oppressive environment. In support for this claim, Humer refers to two qualitative studies: in Mozambique, rural women were found unable to use ICTs, due either to illiteracy or

17 On corruption, Kanyam, Kostanndini and Ferreira (2017) found that "cell phones are powerful tools for reducing corruption" and that "unidirectional causality [exists] from mobile phone penetration to corruption and from internet adoption to corruption." This study also examines and debunks an apparent form of broken windows theory (Wilson & Kelling, 1982). This notion held that, by increasing transparency and thus the overall visibility of pre-existing corruption, ICTs could further normalise corruption and induce more of it (Kanyam et al., 2017, p. 351, referencing Mishra, 2006).

inaccessible content (citing Macueve, Mandlate, Ginger, Gaster, & Macome 2009); and in Uganda, women were found to have become economically empowered and financially independent, but had not attempted to use this power to rectify the on-going disparities between men and women, or even to entertain the idea of female empowerment (citing Kyomuhendo 2009). Thus, Humer argues, technological gadgets cannot *initiate* a shortcut to women's empowerment. Women themselves will need to be the agents in this struggle.

This refers to the *relative* power distribution between men and women within a given society. As we will see below, there is indeed cause for concern, especially with regard to internet adoption, where Sub-Saharan Africa is currently the only world region in which the digital gap between men and women is not shrinking, but *widening* (ITU, 2017).

In rural and urban Ethiopia and in rural and urban Malawi, Geldof (2011) conducted an examination of gender disparity in ICT usage. Having employed a creative combination of interactive methods with some 550 low-literate Ethiopians and Malawians, Geldof found a vast gender divide in usage of, exposure to, and confidence in handling ICTs. Geldof refrained from investigating if the use of ICTs had actually increased or decreased this gender divide (e.g. in education), and took care not to leap to conclusions on causality. But she tentatively suggests that "the gendered domestic responsibilities and time constraints had a limiting effect not only on the use of ICTs, but also on female participation in education" (Geldof, 2011, p. 74).

This apparent correlation between women's use of ICTs and their access to education, relative to men's, seems significant (ITU, 2017).

Absolute women's empowerment via mobile phones?

Contrary to the above *relative* power struggle, however, when examining women's *absolute* empowerment – that is, when examining whether ICTs have helped women generate incomes irrespective of whether or not men have benefitted more – most empirical analyses point to distinctly positive results.

In the mobile money subsection above, I had introduced Suri and Jack's (2016) finding of a two-percentage-point contribution to Kenya's poverty reduction. But I had left out their study's most crucial finding, which is this: most of the 196,000 households that lifted themselves out of extreme poverty via mobile money were female-headed households. The transition took place largely because mobile money helped 184,000 Kenyan women move from less productive subsistence agriculture to more productive petty services, and thus not merely helped the women pull themselves and their children out of poverty, but also helped the country move toward positive structural transformation.

Such promising results are not limited to mobile money. In South Africa, Klonner and Nolen (2010) compared annual household surveys with the specially coded data from the country's leading network provider. The study focuses on rural areas and found significant positive results: the employment rate increased by 15 percentage points when a locality received network coverage, mostly due to greater wage employment of women (the exception were women with small children). They also found that the arrival of the mobile phone network did result in a substantial sectoral shift among the rural employed from agriculture to other sectors, especially among men. This latter finding contradicts Mbiti and

Weil's (2016) finding of mobile money having *increased* agricultural labour, but is in line with Ogutu et al.'s (2014) findings of an ICT-based information service having *decreased* the need for farm labour. With regard to women, however, these positive quantitative findings are in line with the findings of several qualitative studies discussed below.

In Nigeria, Boateng, Hinson, Galadima and Olumide (2013) undertook a qualitative pilot study of 15 small traders and then narrowed their focus to closely observe two female micro-traders (a potato trader and a tomato trader). The researchers found that the more extensive use of mobile phones (that is, not merely for calling and texting, but also for mobile money and other platforms) made the women more effective micro-traders and economically more empowered. The study concluded that "enhancing communication and trading processes through mobile phones directly or indirectly improves revenue and enhances decision making and control, and thereby economically empowers traders" (Boateng et al., p. 44).

For South Africa's urban informal sector, Chair (2014) surveyed five self-employed women on their use of mobile phones for their businesses (two hairdressers, two meat sellers, and one informal pub proprietor). She found that "[a]ll of the respondents valued their phones and were of the opinion that phones really helped … in their business" (p. 13).

At a much larger scale, Bailur and Masiero (2017) – conducting 30 focus group interviews with nearly 200 participants in Kenya, Ghana, and Uganda – studied how poor women (who lived on less than USD 2 per day) used the mobile internet on their phones, and if they were (thinking about) generating an income in this way. The study pointed to a few behavioural patterns that were distinctly different between women and men. Men tended to be more explorative with phones, women more passive; men more possessive of their devices, women more open to sharing with one another. The study's main finding was that earning money via phones was generally something the women had *heard of* but not experienced directly, and that they had few concrete ideas as to how this could be done.[18] Some women reported having heard of general ideas for informal social media advertisements, but "male respondents had more direct experience of income generation" (Bailur & Masiero, 2017, p. 88), and the more particular quotes, for instance for road-side sales, were attributed to men:

> If you want to sell mineral water, you just take a snap and send or share, you can even have groups that you administer yourself, you know, you just send to your group members and say, guys am here selling mineral water. (23-year-old Ugandan man, cited in Bailur & Masiero, 2017, p. 88)

The study found that women saw an overlap between recreational uses of social media and using their mobile internet connections to access information and connections to income generating opportunities:

> I take very long to load airtime to make a call. It is very rare. You are going to find that in most cases, I just load MBs [megabites] and I am going to go to Facebook, I am

18 No timeframe is given for when fieldwork was conducted (as ICT adoption is changing rapidly, this would have been helpful). The article's first date of submission, mid-2016, suggests that the interviews may have been conducted around 2015.

> going to be on WhatsApp and all over. [participants laugh] You are going to be on Facebook as you go to Internet and you are going to find that there are people advertising jobs, you are going to see those groups and may be you like them and may be they help you get the job. Even our own friends, yah. You can chat through WhatsApp like; 'What are you doing? What?' and then they can help you. (19-year-old Ugandan woman, cited in Bailur & Masiero, 2017, p. 89)

This, the authors note, shows the difficulty in separating whether ICTs are used for work or leisure (see also Donner, 2015).

In previous work on India and Uganda, Masika and Bailur (2015) had found that some of the differences between men and women's use of ICTs were due to structural constraints in the family, that is, due to husbands reacting jealously if wives used their phones to communicate with strangers (Masika & Bailur, 2015, cited in Bailur & Masiero, 2017). But in their present study, several female respondents were critical of the patriarchal situation and aware of their own timidity. Some women reportedly noticed a shift in (self-) perception: "the whole society is so much male dominated. Everything is about men. … Women are now coming up gradually. For instance me, I'm now trying to break out of that shell" (Ghanaian woman, no age given, cited on p. 92).

Relative women's empowerment via the internet?

This implies that what may at first glance seem as a banal distinction – being able to communicate more privately, such as not having to take phone calls immediately, but enjoying the freedom to communicate subtly, when time permits, via social media – may be a crucial benefit for many African women. With myriad other responsibilities and operating in patriarchal surroundings (that is, multitasking with children and mollifying spouses), internet access may be a vital tool for empowerment.

This is in line with large cross-country findings by Efobi, Tanankem and Asongu (2018), who examined how ICTs influenced women's economic participation across 48 African countries between 1990 and 2014. Controlling for several other variables,[19] the study apparently found positive impacts across the board: some positive change for women associated with mobile phone penetration, higher positive changes associated with higher regular and mobile internet penetration, and the greatest positive changes associated with fixed broadband subscriptions.[20] The authors tentatively suggest that this could be due to ICTs having led to the substantial growth of the services sectors across Sub-Saharan Africa since 2000 (Efobi et al., 2018, p. 19).

The suggestion that, particularly for African women empowerment, internet access may hold greater potential than basic mobile phones did, is at odds with currently increasing gender disparities among internet users in Africa. According to the latest data available from the International Telecommunications Union (ITU, 2017), in the years 2013 to 2017 the

19 Using ordinary least squares, fixed effects, and generalised method of moments regressions.

20 This study notes that "fixed broadband subscription still maintained a higher effect on female economic participation compared to internet usage and mobile cellular connections. These findings are consistent with a World Bank report that broadband subscription has a higher economic development externality when compared to other ICT indicators like mobile phones" (World Bank, 2016, p. 12).

gender gap in internet usage *decreased in all other world regions*, but *increased in Sub-Saharan Africa:* from 20.7 per cent in 2013 to 25.3 per cent in 2017 (Efobi et al., 2018).[21]

This lack of women's uptake of the internet correlates significantly, according to the ITU, with gender disparities for tertiary education (2017, p. 20). The only world region where women have on average slightly more access to the internet than men, is the Americas, where women also have ample access to tertiary education.[22] This tandem of discrepancies points to an opportunity for priority interventions in both expanding tertiary education for African women and providing greater internet access for African women, especially in view of the coming knowledge economy (see subsection 6.3). For now, the focus on the internet leads over to examining Africa's hitherto miniscule access to broadband internet (see Section 5), and Africa's opportunities for future job creation for all once this access expands.

5 Jobs via broadband internet?

Broadband internet access across Africa varies widely, and data sources and measurement methods differ somewhat. In 2017, some 77.8 mobile phone subscriptions existed for every 100 inhabitants across Sub-Saharan Africa (ITU, 2017 estimates), but hardly anyone had broadband internet via landline. GSMA (2017) estimates the active mobile broadband subscriptions in Sub-Saharan Africa at 26 for every 100. According to ITU (2017), it is 22 per cent of the region's inhabitants who use the internet.[23] Yet, even these figures, if taken at face value (to mean that around a quarter of Africans have unlimited access to broadband internet), are too high, because the way the terms "broadband" and "subscriptions" are used in these statistics can be deceiving. When examining Kenya, one of the continent's best-connected countries, the actual numbers of broadband internet users turn out to be much lower. A leading industry insider in Kenya noted to this author:

> We have 45 million people in Kenya, 39 per cent have smartphones, 18 per cent of those smartphone owners can connect to the internet on a regular basis. Either they have it at home or work or they can pay for a data bundle. And the other 80 per cent [*sic*] who already own the device can't afford it regularly, they may buy a data bundle once this week that is maybe 20MB so they get their sports scores or they send out some Whatsapp messages. (Personal interview, Nairobi, June 2017).

21 However, Asongu & Nwachukwu (2016) cite their earlier work as "recent evidence on the reduction of the gender-divide." And refer to "growing evidence that mobile phones empower women via enhanced channels of financial inclusion. These mechanisms entail improved coordination of female-managed small and medium size enterprises as well as household activities" (p. 3).

22 To my knowledge, a possible causal link between these two factors has not been proven to date.

23 According to Internet World Stats (2018), internet penetration in Africa was 28.7 per cent in June 2016 and 35 per cent in December 2017 (but this includes the North African countries; with higher average incomes, their higher internet usage also drives the overall average usage up).

This leaves some 7 per cent of Kenyans with regular access to broadband internet, but even this access is not unlimited or always fast.[24] Hence, compared with the numerous findings that provided evidence of mobile phones' benefits, (see the sections above), much less rigorous evidence exists for broadband internet's impact on overall job creation in Sub-Saharan Africa.

5.1 Large-number cross country studies on the internet's economic impact

For developing countries, internet adoption has been found to be associated with significant increases in exports (Clarke & Wallsten, 2006); higher GDP per capita growth rates (Qiang & Rossotto, 2009); higher firm productivity (Paunov & Rollo, 2015) and higher labour productivity (World Bank, 2016).

In a sample of 98 countries (22 from Sub-Saharan Africa), Clarke and Wallsten (2006) found that developing countries with more internet[25] access export more to developed countries. The study used data service regulation as one of the controls for reverse causality (that is, for greater exports to rich countries leading to higher internet penetration), and found that

> […] point estimates suggest that a 1 per cent increase in the number of Internet hosts per 100 people would increase total exports as [a percentage] of GDP by 0.05 per cent and exports to high-income countries by 0.08 per cent. (Clarke & Wallsten, 2006, p. 475)[26]

This study does not distinguish what *types* of exports increase with internet connectivity (that is, whether these are productive exports or commodity exports), and does not distinguish whether internet connectivity increases the overall size of trade, or whether more connected developing countries merely gain increased developed-country market share for their exports at the expense of other developing countries (which could end up exporting less).

Qiang and Rossotto (2009) used 1980-2006 data from 120 countries of all income groups to examine the relationship between broadband internet and economic growth.[27] They found that, "*all else being equal* … [t]he growth benefit that broadband provides for developing countries was of similar magnitude as that for developed economies – about a 1.38 percentage point increase for each 10 per cent increase in penetration" (pp. 43-45, emphasis added).

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24 My own research on African online workers involved communicating via Skype with upper-middle class Kenyans who work on online labour platforms or for overseas clients directly. The quality of the internet connection during our interviews was often poor, and interviewees often told me that among their greatest work impediments was unreliable internet (various interviews, 2017 and 2018: see also Melia, Forthcoming).

25 This study does not distinguish between narrowband and broadband internet.

26 Variations of their models with different controls came to slightly different results but all were positive and most were statistically significant.

27 This study was not published as an academic journal article, but as a chapter in a World Bank report. It is not particularly transparent about its methods, and does not disclose which countries made up its sample.

Examining data from 117 developing and emerging countries (39 from Africa) and nearly 50,000 firms (some 13,500 from Africa), Paunov and Rollo (2015) noticed that, between 2006 and 2011, the uptake and use of broadband internet had positive effects on productivity across all productivity levels of firms in Sub-Saharan Africa, and that the effects were highest for firms that were already more productive, and lowest for firms that had been less productive beforehand. This supports the hypothesis that, in spite of the positive overall effects, ICTs contribute to widening the gap between stronger and weaker firms.[28]

In its World Development Report 2016, the World Bank noted that "African firms using the internet[[29]] have on average 3.7 times higher labor productivity than nonusers and 35 percent higher total factor productivity" (World Bank, 2016, p. 52).

The Report refers to an unpublished background paper (Cirera et al., 2015), and does not explain which other variables were controlled for.[30] This leads to a more general problem with these studies: I had emphasised "all else being equal," in Qiang and Rossotto's quote above, because it has been difficult to determine direct *causality* from broadband internet to African jobs. Hence, the next subsection introduces three critiques of the widely held causality assumption, before the subsection after that introduces an extensive 2018 study that seems to have cracked this problem and can actually prove causality.

5.2 Questioning assumed causality between broadband internet and African jobs

In a series of recent studies, scholars associated with the Oxford Internet Institute (OII) have called into question the widely held assumptions on positive causal effects of internet connectivity on African economies, concluding that the internet may not always help African SME's positions in value chains (Foster, Graham, Mann, Waema, & Friederici, 2018); may not cause as much knowledge generation in Africa as is often assumed (Ojanperä, Graham, Straumann, De Sabbata, & Zook, 2017); and may not warrant the general enthusiasm for greater internet connectivity that is often encountered in African policy documents (Friederici et al., 2017). This sub-section summarises these studies and offers short comments thereof in footnotes.

Foster et al. (2018) undertook a qualitative study, examining Kenyan and Rwandan firms in the tea, tourism, and business process outsourcing sectors from a global-value-chains perspective. The study concludes that increased connectivity (that is, internet connection),

28 See Autor, Dorn, Katz, Patterson and Van Reenen (2017), on the growing chasm in firm productivity levels. This is part of the literature on technology's impact on labour's share of GDP. This literature is predominantly focused on high-income countries, and within this, a disproportionately large number of studies is focused on the USA or UK labour markets.

29 Here the World Development Report is vague about whether it is referring to narrowband or broadband internet. The Report's cited background paper, Cirera, Lage and de Oliveria (2015), is not available to the public.

30 A mere correlation is not helpful because similar correlations could be found between productivity levels and any number of infrastructural amenities, such as electricity, indoor plumbing, or air-conditioning. Any indicator of a more established and more productive firm also implies that it is more likely to use the internet.

while leading to increased information availability, can also lead to increased domination, and hence to exploitation by lead firms in a given value chain. Smaller African firms involved in global value chains can lose power to lead players, be they overseas or domestic. The study found, for example, that smaller tea producers could not access the information they needed from bigger players (or did not find it online due to language deficiencies). Foster et al. (2018, p. 80) note that "all firms felt that Internet connectivity had provided efficiency gains and access to more information".

For smaller tourism firms, however, greater connectivity could entail being pushed out of the global value chain, as their intermediary roles became redundant:

> For domestic firms previously heavily involved in local tourism logistics, the presence of online integration was pushing them out of GVCs [global value chains] rather than integrating them. With digitization, international firms can now organize, schedule, or book online from afar […]. (Foster et al., 2018, p. 79)

This finding is in line with Murphy and Carmody's (2015) warnings of forced mobile phone adoption, and with more general warnings of increased openness to globalisation and unfettered markets (Adelman, 1984). While this argument runs counter to most of the advice in the literature reviewed here, it may be a point to bear in mind when pushing for greater market integration of small-scale African SMEs or farmers into (local or global) value chains.[31]

Ojanperä et al. (2017) examined the relationship between broadband internet connectivity and the African knowledge economy, namely how increased access to the internet is associated with i) the region's number of academic journal publications; ii) the region's collaborative coding activity on GitHub[32]; and iii) the number of domain names registered in a given African country. The study controlled for three other influential variables: wealth (measured in GDP); educational attainment (measured in tertiary enrolment and education spending); and innovation capacity (measured via World Economic Forum questionnaire assessments on whether or not respondents thought companies in their respective countries were able to innovate). Their results suggest positive associations across the board: 1 per cent increase in internet connectivity is associated with an increase of 0.11 per cent or 0.28 per cent (depending on the model used) in academic articles published; an increase of 0.51 per cent or 0.75 per cent in collaborative coding; and

31 A Schumpeterian perspective would challenge Foster et al.'s (2018) premise. Notably, the finding that internet connectivity forced individual African SMEs to exit need not be negative for *overall* job creation. It could even generate positive net entry of African SMEs. A Schumpeterian interpretation holds that growth entails initial inequality. If productivity in a sector increases, the destruction of some firms can create opportunities for others. If we assume, however, that the dynamic that Foster et al. point to is solely negative for African SMEs, it remains unclear how large the subset of interviewees was who declared these setbacks in their value chain positions. The number seems small and limited to the tourism sector. Hence, these *negative* findings would need to be weighed against the various *positive* anecdotes for African SMEs who use the internet for *better* value chain integration. Here are two examples of the latter: Oestermann et al. (2013) found that a digital African Cashew Initiative had helped farmers within their value chains in Ghana, Côte d'Ivoire, Burkina Faso, Benin, and Mozambique (p. 52). And MGI (2013) note that a Mozambican firm uses "a smartphone app to connect informal traders with available taxi drivers who can deliver parcels from wholesalers, creating a faster, mobile-based supply chain" (p. 46).

32 GitHub is an online platform, hosting code that can be developed and shared by anyone.

increases of 0.46 per cent or 0.84 per cent in domain registration. This led the authors to note that: "[…] connectivity is clearly an important enabler of digitally mediated content creation […] (Ojanperä et al., 2017, p. 48).

But the study also finds significant increases associated with the control variables: 1 per cent increase in GDP is related to about 0.6 per cent in each of the dependent variables, and, particularly, 1 per cent increase in innovation capacity is associated with much larger increases in the knowledge-economy variables – between 2.3 per cent and 3 per cent.[33] This led the authors to emphasise caution with regard to unbridled optimism about internet connectivity: "In this vein, merely increasing connectivity without supporting GDP growth or increasing innovation capacity might not allow countries to leapfrog to higher levels of digital content creation and has an even smaller effect on production of academic articles" (Ojanperä et al., 2017, p. 46).

Interesting to note, here, is that Ojanperä et al. (2017) *do* find positive relationships between broadband internet and the outcome variables, but frame their conclusion in cautionary terms, since other variables also showed positive relationships with the outcome variables. It is this cautionary framing that is at odds with other studies, more so than the study's statistical findings. For example, Asongu and colleagues (see Asongu & Nwachuku, 2016, or Asongu & Le Roux, 2017) also found positive effects for various other variables, but tend to frame their articles (in headlines, and conclusions) in distinctly positive terms, noting synergy effects between ICTs and other improvements, and suggesting increased investments in ICTs as comparatively cost efficient ways of achieving desirable outcomes.[34]

Friederici et al. (2017) conducted a discourse analysis of seven African ICT policies and 13 reports by international organisations. Investigating these documents' claims about the impact of internet connectivity on economic growth and inequality in Africa, the study found these policy documents and reports to have been: i) overly optimistic; and ii) not based on the findings of rigorous research. Friederici et al. (2017) compare these bullish policy statements with an overview of academic literature, and conclude that

33 Investment in tertiary education and population sizes were also positively associated.

34 This opens questions for Ojanperä et al. (2017): Other studies have found positive relationships between increased broadband internet and variables that bare close resemblance to several of Ojanperä et al.'s control variables. Taking the studies mentioned immediately above: Quian and Rossotto's (2009) dependent variable of "higher GDP per capita growth rates" may or may not be related to Ojanperä et al.'s control variable of "wealth/GDP." But Paunov and Rollo's (2015) outcome variables of "higher firm productivity;" the World Bank's (2016) "higher labour productivity;" and Clarke and Wallsten's (2006) "significant increases in exports" all seem closely related to Ojanperä et al.'s "firm capacity for innovation." This suggests that, if causal relationships exist between broadband internet and any of these related variables, broadband internet may also have an impact on Ojanperä et al.'s control variables. This implies that the internet also has an indirect impact (that is, by influencing these control variables) on Africa's knowledge economy. If, solely relying on Ojanperä et al.'s own statistical results, we assume however that one can adequately control for the internet's impact on any of the other variables, a more straightforward problem emerges with their cautionary conclusion. From a return-on-investment perspective, it could still be more feasible for African governments to invest in broadband internet expansion than to invest in increasing any of the control variables (that is, "higher GDP" is a meta-variable which is difficult to bring about directly, and 1 per cent increase in "tertiary education enrolment rates" could turn out to be more expensive to bring about than a 1 per cent increase in "broadband internet").

> the evidence on growth-enhancing and inequality-reducing impacts of connectivity is inconclusive, especially for low-income contexts. Most evidently, the academic literature has little to offer in support of claims that the Internet causes widespread and inclusive economic impact, thereby tackling inequality. (Friederici et al., p. 6)

Thus, Friederici et al. (2017) rebut these policy documents' claims that expanding broadband internet connectivity is of great importance for African firms and citizens. The study concludes:

> we have shown that the evidence base to support such claims is thin. More worryingly, once we see the techno-determinist and modernist assumptions at the core of many visions, visions of rapid development precipitated through ICTs might not just fail to achieve their goals (even on their own terms), they could actively undermine those very efforts in a world of scarce resources. (p. 19)

But the "evidence base" presented in Friederici et al. (2017) comes in the form of a brief and somewhat problematic overview of the academic literature.[35] This is at odds with the present review of the literature, which, overall, comes to distinctly positive conclusions (and would thus back several of the bullish claims made in the African vision documents). In fairness to Friederici et al. (2017), this positive assessment is in part based on one landmark study that appeared in the interim period between our reviews (namely, Hjort & Poulsen, 2018, see below).

35 Here is why this present literature review diverges from Friederici et al.'s (2017) conclusions: The bulk of Friederici et al.'s (2017) contribution is its thorough review of the policy reports pertaining to Africa. But its critical conclusions are based on findings of their academic literature review, which are at odds with the findings of my literature review here. Of the 27 studies referred to in Friederici et al.'s review of the academic literature, they list more than half (15) as having come to various positive results. Of the remaining 12, one is a short commentary with no original empirical findings (namely, Humer, 2011; see also my review above); four are comparatively old (Dewan & Kraemer, 2000 [using data for 1985-1993]; Pohjola, 2002 [using data for 1985-1999]; Duncombe & Heeks, 2002 [a case study for Botswana; see my review above]; and Lee et al., 2005 [using data for 1980-2000]); four are case studies from other world regions – two of which came to mixed results for South Korea and Iran, respectively (Ju 2014; Rasoulinezhad & Nouri, 2010); one came to no significant result for Ireland (Haller & Lyons, 2015); and one came to tentatively negative results for India (Martinez et al., 2011). This leaves two relevant studies: Skuse and Cousins (2007) which came to mixed results for South Africa; and Yousefi (2011), which came to no positive results for ICT impact in 17 lower-middle-income countries/low-income countries among its sample (there were no African countries in the sample; see also my summary of this study's findings above). Yousefi's non-results for poorer countries could be extrapolated to Africa, but the findings are based on data leading up to 2006, when internet bandwidth was narrow and access much more limited than it is today. There could well have been a tipping point in the meantime (one that had not been reached by Yousefi's sample countries in the early-2000s, but is now being reached in African countries). Most of the recent studies from Africa, reviewed in this present paper, point in that positive direction (see Section 2 and subsection 5.1 above, and especially subsection 5.3 below). Considering that Friederici et al. (2017) focused on Africa, referring to these more recent and Africa-specific studies as their evidence base could have led to a less critical stance toward the various African vision documents.

5.3 First real evidence of causality between broadband internet and African jobs

This recent study has set a new milestone for research on broadband internet impact on African jobs. Hjort and Poulsen (2018) conducted an extensive quasi-natural experiment in tracing the landings of ten submarine fibre optic cables in 12 African countries between 2006 and 2014. These landings marked the arrivals of broadband internet that significantly increased the quality and quantity of bandwidth available in the connected locations. Hjort and Poulsen compared these broadband arrivals with various before-and-after measurements, using the location-specific panel data of six large surveys, as well as time series of night light satellite analyses. The panel data of two household surveys used (Afrobarometer and DHS), covered 9 and 8 countries respectively of their 12-country sample. Location specific firm-level panel data of 7 countries (via World Bank Enterprise Surveys), and a detailed labour force survey from South Africa, as well as before-and-after arrival panel rounds of an extensive manufacturing firm survey for Ethiopia were used to cross-check and build in several robustness checks.

These different outcome measurements unveiled a host of positive results. Wherever the data allowed for measuring an impact, Hjort and Poulsen found substantial positive results. The DHS and Afrobarometer household surveys revealed that

> the probability that an individual is employed increases by 6.9 and 13.2 per cent in the two groups of countries covered […] when fast Internet becomes available [and increases by 3.1 per cent in South Africa]; [that these increases are] not due to displacement of jobs in unconnected areas; [… and that] fast Internet […] appears to shift employment shares towards higher-productivity occupations, [… meaning that] employment inequality if anything falls when fast Internet arrives in Africa. (Hjort & Poulsen, 2018, p. 3)

Specifically, broadband internet arrival led to 23 per cent more firms (that is, net firm entry) in South Africa, particularly in higher value-adding sectors, and to significant increases in productivity levels among Ethiopian manufacturing firms. Their World Bank Enterprise Survey results showed that firms now accessing broadband internet increased their overseas communications by 13 per cent, and had "a decrease in in-country sales, and large increases in both indirect and direct exports" (Hjort & Poulsen, 2018, p. 22); employed some 17 per cent more workers and were *twice* as likely to offer in-house training to staff. Hjort and Poulsen note that these various increases – more firms, more productivity within existing firms, more exports, and more on-the-job training – may explain the mechanism behind their most astonishing finding. Examining which workers, across the education spectrum benefit most from the arrival of fast internet, they found that nearly everyone benefitted (as the following quotations from Hjort & Poulsen, 2018 show):

> In both the DHS countries and South Africa, a relatively large increase in the probability of 'moderately' skilled (ISOC [International Standard Classification of Occupations] level 2) employment appears to contribute most to the overall increase in skilled employment. The point estimates also point towards a sizable increase in 'highly' skilled (ISCO level 4) employment in the DHS countries, when fast Internet becomes available (p. 17).
>
> Remarkably, the estimated increase in the employment rate is of comparable magnitude for those with primary school, those with secondary school, and those with tertiary education in all three samples. Those with primary school in fact see a moderately bigger estimated employment gain than those with secondary school in all three samples,

> though not statistically significantly differentially so. In the Afrobarometer countries – but not in the DHS countries and South Africa – fast Internet also increases the employment rate for those who did not complete primary school significantly (p. 14).
>
> In the DHS countries, those with tertiary education see by far the biggest increase in *skilled* employment. The smaller, but nevertheless noteworthy, estimated increase in skilled employment is of identical magnitude for those with primary and those with secondary education, but more precisely estimated for the latter group. Employment in unskilled occupations increases significantly for those with primary school in both the DHS countries and South Africa (p. 18).

This increased employment for workers across the skills spectrum is taking place in higher value adding firms. Hjort and Poulsen suggest that the arrival of fast internet may thus explain some of the positive structural transformation (from less productive sectors to more productive sectors) found across Africa (see McMillan & Rodrik, 2014).

Lastly, night light density can be used as a proxy for average incomes in a given location. Hjort and Poulsen found a 2.4 per cent or 3.3 per cent (depending on the model used) increase in night light density when fast internet arrives in a given African location.

This was a quasi-natural experiment (that is, the many different arrival times of cables depended on geographic accessibility, not on one of the other variables that tend to interfere with the results of other studies, such as economic trajectory of a given country or city. Various robustness checks (for example, for other infrastructure, and for labour displacement effects via commuting) showed no discernible changes on the positive outcomes. Hence, the arrivals were next to random, and this study comes close to proving that the positive employment effects were actually *caused* by broadband internet connectivity.[36]

6 Discussion and policy options

As in any body of literature, the research reviewed here has shown some inconclusive and partially contradictory results, particularly with regard to ICT-based market information services for smallholder farmers (subsection 2.2). But of the studies reviewed, none provides evidence for "negative adoption" as per Murphy and Carmody's (2015) interpretation,[37] and the overall direction in the evidence reviewed here points to distinctly positive economic effects of mobile phones, mobile money, ICTs more generally, and the internet.

36 This is a review of the January 2018 NBER working paper version. The forthcoming journal article may yet come to revised results. (According to one of the authors, the paper is set to appear in the *American Economic Review*).

37 The exception may be Foster et al.'s (2018) finding that global hotel booking platforms may be pushing some African SMEs out of value chains. This claim should be taken serious, and my own ongoing research into ride-hailing apps (that is, Uber, Taxify, and LittleCab) in Kenya also points to similarly disadvantageous trajectories for Kenyan drivers in the years 2015 to 2018. But these concerns pertain to the newly evolving 4IR technologies (Melia, Forthcoming), on which little rigorous empirical evidence exists to date.

A few policy options can be discussed on the basis of these findings. The following subsections each build on a corresponding section above and flesh out policy ideas for utilising these findings going forward. I also introduce some new empirical evidence, not on whether these technologies are helpful for African jobs (that has been established above), but on how one could best go about spreading them. Spreading, promoting, and utilising ICTs, in the present era, also entails thinking about the changes that these technologies are currently undergoing, and how they interact with newer phenomena, such as the blockchain or platform economies.

6.1 ICT-based information services

For farmers, both advice on farm productivity and market information services for crops can be greatly amplified via ICTs and can thus have significant positive outcomes.[38] But this success of ICT-based services is not automatic. Poorly designed or poorly implemented services fail, regardless of their level of ICT-based amplification.[39]

Feedback mechanisms

Policy recommendations for those interested in improving ICT-based support schemes highlight the importance of feedback mechanisms. The popularity and applicability of support interventions need to be tested regularly by asking recipients what works. If services are inadequate or unreliable, the service provider needs to establish whether the quality of its core service is to be blamed, which could be fixed via generic technical tweaks, or whether the provider is suffering from other institutional, business environmental, or capacity problems, which would demand very different, context-specific remedies. If some recipients find the services useful but others have difficulties deciphering them – for instance, if text-based services prove difficult – the service provider needs to establish whether this is mainly due to poor eyesight, inadequate devices, lack of electricity to receive messages, lack of credit (that is, funds) to send queries, language deficiencies, or a general unfamiliarity with the technology. Each of these problems has been identified in the literature and each demands a different policy solution or service innovation. It can be a mixture of these and other obstacles, and establishing which is most important in a given location and how it is best addressed is an on-going process of trial and error improvement. For finding this right solution, some form of market-based approach (that is, a for-profit, or self-sustaining social business model) may be more suitable than a state-led or donor-driven initiative, as some of these obstacles can be overcome by entrepreneurial providers (that is, voice services can circumvent poor eyesight, illiteracy, or phones with broken backlighting, while solar panels can circumvent being off the electricity grid). But some of the underlying obstacles (such as infrastructure, education, health) can only be fixed by more coordinated efforts that go beyond one single intervention strategy. Such wider initiatives cannot be provided by individual companies, and need to be led by state coordinators or larger partner programmes.

38 See the reviews of Aker (2008); Casaburi et al. (2013); Cole & Fernando (2016); Ogutu et al. (2014); Svensson & Yanagizawa (2009); Kzii et al. (2011); Al-Hassan et al. (2013); and Hildebrand et al. (2015).

39 See the reviews of Ragasa & Mazunda (2018); Wyche & Steinfield (2015); Tadesse & Bahiigwa (2015); and Aker & Fafchamps (2014).

Development partners interested in improving ICT-enabled intervention schemes in Sub-Saharan Africa should consult the results of randomised controlled trials that are most closely related to the anticipated project. Nowadays such trials accompany many of the larger interventions. The results of meta-studies and broad literature reviews of the kind undertaken in Section 2 can only indicate a vague direction; the nuances in the individual cases are significant: interventions fail or succeed depending on unique contextual circumstances, or for reasons that are easily corrected in some fields but not in others. Deciphering such nuances is difficult, even for long-time experts. Development partners who seek to create a successful ICT-based intervention should attempt to do so in partnership with experienced researchers in the field. Before the project begins, guidance should be sought from experienced observers.[40] If possible, a professionally implemented randomised controlled trial should accompany the project for future knowledge generation (see, for instance, Banerjee & Duflo, 2011).

Targeting young farmers

Successful ICT-based interventions can decrease the need for farm labour (Ogutu et al., 2014). This seems to be a conundrum for support measures aimed at rural employment: while technology *increases* farm productivity and output, it *decreases* the need for farm labour, thus decreasing the number of rural jobs. But zooming out to the economy-wide angle may solve this puzzle. The jobs lost on farms are the ones least desirable and least value-adding. If technological upgrading makes agriculture more profitable *and* less labour intensive, good things happen. A green revolution leads to positive structural change of the economy. Farm workers are freed up to pursue education or more desirable work, rural-urban migration ensues, more productive sectors emerge in cities and begin to compete globally. The mechanism is twofold: as agriculture becomes more productive, produce becomes more affordable domestically (allowing urban workers to be more price competitive vis-à-vis overseas workers); alternatively, more produce can be exported (earning the country foreign exchange reserves, which can be invested in production inputs or the needed infrastructure – which makes local companies competitive vis-à-vis overseas firms). The effect is the same: more jobs ensue in more productive sectors.

But options exist for development partners who are interested in using ICTs directly to provide rural employment and slow down the urbanisation process. One suggestion on ICT-based interventions is to specifically target *younger* farmers, as this would lead to higher adoption (Al-Hassan et al., 2013). Younger farmers are more likely to leave the farm to head to a city but they are also more likely to use ICTs. Hence, they could become the most productive farmers. In Kenya, for example, one such approach is that of GreenDreams, using the technology specifically for attracting young Africans to farming (Kahumbu Stephanou, 2017).

40 For selecting such experts, a citation count in the relevant field can serve as a starting point. Among others, this would point to Jenny C. Aker of Tufts University and the Center for Global Development.

6.2 Mobile money

The impressive results for mobile money's impact[41] suggest that it should be a crucial policy objective to help increase the continent-wide spread of this technology, particularly in countries with low adoption rates. Essential to such support would be to know why mobile money spread so fast in some countries (such as in Kenya) and much slower in others (for instance, in Nigeria). Lepoutre and Oguntoye (2017) found that in Kenya, Safaricom's ability to quickly reach a critical mass (as quasi-monopolist), allowed it to reinvest in fortifying its dominant position and extending its ever-growing network of agents around the country. In Nigeria, by contrast, anti-monopoly policies induced negative incentives for potential first movers. The slower uptake problem in Nigeria (and by extension in other "slower" countries) could disappear, they note, once the market-leader reaches a critical mass of users.[42] If such network externalities are the main factor at play, mobile money can be profitable for providers once the business environment is right. This suggests that support could come in the form of macro-level advice to regulators, as well as in the form of specific support for overcoming particular market failures.

For all its glory, however, in times of digital-era changes, mobile money should be seen as a "stop-gap" rather than a final solution to the poor's financial woes. In Kenya, sending Ksh 2,000 (USD 20) via M-Pesa currently costs 69 shillings (USD 0.69) (41sh for the sender, and 28sh withdrawal fees for the recipient).[43] According to one interviewee,

> it's hard enough for people staying in Nairobi, especially the slums, so 40sh is a lot of money for slum dwellers, a whole meal for the day […] Now you need […] 67sh to make transfers. It's actually a lot of money (Whatsapp conversation, January 2018).

The service is immensely useful, but the gains made via mobile money could soon be overtaken by decentralised ledger technologies.[44] The innovations built on the blockchain keep evolving and in some form they could one day upend mobile money providers who currently operate at sizable profit margins, as well as firms specialising in trans-border money transfers, such as Western Union, which can charge as much as 12 per cent for transactions. In the short term, firms like BitPesa in Kenya are interesting. BitPesa seeks to use Bitcoin transactions to bring the price of overseas remittances down to 25 per cent of their current costs (Rossiello, 2017, p. 156).[45] In the medium term, a variant of the technology's underlying crypto currencies could have an effect similar to that seen in the global telephony market throughout the 1990s/2000s: bringing the cost of international transactions down by orders of magnitude, and eventually perhaps to zero.

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41 See the reviews of Suri & Jack (2016); Economides & Jeziorski (2015); Jack & Suri (2011); Suri (2014); Plyler et al. (2010); Mbiti & Weil (2016); and Beck et al. (2016).

42 Other commentators had suggested that the regulator was to blame (Kenya allowed mobile network operators to act as quasi-banks, whereas Nigeria did not); Lepoutre and Oguntoye (2017) make the convincing point that, if this had been the decisive difference, mobile money should have failed in Bangladesh where it spread fast, and succeeded in South Africa where it has yet to take off.

43 See also https://www.safaricom.co.ke/personal/m-pesa/getting-started/m-pesa-rates.

44 Blockchains are distributed ledger technologies, meaning that they are based on consensus mechanisms on data shared openly in peer-to-peer networks. Cryptography helps make the legitimacy of new blocks in a blockchain easy to identify but nearly impossible to alter or duplicate once in place (Ohnesorge, 2018, p. 5).

45 For BitPesa, see https://www.bitpesa.co/.

The field of crypto currency may play a critical role in African development over the coming decades. It may well lead to the leapfrogging of an industry as profound as that seen in mobile money. Yet the blockchain-related field is so new and rapidly changing that providing concrete advice as to how and when such a leapfrog would occur seems unwarranted; (it could be related to banking, insurance, legal or other contractual agreements, organisational mechanisms such as voting systems, the sharing economy, the internet of things (IoT), personal identification, direct cash transfers, or some combination of the above).[46] Development partners interested in improving access to financial tools in the narrow sense (that is, the Bitcoin model), and in exploring new tools for mitigating transaction costs for contractual agreements in the wider sense (that is, the Ethereum model), should stay informed of the ever-changing landscape of decentralised ledger technologies.[47] This can be done by i) consulting the relevant literature (for example, Casey & Vigna, 2018); ii) contacting firms and organisations active in the field in Africa, such as BitPesa, for advice and possible collaboration; or iii) setting up an in-house expertise unit, such as GIZ's Blockchain Lab.[48]

Can development partners be pro-active in bringing such monumental changes about? It is a trial and error process, but success stories do exist. Let us revisit the actual birth of the world's first mobile money service, M-Pesa. The Vodafone employee who invented the concept, Nick Hughes, described his experience as follows:

> I was approached by a representative of the UK government who controlled a [Financial Deepening Challenge Fund] project set up by the Department for International Development (DFID). Our discussion centered on the following: Private sector organizations such as Vodafone are legally bound to use their shareholders capital to achieve the best returns. But many organizations use internal competition to allocate funds to their projects, and this competition is based on potential returns on investment. As a result, any initiatives that relate to the development agenda usually get squeezed out. […] I spent a few weeks in mid-2003 putting together a proposal […] and [we] were awarded funding of nearly £1 million, which was matched by Vodafone. A few weeks later, contracts were signed and we set about organizing a series of open workshops in Nairobi and Dar es Salaam. (Hughes & Lonie, 2007, pp. 66-67)

While other factors were certainly important, this account shows that, without donor support, the idea of "mobile money" might never have turned into the real-world service that now pulls millions out of poverty.[49] This is not to suggest that such challenge funds are the best solution. The example is meant to show that well-informed development partners can be proactive in bringing about seismic shifts in digital-era breakthroughs.

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46 Ohnesorge (2018) sees the greatest immediate possibilities in financial services (for instance, remittances) and property rights (that is, land registries). For an example of an existing pilot in blockchain-based development cooperation, see the Kreditanstalt für Wiederaufbau (KfW)'s TruBudget of 2017 available at https://www.kfw.de/KfW-Group/Newsroom/Latest-News/Pressemitteilungen-Details_426112.html.

47 Bitcoin's blockchain is designed purely as a digital currency. Etherium's blockchain is meant to be used more broadly in various other realms beyond finance, such as "smart contracts" with automatically enforced transactions according to previously stipulated rules.

48 GIZ's Blockchain Lab has been testing new applications of decentralised ledger technology in land registries, and decentralised energy markets. See https://www.giz.de/en/worldwide/67045.html.

49 Suri and Jack's (2016) finding that 196,000 Kenyans were pulled out of poverty by mobile money, suggests that similar processes occur in other mobile-money countries – hence my vague claim of "millions".

6.3 Women

Many smallholder farmers across the subcontinent are aging women (Palacios-Lopez, Christiaensen, & Kilic, 2017). Using digital technologies in agriculture thus has a large and immediate impact on women in Sub-Saharan Africa. Services such as HelloTractor in Nigeria, which alerts tractor owners if nearby small plots need ploughing, can help make toiling the land much less arduous for poor rural women and increase their profits (HelloTractor calls itself "the Uber for tractors" (Foote, 2018)).[50] Similarly, in urban areas, motorbike taxi services such as SafeMotos in Rwanda, which closely monitor their drivers, can reduce traffic accidents significantly, thus faring passengers of both sexes safely to and from work, and making women's journeys safer if travelling alone at night.[51] In the same city, Kasha, an e-commerce platform, delivers contraceptives and menstrual health products to women confidentially.[52] And Zipline's SIM-card-steered drones deliver blood supplies to Rwandan clinics when postpartum haemorrhaging occurs (which often causes maternal fatalities).[53] These are all services that i) could not exist without the current state-of-the-art ICTs, and ii) help women either directly in making their work lives easier, or indirectly by increasing safety, health, and dignity.

Particularly helpful for women's empowerment has been the internet (Bailur & Masiero, 2017). But unlike other world regions, the gender gap in African internet usage appears to be widening. An apparent correlation between female tertiary enrolment rates and women's access to the internet (ITU, 2017), suggests that development partners should try to help increase both.

Interesting, as well, is how women could become more involved in more digital work directly. Bailur and Massiero (2017) had found that women were, on average, more reserved and less exploratory when it came to engaging with new technologies.

My own case examples elsewhere (Melia, Forthcoming) show that nudging women towards, or merely showing an opening to working with technology can be extremely beneficial at all levels of the value addition ladder: i) Particularly well suited for helping women in getting started in the most basic type of digital labour – which is currently image tagging – are impact sourcing service providers such as Samasource.[54] ii) Partners interested in promoting women's independent online work could seek out and consult with African women who are themselves at various stages of independent online work. The Rockefeller Foundation has worked in the field of promoting African involvement in online labour platforms over the past years, and could provide helpful insights.[55] iii) Partners interested in promoting women's participation at the top of the value addition ladder, in professional software engineering could concentrate on narrowly targeted

50 For HelloTractor, see https://www.hellotractor.com/home.

51 For SafeMotos, see http://www.safemotos.com/.

52 For Kasha, see https://kasha.co/.

53 For Zipline, see https://www.flyzipline.com/.

54 For Samasource, see https://www.samasource.org/.

55 For the Rockefeller Foundation's "Digital Jobs Africa" initiative, see https://www.rockefellerfoundation.org/our-work/initiatives/digital-jobs-africa/

interventions of linking established female coders to one another. Direct communication with organisations such as Andela or Akirachix could be helpful.[56]

6.4 Internet connectivity

Other observers have been critical of the enthusiasm around connecting Africa to broadband internet.[57] But the evidence in this current literature review indicates that investing in better and more accessible internet connections may be a fast and comparatively cost-effective way towards African private sector development and job creation. Early findings suggested that the internet has positive effects across all levels of wealth and firm productivity, but that it may have the greatest effect for the already better off, hence, increasing the digital divide between more and less productive firms and between more and less wealthy countries.[58] However, I showed above that an extensive new study (Hjort & Poulsen, 2018) found that workers of all income brackets profit from the arrival of broadband internet in African cities.

This implies that better internet connectivity could become the underlying infrastructure for most aspects of economic activity, particularly for exporting to global markets, but for domestic business opportunities as well (because digital platforms and new innovations such as distributed ledger technologies also hold potential for reducing transaction costs in domestic markets).[59]

In spite of this importance of the internet, the data show that mobile phone usage is converging in all world regions, but internet penetration is much lower in South Asia and Sub-Saharan Africa than elsewhere, and that these two regions are currently falling behind; in other words, a global divergence in internet penetration exists (World Bank, 2016, p. 103; but compare ITU, 2017).

Thus, the collective evidence reviewed here indicates that development partners should seek to increase internet access across Africa. How could this best be done? A study by Wentrup et al. (2016) asked which factors had the biggest impact on internet penetration in the region. They hypothesised that four factors would influence internet penetration in Africa: i) authoritarian censorship in the form of firewalls or cyber espionage; ii) internet provider competition (that is, non-monopoly, and hence, presumably, lower prices and better quality). Their study found that these factors actually had *little* influence on whether or not the internet spread in a given country in Africa.

More influential were the other two factors: iii) how actively the standardised Internet inclusion policy, that is, the ITU's Universal Service Fund (USF), is implemented in a given country (USFs are meant to guarantee equal availability, affordability, and accessibility of

56 For Andela, see https://andela.com/. For Akirachix see http://akirachix.com/

57 See the reviews of Foster et al. (2018); Ojanperä et al. (2017) and Friederici et al. (2017).

58 See the reviews of Lio & Louie (2006); Paunov & Rollo (2015).

59 As noted, the World Bank (2016) stresses the importance of "analogue complements to digital dividends," meaning that regulations, skills, and institutions will ultimately determine to what degree ICTs can be utilised in a given country.

the internet).[60] And, iv) the import tariffs and value added tax levels on computer equipment (and whether or not a subsidy exists for hardware). The reasoning is that lack of access to adequate hardware is still a main impediment to using the internet in Africa.

Hence, Wentrup, Xiangxuan, Nakamura and Ström's (2016) findings suggest that, in order to spread the internet across Sub-Saharan Africa, interventions are more effective if aimed at equal access guidelines (that is, the USFs), and at lowering taxes on (or even providing subsidies for) computer hardware.

But intervention strategies need to be country-specific. For example, in Wentrup et al.'s (2016) sample of African countries, total taxation on computer hardware varied significantly – it was nearly 30 per cent in Cameroon (highest), and only 7.5 per cent in Nigeria (lowest). This shows the obvious need for locally tailored interventions: while it may be more important to concentrate on bringing down taxation in one country, in another, improving USF implementation may be more warranted.

Overall, bringing affordable internet and low-cost computing devices to the continent can make a big difference. As one of Nairobi's accomplished online workers told us:

> there are people who did very well in school, especially primary, high school, but sometimes they get stuck, not because they are not smart. Most of the time there are many people [who] get stuck because they don't have the money to proceed. […] I was talking to one guy who is really interested [in online work], but he can't get the money to buy the laptop, he can't get the money to, okay, he got someone to buy him a laptop, then now he has this issue of the internet, he can't afford it, it's too expensive for them. Now, for someone like that, and he's a smart guy, because, he has finished college. So, he can't proceed because of those obstacles. It might seem like very small issues, but they are not, for such a person, internet, laptop, such things. (Personal interview, Nairobi, June 2017)

This quote shows how dire the situation is in some African metropolises, where demographic change and jobs scarcity leads to unemployed university graduates who lack the funds for the most basic inputs needed to become productive in the digital era.

Pushing traditional telecom providers to better adhere to the USF guidelines can be useful. But ambitious initiatives are currently underway for providing globally free broadband internet connections, for instance, by Alphabet's Loon or SpaceX's Starlink.[61] Should these or similar initiatives succeed in bringing free broadband internet to Africa, it would become less urgent for partner interventions to help facilitate the connection, and more important to help Africans acquire the necessary equipment.

Convincing governments to lower import duties and value-added tax for personal computers could be a crucial contribution to job creation. Targeted subsidies, or improved schemes for low-cost imports of second-hand computers could help as well. This runs the risk of

60 Many governments and telecommunication companies promote "Universal Service." It is meant to increase equal access and digital inclusion across various socio-economic chasms, such as income, region, gender, ethnicity, disability, and so on (see Wentrup et al., 2016, pp. 249-250).

61 For Alphabet's Loon, see https://loon.co/, and for SpaceX's Starlink, see https://www.teslarati.com/spacex-starlink-us-military-500-700m-raised/.

becoming environmentally dangerous. Even if a scheme were strictly limited to well-functioning and relatively young devices, the recipient countries' electronic waste management systems could be unable to absorb the e-waste this would entail down the line.

Yet, from the perspective of generating African work in the digital era, the short usage cycles of devices in high-income countries provide an opportunity for bringing Africans online (if second-hand imports are coupled with strict quality oversight, and with support for African waste management systems). However best achieved in practice, increasing African access to fast internet may be among the most effective ways of facilitating jobs in the region.

7 Conclusions

This paper began by pointing to a difference in outlooks: between, on the one hand, global economic consultancies and African policymakers who welcome the ICT revolution in Africa as a trade-increasing and job-creating mechanism; and, on the other hand, critical social scientists who voice scepticism of the presumed merits of information and communication technologies and point to evidence that indicates either no clearly discernible benefits of ICTs in Africa, or even outright negative effects, for instance, in terms of increased exploitation and "negative adoption." The motivation for this literature review was to identify what the actual empirical results of the available, most rigorous scientific studies can tell us about this question. The results are surprisingly clear: none of the methodologically rigorous studies reviewed here find negative effects of ICTs on African jobs, directly or indirectly. A minority of studies show no positive effects. The latter are sometimes cited in support of the critical literature, but on closer inspection, they mostly point to inconclusive results due to particular circumstances that would need tweaking before ICTs could have their expected positive impact.

This positive conclusion does not imply that critical studies of ICTs in Africa are of no value. To the contrary: it is possible that positive biases crept into the various empirical trials cited here, and that, in future, rigorous studies will expose this. But for the time being, these studies provide the best existing evidence, showing various channels of positive effects of ICTs on African jobs.

With the spread of fast internet and the emergence of newer technologies, such as distributed ledgers or platform economies, newly undertaken research will need to establish whether the positive trajectory depicted here will continue in the future, or whether Fourth Industrial Revolution technologies will bring about a different set of challenges. Apart from their argument of "negative adoption," Murphy and Carmody (2015) made a more central claim: they note that, while new technologies *do* lead to greater connectivity to global markets, this entails increased dependence on imports and decreased capacity for productive exports. Murphy and Carmody's case studies show that in Tanzania and South Africa, furniture is increasingly imported from China (squeezing out local furniture producers), while global booking platforms gain ever-more market share (extracting grater revenues from local tourism SMEs). Such structural claims are difficult to verify/falsify – which led me to exclude them from this literature review. But such negative phenomena may indeed exist in parallel with the success stories depicted in the various studies reviewed above. Technology could have positive effects at a micro-

level (for example, saving bus fares) while having negative effects on a macro-level (for instance, making African economies ever-more path dependent on exporting raw commodities and on importing more sophisticated products and services). Hence, in the era of global platforms and ever-greater internet connectivity, future research should explore these questions. One aspect is to ask what possibilities exist for African productive exports in the age of the Fourth Industrial Revolution (Melia, Forthcoming).

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