The Contribution of Information and Communication Technology to the wellbeing of the urban poor in South Africa

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1. Problem Statement

Since the commercialisation of the Internet in the 1990's, as well as the rapid uptake of mobile phones in the developing world, the international development community has hailed digital Information and Communication Technology (ICT) as a potential developmental tool for the poor (World Bank, 2016: 6; McNamara, 2003: 13; Aker & Mbiti, 2010: 208). This promotion of "ICT-for-development" has stemmed from its putative potential to enable more convenient communication and instantaneous information flows, in addition to presumed broader developmental gains or "digital dividends" in the form of job creation, financial inclusion, enhanced social connectedness and strengthened human capital (Odendaal, 2011a; McNamara, 2003; World Bank, 2016: 2). In a world increasingly spent "online," digital inclusion has evidently become synonymous with not only economic and social inclusion, but also with the empowerment of the poor in assuming agency in their own wellbeing (World Bank, 2016: 2; National Planning Commission (NPC), 2012: 190).

It is for this reason that the South African Government has increasingly regarded ICT and mobile phones as critical components in addressing the alleviation of poverty and the reduction of inequality (SACN, 2016: 142; GSMA, 2017: 9; NPC, 2012: 190). This is highlighted in the 2012 National Development Plan (NDP), which postulates that by 2030, ICT will provide the underpinning of "a dynamic and connected information society…..that is more inclusive and prosperous" (NPC, 2012: 190). This is notably predicated on the narrowing of all digital divides along racial, spatial and socio-economic lines through the achievement of a 100 percent broadband penetration rate by 2020 (National Planning Commission, 2012: 195; Department of Telecommunications & Postal Service, 2016: 1).

In pursuit of this goal however, national policymakers have been observed to particularly focus on the amelioration of the urban-rural digital divides as a product of discriminatory Apartheid laws (Lewis, 2013: 96). This appears to have been guided by the implicit assumption of the State that all urban dwellers are inherent beneficiaries of ICT due to both their historical, and current, proximity to technological infrastructure and wealth (Lewis, 2013: 95). This assumption appears to be further aligned with popular international development narratives which identify the rural poor as most excluded in society (Fourie, 2008; Odendaal et al, 2008; Odendaal, 2011b; May, 2010; Heeks, 2010). As a result, it has often been the rural poor, in favour of those urban, who have been the primary recipients of broad State-funded universal service and access interventions such as telecentres, fixed-line infrastructure, and ICT awareness campaigns (Lewis, 2013: 96-152). Although recent efforts have been made to establish Free Public Wif-Fi in under-served urban areas under the 2013 SA Connect broadband national policy, these have been largely been based within cities as opposed to marginalised communities along the periphery (Geerdts et al, 2016: 60-100). In this way, it would appear that despite State commitments to an inclusive digital society, its efforts to achieve this have been based on the erroneous belief that urban ICT supply equates to universal digital inclusion and thus requires less intervention in enabling citizens to realise digital dividends.

In light of the growing prevalence of convergent Internet technology and the sentiments of an emerging "beyond access" literature however (Van Dijk, 2006; Van Dijk & Hacker, 2003; Heeks, 2010; Odendaal, 2008; 2011a; World Bank, 2016), it is becoming increasingly apparent that although access to ICT may be a necessary prerequisite for development, it is insufficient to ensure that it will be used effectively to achieve optimal developmental gains. This realisation has become especially relevant for South Africa.

This is given by the fact that despite the increased ownership of Smartphones within urban areas, the cost of these devices together with persistently high priced data, has increasingly appeared to risk the sub-optimal usage of these devices and their popular "data-hungry" mobile applications (Geerdts et al, 2016: 14). Moreover, the cost of mobile broadband further presents the danger of imposing extractive effects on the income of the poor, rather than that poverty alleviation, when demand for these application are relatively inelastic demand (Miller et al, 2005). Compounded by a historical lack of quality education to support greater digital literacy, it is these barriers which have therefore blurred the extent to which the urban poor are truly capable of leveraging digital technology for their enhanced wellbeing (Servon & Nelson, 2001: 280). As highlighted by 2016 social movements by disgruntled mobile phone users, this resonates with the growing concern that while ICT may encourage inclusion, it may possess an even greater potential to reinforce existing inequalities experienced by the marginalised and undermine the value of any digital dividends drawn from ICT (Gillwald, 2017: 2).

Given these barriers within the wider context of increasingly urbanised poverty, the failure of the South African Government to fully understand the relationship between ICT and the wellbeing of the urban poor can consequently be seen as not only conducive to perpetuating existing inequalities, but also exacerbating the "concentration of poverty and….de-concentration of opportunity" experienced within these marginalised communities (NPC, 2012: 105; SACN, 2016: 24; Graham, 2002: 38). Furthermore, by failing to acknowledge the limitations of ICT access alone to catalyse development, policymakers currently risk underestimating the benefits accrued from existing urban-based ICT initiatives, such as Free Public Wi-Fi, in alleviating cost pressures for those who require the most assistance along the periphery. In order to limit these risks, a clearer understanding is therefore required by Government of not only the urban-rural digital divide, but also how efficaciously ICT is currently used by the urban poor to derive optimal digital dividends.

Research Questions and Methodology

In pursuit of narrowing an evident gap in understanding poor urban digital inequality at a national level, and to potentially inform policy in this regard through robust quantitative findings, this thesis seeks to analyse the role of ICT and the extent to which its current use by the urban poor contributes towards their improved wellbeing in South Africa.

Thus, three key questions are explored: i) What level of access to ICT do the urban poor have? ii) To what extent are Internet-enabled mobile phones being used by the urban poor for improved wellbeing? iii) What are the determinants or barriers to optimal ICT use by the urban poor?

These questions are answered through the quantitative application of Roxana Barrantes' (2010) demand-focused Digital Poverty Framework (DPF), adapted for convergent mobile technology, using data from the 2017 "After Access" Research ICT Africa (RIA) Household and Individual ICT access and usage survey. This is supplemented by a Generalised Ordered Logit regression model to identify statistically significant determinants for optimal Internet-enabled mobile phone usage among the urban poor.

Findings from this analysis indicate that despite being highly connected in terms of Smartphone ownership and Internet access on average, only 12 percent of urban poor respondents are estimated to actively utilise their Internet-enabled mobile phones on a daily basis to engage with key social, economic and educational mobile applications. By further estimating this level of optimal Smartphone usage to only occur with a 5 percent predicted probability, holding all else constant, this study asserts that Internet-enabled mobile phones have only been able to produce sub-optimal contributions to the improved wellbeing of the urban poor. Accounting for the confounding effects of students within the sample, this study identifies digital literacy and mobile broadband pricing as dominant barriers to optimal ICT usage and contributors to observed digital inequality among the urban poor. Based on these results, it has become clear that unless the State makes greater efforts to reduce these barriers to meaningful and active ICT use through substantiative demand-based interventions and wider Internet alternatives to expensive mobile broadband, instead of bringing about an inclusion of the urban poor to an increasingly digital world, it may increase the risk of further marginalizing them, and worsening the divide.

The next chapter explores the literature on the ambiguous role of ICT on development while Chapter Three outlines the context of the present ICT sector. Chapter Four provides a brief overview of prevailing national policies governing the ICT sector and its consideration for the digital inclusion of the urban poor. Chapter Five subsequently outlines the conceptual framework linking ICT to development in terms of the Digital Poverty Framework. This is followed in Chapter Six by a description of the methodology used to quantify the Framework. Chapter Seven provides an analysis of the descriptive statistics of the population sample and an evaluation of the findings produced by the DPF in terms of the ICT usage of the urban poor. Chapter Eight outlines the econometric model applied to the urban poor and provides a description of significant barriers to optimal Internet-enable mobile phone usage. Chapter Nine presents a discussion on the broad implications of the results before the study limitations are outlined in Chapter Ten and a conclusion is reached in Chapter Eleven.

2. Literature review

Emergence of the Information Society

Since the invention of the telegraph, communication technology has been recognized by international policymakers as a key component to economic development (McNamara, 2003: 13). However, it was not until the commercialisation of the Internet during the 1990s that the global Information society emerged to promote the wider availability of opportunities and developmental gains for developing countries in particular (McNamara, 2003; Castells, 2004; Heeks, 2008; Heeks, 2010; Howard & Mazaheri, 2009). In defining this society as a "social structure…made of networks powered by microelectronics-based information and communication technologies," Manuel Castells astutely identifies these developmental gains as dividends derived from inclusion to global communication flows and instantaneous access to information (Castells, 2004: 3; World Bank, 2016: 2). With its potential to propel developing countries into the global Information society and possibly empower the active participation of its poor to reap these benefits, information and communication technologies (ICTs) have therefore not only been linked to greater agency, but also the improved wellbeing of the poor (Blackman and Srivastava, 2011: 4).

To investigate and attest the key linkages between ICT and its turnkey effect on development, a number of studies have emerged to underpin the rhetoric of ICT-for-development (ICT4D) studies (McNamara, 2003; Oestmann & Dymond, 2001).

ICT and Economic Growth

The most common link drawn between ICT and development within the literature has typically been in terms of the impact of its supply on economic growth and its "trickle-down" effects for the poor (May et al, 2014: 8). For developing countries with rising urban populations, this level of ICT supply has been linked to the substantial penetration of mobile phones in the region from less than 10 percent in 1999, to over 70 percent in 2010 (Waverman et al, 2005; Aker, 2009; Aker & Mbiti, 2010:208).

Although initial pull factors of convenience and cost-effective airtime payment options, such as "pay-as-you-go," supported these rates of penetration in a substitution effect away from telephones, recent trends in mobile phone penetration are increasingly explained by their increased multi-functionality following their convergence with computing capabilities which have enabled devices to become Smarter, serving as portals for Internet access (McNamara, 2003; Miller et al, 2005; Obayelu & Ogunlade, 2006; Jensen, 2007; Fourie, 2008; Souter et al, 2005; Donner, 2009; Zibi, 2009; Roger, 2009; Hellström & Tröften, 2010; Etzo & Collender, 2010). This assertion was supported by a 2013 publication, a study spanning 11 African countries, which identified mobile Internet as not only a key driver for mobile phone usage, but a primary source of Internet access (Stork et al, 2013).

The penetration of mobile phones has notably underpinned the "technology boosterism and cyber utopianism" of heterodox supply-based literature given its resultant identification as goods of "absolute necessity" for both communication and Internet connectivity (Miller et al, 2005: 34; Pieterse, 2009: xiv). This was underpinned by evidence for the positive association between mobile phone penetration and GDP gains that were at least twice as large for developing countries relative to those received by developed countries (Waverman et al, 2005: 18). This reinforces previous findings between 1996 and 2003 of the association of a 0.6 percentage point increase in GDP per capita with a penetration rate of 10 mobile phones per 100 people within an average developing country (Waverman et al, 2005: 11). However, although suggesting a linear and positive relationship between penetration and development, this association has been critically qualified by the prerequisite need to achieve a critical mass in mobile-density for gains to be observed (Waverman et al, 2005; McNamara, 2003; Koutrompis, 2009). Consequently, with mobile penetration asserted to be positively associated with urbanisation, rapidly urbanising Sub-Saharan African (SSA) countries such as South Africa have been identified as prime recipients of digital dividends within the growing internal Information society (Graham, 2002; Manyika et al, 2013; Deloitte, 2015/2016).

Mobile phones for inclusion and development

Beyond these macroeconomic growth dividends however, a paucity of studies exists associating urban poor mobile phone access to developmental gains when gains are defined as capitalised opportunities and strengthened freedoms (McNamara, 2003: 4). Despite this, three core channels can be identified within this limited research area which provide insight to the connection between mobile phones and their contribution towards the improved wellbeing of the urban poor. These include economic advancement, social inclusion, and human capital enrichment.

1. Economic advancement

For poor opportunistic urban micro-entrepreneurs operating within the informal sector, a relatively large literature exists that link mobile phones to economic gain (Frederick, 2014; Etzo & Collender, 2010; Johnson & Thakur, 2015; Odendaal, 2011b; Miller *et al* 2005; Carmody, 2012; Deen-Swarray *et al*, 2013; Diga, 2013). Research on urban informal traders reveals that this arises from the usefulness of mobile phones in overcoming asymmetric information, enhancing productivity, and boosting efficiency without the need to physically source either suppliers or customers beyond "immediate geographical reach" (Donner, 2006; Samuel et al, 2005; Chen, 2016). Similarly, evidence from Rwanda and across Africa highlights the usefulness of mobile phones to attract "new business ties" through improved advertising, availability and convenient access to virtual markets such as Google Trader or eBay (Donner, 2006; Donner, 2009; Hellström & Tröften, 2010; World Bank, 2016). This is in addition to research attesting to the value of these devices for strengthening or maintaining existing business networks (Hyde-Clarke, 2013; Molony, 2008; Carlson, 2012; Samuel et al, 2005; Ussher, 2015).

Beyond their contribution to existing livelihood activities, employment opportunities are further linked to mobile phone ownership by virtue of their access to instantaneous communication and information at reduced costs (World Bank, 2016). This has the potential to result in optimised job-seeking activity and labour market participation through the ability to access and utilise online recruitment databases (Donner et al, 2011; Aker and Mbiti, 2010; Manyika et al, 2013). Further studies however have also associated mobile phone penetration with direct job creation in urban informal settlements within SSA through the establishment of "spaza shops" or street vendors orientated towards catering for mobile-phones needs such as repair, battery-charging, unlocking and data sales as prime examples (Chéneau-Loquay, 2009; Johnson & Thakur, 2015; Hyde-Clarke, 2013). Micro-employment in digital service industries, such as driving for Uber, have additionally been recognised for their potential as a prime sources of job creation in modern urban economies for those who are unskilled but own Internet-enabled mobile phones (Rockefeller Foundation, 2013;). Although further evidence suggests the limited uptake of these jobs in Africa and their potential to disrupt traditional labour markets, these findings fails to dispute the value of digitised work to "enables job seekers in poor countries to enter labour markets in rich countries, previously inaccessible due to high communication costs and barriers to labour migration" (Gillwald, Onkokame and Van Shoentegen, 2017: 2).

<u>Financial inclusion</u>

Following the successful innovation of the Kenyan-based mobile-banking application, MPESA, a body of literature has further emerged to identify the developmental potential of mobile-banking through financial inclusion (Aker & Mbiti, 2010: 221). According to the literature, this potential for financial inclusion arises from the ability of mobile-banking to act as a store of value for aspirational urban micro-entrepreneurs, a vehicle for personal savings and micro-credit, and a platform for cross-border money payments (Manyika et al, 2013; Morawczynski, 2009; Frederick, 2014; Duncombe & Boateng, 2009; Fanta et al, 2016). The latter has been observed as particularly relevant for SSA countries given their high rates of urbanisation in association with rising rural-urban and cross-border migration (Morawczynski, 2009).

2. Social inclusion

Given above findings for economic gain through mobile phones, a significant body of literature exists to suggest the "blurred" nature of this benefit with the popular use of mobile phones for social networking and connectedness (Donner, 2007). This is corroborated by a plethora of studies identifying the strengthening of networks with friends, social groups, "stretched households," and other forms of social capital, as the most popular use for mobile phones (Barberousse et al, 2009; Gikenye and Ocholla, 2010; Molony, 2007; Myhr and Nordstrom, 2006; Fisher et al, 2015; Gillwald et al, 2012; Sey, 2010). Although research on rural populations have typically attributed this to the ease of communication flows over distances, the strong desire for a social media presence has increasingly been identified as a primary driver for Smartphone use by the urban poor within highly digitised societies (Skuse & Cousins, 2005; Barberousse et al, 2009; Hellström & Tröften, 2010; Porter et al, 2016). This is especially common among the urban youth in South Africa and across four East African countries, with social media such as Facebook and instant messaging rated as top mobile Internet uses (Kreutzer, 2009; Hellström & Tröften, 2010).

However, while substantial value has been attributed to mobile phones for strengthen existing ties, it is its capacity to foster new or "bridging social ties" which have significantly underlined the potential of mobile phones to promote the "upward social mobility" of the urban poor (Molony, 2010; Carmody, 2012; Kreutzer, 2009; Chigona, 2009; Sey, 2010; Hellström, 2010; Barberousse et al, 2009; Johnson & Thakur, 2015: 17). This supports arguments within the literature of the importance of mobile phones as not simply a means to contact loved ones, but as a tool to improve social status, both on and offline, towards facilitating new connections and enhancing inclusion within the global Information Society (Gikenye and Ocholla, 2010; Carlson, 2012; Skuse & Cousins, 2008). Rather than simply building shallow connections, it is these mobile phone-induced bridging ties which have linked the urban poor to successful job-seeking, effective social integration as foreign refugees, the collectivisation of political movements, the development of interdependent "informal business networks" among invisible or illegal urban informal workers, and the incentives for individuals to interact with government, online learning and educational programs through positive feedback loops (Molony, 2007; Bacishoga et al, 2016; Johnson & Thakur, 2015: 19; Srivastava, 2005; Manacorda and Tesei, 2016; Chiumbu, 2012; Wang, 2015).

3. Educational enrichment

Given its potential to secure access to vital information and knowledge, the capacity of ICT to empower the marginalised with greater human capital is well established within the literature. However, while this has traditionally been dominated by the successful provision of computer e-learning programmes in developed countries, excluding pilot studies in affluent urban classrooms, reports of its success in SSA schools have been notably scarce (Porter et al, 2016; Brown, 2003; Manyika et al, 2013; Hornsby, 2015).

Studies finding these initiatives attenuated by structural barriers such as infrastructure deficits and absenteeism have consequently highlighted the potential of mobile phone-based learning (m-learning) as an alternative to e-learning in poor SSA classrooms, given its capacity to leverage the existing ubiquity of mobile phones for educational gain, both within classrooms, and at a distance (Manyika et al, 2013; Brown, 2005). However, although evidence has been produced for these benefits at a school level, such as the "400 percent increase in the number of books read in beneficiary schools over four years" in South Africa as a result of digital literacy mobile applications, as well as increased mathematics competency by 14 percent due to tutoring via instant messaging applications, evidence for poor urban schools have been more sparse and contentious (Manyika *et al*, 2013: 41). Specifically, although research has highlighted the potential danger of m-learning to encourage distraction within classrooms, contrary evidence argues for the observed usefulness of broader mobile applications, such as YouTube and Google, for knowledge-seeking by digitally literate poor urban youth in order to complete homework and support their wider empowerment in knowledge-based societies (Kreutzer, 2009; Porter et al, 2016).

Digital divide versus digital inequality

Despite the potential for these developmental gains however, an increasing body of literature by self-proclaimed ICT pessimists highlight the persistent inequality with which ICT is truly enjoyed by groups of poor and marginalised individuals around the world. Traditionally conceived as a problem of insufficient ICT supply, this digital divide both between and within countries has been notably addressed and well incorporated into international policy discourse (Kirkman et al, 2002; International Telecommunication Union, 2005; Guillen and Suarez, 2005; Chin & Fairlie, 2007; Hanafizadeh et al, 2009; Chapman & Slaymaker, 2002; Gillwald, 2001; Obayelu & Ogunlade, 2006), Gillwald et al, 2012; Stork et al, 2013). However, despite studies continuing to find discrepancies in fixed-line Internet access, the increase in penetration of Smartphones by over 50 percent in SSA since the 1990's has encouraged institutions such as the World Bank to refute the attribution of digital exclusion solely to that of insufficient access (Gillwald et al, 2012; World Bank, 2016). Rather, seminal work by analysts in this field, such as Warschauer (2002), postulate that it may be the inability of impoverished ICT owners to effectively utilise ICT in meaningful ways that truly underpin their inability to extract developmental benefits from ICT.

By highlighting that ICT may only be a "necessary but insufficient condition for economic development" in the presence of deprivation and usage barriers, the ambiguity of ICT's true contribution to the wellbeing of the poor is increasingly emphasised by a growing strand of dissenting ICT4D literature (Obayelu & Ogunlade, 2006: 12). Given the noted potential for sub-optimal ICT usage to not only perpetuate but exacerbate existing systems of inequality, it is this body of literature which asserts that while access divides may exist, the potential for digital inequality may be even more severe (Chapman & Slaymaker, 2002; Warren, 2007; Kularski & Moller, 2012; Servon & Nelson, 2001, Gillwald, 2017).

Shifting discourse

In unravelling the ambiguous role of ICT, a number of studies have advocated for research to go "beyond access" (Van Dijk, 2006: 224). In doing so, this body of literature attests to the vital need to shift away from the dominant ICT4D and policy discourse that automatically associates supply with digital dividends, and towards narratives that place the digital demands of users, as well as the influence of their context, at the forefront (Mutula, 2005). This is based upon the recognition that in order to understand digital inequality, consideration must be given to the existing contextual disparities which promote inequality and weaken the extraction of developmental gains (Oyedemi. 2009; Kaplan, 2005; Oyedemi, 2004; Barranes, 2007, 2010). This realisation is particularly reiterated by Warschauer (2002) in highlighting that since ICT is intertwined in "a complex manner in social systems and processes," it is important to understand the processes and mechanisms that promote or inhibit marginalised groups from using ICT for inclusion rather than to simply overcome access divides (2002: 4). Three core usage constraints are consequently identified as key preconditions or processes for digital (in)equality among the poor within the "beyond access" literature.

1. Digital illiteracy

A primary barrier postulated as inhibiting optimal ICT use, is the lack of general- and digital-specific literacy (Gigler, 2011; Warschauer, 2002; Gurstein, 2003; Mutula, 2004; Kularski & Moller, 2012; Manyika et al, 2013; Hellström & Tröften, 2010; Etzo & Collender, 2010; Ojo et al, 2012; Hampshire et al, 2015; Jain, 2006; Warren, 2007; Donner et al, 2011; Miller et al, 2005; Ussher, 2015; Chair, 2017). Given that an ICT revolution in development can only take place if the poor have sufficient knowledge and comprehension to meaningfully engage with technology (Warschauer, 2002; Jain, 2006; Odendaal, 2011b; Mutula, 2004; Sinha & Hyma, 2013), when placed within the context of Africa and many developing countries, it is this lack of "informational capabilities" which has been observed to hinder the poor from using digital ICT meaningfully (Gigler, 2011: 2).

More specifically, due to the inability of SSA countries to universally provide quality basic education and literacy, as necessary prerequisites for the development of adequate levels of digital literacy, poor individuals have been observed as being limited in using owned mobile phones "effectively" (Mutula, 2004: 128; Gurstein, 2003). Defining "effective use" as "the capacity and opportunity to successfully integrate ICTs into the accomplishment of self or collaboratively identified goals," low digital literacy is identified as stemming from low awareness of the importance of mobile phones for opportunities (Gurstein, 2003: 6; Mutula, 2004; Sinha & Hyma, 2013). Given the reality of language barriers and a lack of local content in mobile applications to match the "cultural milieu" of given contexts, it is not surprising that weak digital skills are consequently attributed to not only low ICT adoption among the poor, but a lack of motivation to develop critical skills that are essential to using ICT actively in terms of content creation (Mutula, 2004: 124; Van Dijk, 2006). By failing to overcome this psychological barrier in motivation, numerous studies have consequently associated weak development outcomes with negative ICT perceptions that result in technophobia or self-imposed barriers towards both active ICT use and acquiring digital skills (Porter et al, 2016; Obayelu & Ogunlade, 2006; Donner & Gitau, 2009).

1. Social relations

Certain demography factors have additionally been underscored in numerous studies as barriers towards optimal ICT usage. This is particularly illustrated by the case of male dominance in ICT access and use. Although less significant when education and income were controlled for, this skewed usage and access gave indication of a prominent barrier to meaningful ICT adoption across 11 African countries (Deen-Swarray et al, 2012). This replicated previous findings of a gender gap in both access and use across four East African countries where 33 percent of women were found to own a mobile phone relative to 43 percent of men, and only 8 percent of women to have an email account compared to 12 percent of their male counterparts (May, 2010: 16).

The significance of this discrepancy further emphasized findings for the negative association between being female and the levels of social inclusion derived across 10 African countries through sub-optimal Internet use (Wang, 2015). This expands upon the well acknowledged influence of patriarchal gender inequalities on poverty and its impact on both how ICT is utilised and by whom (Obayelu & Ogunlade, 2006; Kularski and Moller, 2012). Although evidence from poor urban communities in South Africa seem to contradict this finding given the strong desire of females to social network and remain in contact with friends and family, their access to and usage of ICT remains highly dependent on the income of male breadwinners or consorts (Porter, 2012: 244).

An additional key barrier identified demographically is the "grey digital divide" (Millward, 2003: 1). This relates to the negative perceptions held by the elderly that their capabilities are too low to effectively use ICT, therefore "leading to a long-term…lack of interest in using the Internet" (Millward, 2003: 1). This is supported by findings of the parabola-shaped mobile phone penetration rate in four East African countries with adoption increasing with age to 60 percent at 30 years before falling after 55 years, thus alluding to similarly inverse relationships between ICT diffusion and age (May, 2010; Roger, 1983). Although this reflects more of a self-imposed barrier possibly based on a prior lack of ICT knowledge or supply, studies additionally identify age as a primary determinant against the acquisition of digital literacy itself (Kularski & Moller, 2012). However, given contradictory findings of a positive relationship between age and information-seeking Internet usage, it has become clear that a much more complex relationship may exist between age and ICT usage (Wang, 2015; Kania-Lundholm & Torres, 2015). This is particularly relevant for urban communities, where although its typical youthfulness may compensate for the severity of this barrier to effective ICT usage, it is not a given when there are discrepancies in digital skills among the poor (SACN, 2016: 29).

2. Affordability

One of the most consistent obstacles found within the literature to meaningful mobile phone usage is affordability (Falch & Anyimadu, 2003; Heeks, 2010; Gillwald, 2015; Brown & Brown, 2008; Gillwald, 2017; Alliance for Affordable Internet, 2016; Valk & Fourati, 2013; Oestmann & Dymond, 2001). Specifically, while the cost to purchase mobile phones has fallen in various parts of SSA, the price of using daily mobile data optimally for increasingly "data-hungry" mobile applications has remained persistently high (Geerdts et al, 2016). Numerous studies contend that high costs of mobile broadband have not only inhibited the full extraction of potential digital dividends, but have also imposed significant opportunity costs to do so in terms of household consumption foregone (Heeks, 2010; Geerdts et al, 2016).

This mirrors findings quoted from the 2008 RIA household and individual ICT survey in which users at the bottom of the pyramid across 14 African countries were found to be allocating in excess of 15-20 percent of their monthly income not only to access, but also to use mobile phones (Heeks, 2010). However, reports of the dedication of more than 27 percent of personal income towards mobile phone expenditure by informal settlement residents in South Africa, has suggested the particularly high value possibly attached to digital inclusion by the urban poor (Aker & Mbiti, 2010; Carmody, 2012; Hyde-Clarke, 2013). This is despite low levels of income and the observed dependency of the urban poor on mobile Internet in SSA countries, which highlights the particular vulnerability of these individuals to the extractive impact of costly ICT usage on wellbeing (Miller et al, 2005; Townsend, 2015; Alliance for Affordable Internet, 2016). Since the possibility resultantly exists that income expenditure may exceed the return of optimal digital dividends, affordability has increasingly been acknowledged as not only a trigger for vicious cycles of digital inequality, but an obstacle against human development in turn (Miller et al, 2005; Donner & Gitau, 2009; Ismail et al, 2011; Gikenye & Ocholla, 2010; Brown & Brown, 2008).

Digital inequality of the urban poor

While it has become clear that ubiquitous ICT penetration may be necessary for development in the modern Information age, given the demand barriers described, for the marginalised poor it is neither sufficient nor is it an automatic consequence of urbanisation (McNamara, 2003). Consequently, while studies on the ICT "urban bias" have frequently touted the superior gains accrued by all urban dwellers as a function of their access to ICT, the degree of digital exclusion experienced by the urban poor has largely been discounted (Mutula & Mostert, 2009; May, 2010). However, as argued most widely by Graham (2002) and Odendaal (2011a), it is precisely this issue of digital exclusion which is particularly germane to unequal developing countries, such as South Africa, given the actions of previous political regimes to splinter urban landscapes for their ease of control. It is therefore these entrenched patterns of spatial inequality which have consequently suggested the increasing relevancy of poverty and ICT demand barriers within urban sprawls (Odendaal, 2011a). However, due to an apparent lack of substantive acknowledgement as "blind spots" within digital inequality analyses, greater understanding of how ICT truly interfaces with urban poor lives remains relatively unattained (Odendaal, 2011b; Odendaal et al, 2008: 103). This analytical opacity is especially severe within the national level analyses given the need to accurately quantify and understand the effect of pervasive convergence technology in the face of increasing threats of urbanised poverty in developing African countries (SACN, 2016: 24).

With one of the highest levels of urbanisation in SSA, inclusive of deepening pockets of urban poverty and Gini coefficients above the "international alert line," the paucity of relevant accurate information within the body of ICT-related literature appears particularly alarming for South Africa (SACN, 2016: 142). Although a number of local ICT analysis have emerged to consider converged technology within the context of demand barriers, these have largely been targeted at the community or enterprise-level (Molony, 2008; Deen-Swarray et al, 2013; Odendaal et al, 2008; Chen, 2016; Bacishoga & Johnston, 2013; Kreutzer, 2009), and therefore limited to producing only anecdotal findings which cannot be generalised to inform national policy discussions (Rahman & Akter, 2010: 5). This is further compounded by the inability of these studies to account for the wider policy context and the influence of the ICT sector, on the digital lives of the poor (Oyedemi, 2004; Kaplan, 2005; Gillwald, 2017). In the absence of any known national analyses which account for these deficiencies, not only may there be a significant gap in understanding the real contribution of ICT to the wellbeing of the urban poor in South Africa, but also a subsequent inability to draw insights necessary to inform evidence-based ICT reform and policies.

In an attempt to narrow this gap, this thesis contributes to the body of knowledge in this area by analysing the role of ICT and the extent to which it contributes to the wellbeing of the urban poor in South Africa. To overcome existing limitations within the literature, the national representative dataset from the 2017 RIA "After Access" survey on South African ICT access and use is analysed in relation to urban poor, and within the national ICT and policy context. In doing so, this thesis produces findings which could directly inform current policy debates, using the latest available data, on how to effectively promote digital inclusion among the most marginalised in society. Given this aim, and in light of the evidence available from the above literature, this analysis will be guided by the assessment of three core hypotheses:

H1: Although the level of ICT access at the national level may be greater than the access enjoyed by the poor, a bias in access in favour of the urban poor exists among the poor on average.

H2: Although the urban poor may extract substantial digital dividends from mobile phone usage, in the presence of socio-economic driven barriers to ICT demand, these gains are sub-optimal in terms of the intensity and quality.

H3: Barriers in relation to human capital and affordability present the greatest risks of limiting the contribution of mobile phones to the sustainable wellbeing of the urban poor.

3. The South African ICT Sector

In order to understand the urban poor's current potential for digital exclusion within South Africa's digital society, this chapter provides a contextualisation of the ICT market in which the urban poor are customers. Towards this, key trends in both access and affordability are broadly outlined for telephones, mobile phones and Internet connectivity.

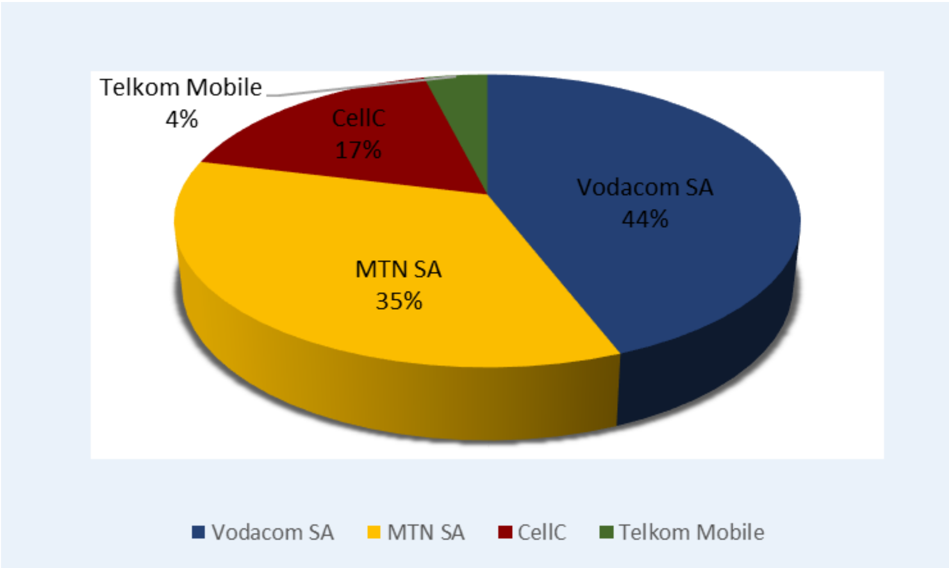
Fixed-line telephone market

Consistent with international trends, the ICT market has been characterised by the steady decline in fixed telephone line subscriptions for past decade from 18.5 percent in 2006, to 9.42 percent in 2016 (Telkom, 2005: 13; Telkom, 2016: 17; Gillwald et al, 2012: 38; Statistics South Africa (StatsSA, 2017: 5). Although more urban households reported cancelling subscriptions in 2012 by 13 percent, relative to 6.2 percent of those rural, this trend has been explained by the historically low tele-density among the latter (Gillwald et al, 2012: 43; Lewis, 2013: 95). Affordability, however, has been the cross-cutting motivation overall for reduced subscription by 42 percent of the population according to the 2011/2012 RIA survey (Gillwald, Odufuwa, Rademan and Esselaar, 2016: 34; Gillwald et al, 2012: 43). As a result, the same survey identified 87 percent of non-landline as substituting telephones for mobile phones (Gillwald et al, 2016: 33-43; Lewis, 2013: 99).

Mobile phone market

As a result, the mobile phone market in South Africa has grown substantially over the past decade to penetrate 96 percent of the adult population in 2016 (StatsSA, 2017: 141). Despite the efforts of mobile network operators (MNO), Cell C and Telkom Mobile, to compete on price and promotional offers, the majority of this mobile-density has been serviced by the effective duopoly between MTN and Vodacom with a joint shareholding of nearly 80 percent in 2016 (Gillwald et al, 2012: 4; Africa Analysis, 2014: 39; RIA, 2016: 2; Mothobi, 2017: 3-6). Between 2006 and 2016, MTN alone experienced an increase in mobile subscription from 12 million to over 30 million (MTN, 2006: 9; MTN, 2016: 5). In 2015, this penetration was notably characterised by the adoption of Smartphones by 50 percent of the adult population according to the South African Audience Research Foundation (SAARF)'s AMPS survey (SAARF, 2015). According to a 2015/2016 Deloitte survey, this reflected the Smartphone penetration rate of 99 percent in urban areas, and 83 percent in rural regions (Deloitte, 2015/2016: 27). However, while more than 74 percent of adults at the Bottom of the Pyramid (BoP) reported to own a mobile phone in 2012, only 22 percent of individuals in the lowest Living Standards Measure (LSM) brackets were recorded as Smartphone users in 2015 (Gillwald et al, 2012: 47; SAARF, 2015).

Figure 3. 1 - 2016 MNO market share in South Africa



Source: ResearchICTAfrica.net. 2017. Policy brief No. 3.

Broadband Internet market

In contrast to the expansion of mobile phones, the penetration of fixed-line Internet has been more subdued in South Africa. In 2016, only 9.8 percent of households reported access to fixed-line Internet with an 8.3 percent bias towards those urban relative to 2 percent in rural regions (StatsSA, 2017: 51-59).Furthermore, although the adult penetration rate more than doubled since 2007 to 52 percent in 2017, this progress has not been balanced (Gillwald, 2017: 1 Qwerty Digital, 2017: 5). Although over 70 percent of individuals in top LSM brackets reported access to fixed-line Internet between 2014 and 2015, only 16.6 percent of those in bottom LSM categories reported this achievement during the same period (Department of Telecommunications and Postal Services, 2016: 17).

The predominant, and often only, form of fixed-line Internet access in South Africa is mobile broadband (StatsSA, 2017: 51). In addition to the penetration of Internet-enabled phones, this dominance is explained by the relatively high price of traditional Asymmetric Digital Subscriber line (ADSL) and the insufficient coverage of costly Fibre-optic broadband networks (Dark Fibre Africa, 2016; Gillwald et al, 2016: 34). Resultantly, mobile broadband subscriptions represented more than 70 percent of the total broadband market in 2014 and over 75 percent of broadband traffic in 2017 (Africa Analysis, 2014: 44; Qwerty Digital, 2017: 7). In 2017, it represented the main form of Internet access for 57 percent of households, 62 percent of which reflected urban households relative to 40 percent in rural regions (StatsSA, 2018: 49).

Although relatively more cost-effective and faster compared to ADSL, mobile broadband remains a relatively expensive alternative due to the lack of available and efficient digital terrestrial spectrum required to optimise MNO capacity (Gillwald et al, 2016: 32; Gillwald, 2015: 10). This is reinforced by weak competition in prepaid mobile data prices under the MNO duopoly (Mothobi, 2017: 6). In 2017, the lowest-priced 1 GB of prepaid data amounted to R99, placing South Africa 25th out of 49 African countries on the RIA Africa Mobile Price (RAMP) Index (Mothobi, 2017: 2-8). In 2017, this ranking further reflected the price of prepaid mobile data to be twice as expensive as post-paid data, the latter option least preferred by low-income users (Mothobi, 2017: 6). Despite the increasing provision of bundle data-specials and innovative zero-rated services by MNOs such as instant messaging and data-free Facebook, the uptake of these offerings remain limited to date due to their "complex cost structures and conversion strategies (based on airtime availability and USSD codes)" (Mothobi, 2017: 7).

Wireless Fixed Broadband

Despite its limited provision in South Africa, 46 percent of mobile phone users were found to depend predominantly on wireless broadband in 2015 (Deloitte, 2015/16: 10). Due to its cost-effectiveness relative to mobile broadband, focus groups in 2017 further identified free Wi-Fi as a key cost-saving mobile data strategy for poor urban and peri-urban residents (Chair, 2017: 4). In 2016, the cities of Cape Town and Tshwane, launched Free public Wi-Fi (FPW) initiatives as part of the national broadband plan (Geerdts et al, 2016: 3). It aims to add to existing (though private) network of commercial Wi-Fi hotspots by establishing nearly 300 and over 100 public Wi-Fi hotspots over the next few years in Cape Town and Tshwane, respectively (Geerdts et al, 2016: 27-55). To date however, the success of these initiatives have been limited by both their lack of network reliability and coverage beyond public buildings or inner city public spaces such as shopping centres (Geerdts et al, 2016: 100).

4. ICT Policy And Regulation

This chapter highlights the evolving process of ICT reform and its consideration for the digital inclusion of the urban poor through a cursory overview of institutions and key policy developments aimed at reducing digital divides. For the purposes of this thesis, only policy or legislature publically available as of June 2017 are considered.

Early reform

Since 1994, national ICT policy in South Africa has been defined by the need to reform a historically unequal ICT ecosystem to allow for optimal participation within the international Information society and the enablement of socio-economic, racial and spatial transformation of the country (Gillwald, 2005). The 1996 White Paper on Telecommunications therefore represented one of the premier national ICT policies seeking to produce a policy environment conducive to ensuring universal services to disenfranchised urban and rural areas (Department for Communications, 2014: 13). Despite this aim however, the subsequent release of White Papers on Postal Policy (1998), Broadcasting (1998) and e-Commerce (1999); notably embedded a default approach to ICT reform in South Africa characterised as State-centric, supply-side and rural focused (Department of Communications, 2014: 8; Gillwald et al, 2016: 28-29).

Following the promulgation of the Telecommunications Act in 1996, and the Independent Communications Authority of South Africa (ICASA) Act in 2000, ICASA was established as the independent regulator of the ICT sector (Republic of South Africa, 2000: 1). As the product of the merger between the South African Telecommunications Regulatory Authority (SATRA) and Independent Broadcasting Authority (IBA), the mandate of ICASA has been reflective of this approach to reform through its high-level supply-side objectives for the privatisation of the telecommunications monopoly incumbent (Telkom) and liberalisation of the market (Gillwald, 2005: 471; Horwitz & Currie, 2007: 445). Despite implying its responsibility to monitor the quality and affordable provision of universal ICT access, in addition to sector pricing practices, it was the enactment of the 2005 Electronics Communication Act which formally imposed upon ICASA the responsibility of ensuring the inclusion of "rural and under-serviced areas" in the convergence of the ICT sector (Republic of South Africa, 2000; Tibane, & Lentsoane, 2016: 91; Department of Communications, 2014: 18).

However, without a plan designed for direct intervention into marginalised areas or formal mechanisms to regularly evaluate their ICT demand, ICASA has focused broadly on re-licensing the entire sector along horizontal lines; local loop unbundling; conducting spectrum valuations and promoting the migration of radio frequency spectrum to digital for the benefit of the sector as a whole (Republic of South Africa, 2006: 23; Gillwald et al, 2012: 7). Although essential to the technical optimisation of the sector, this expanded mandate under the 2005 ECA seemingly resulted in the low institutional capacity of ICASA in both its supervisory objectives and translating reform objectives into the digital inclusion of all marginalised communities (Gillwald, 2005: 483-485).

The creation of the Universal Service and Access Agency of South Africa (USAASA) in terms of the revised version of the Universal Service Agency (USA) under the Electronic Communications and Transactions Act 2002 was aimed at providing clearer targets for the digital inclusion of the marginalised. Moreover, given its mandate to promote universal access and ICT services which are available, affordable and accessible to all segments of society, USAASA is charged with the responsibility of dedicating funding from the Universal Service Access Fund (USAF) towards schemes based on the subsidised "extension of networks into under-served, uneconomic areas and to increase usage by needy people" (Tibane & Lentsoane, 2016: 95; Gillwald, 2005: 475). These schemes however, have often referred to the unsustainable creation of cyberlabs in predominantly rural or central urban regions, rather than the successful implementation programmes that are demand-based and promote the availability of affordable broadband access (Samuel et al, 2005: 25; Connect Africa, 2010; Lewis, 2013: 102). This has regularly highlighted the inability of USAASA to conduct needs-based research in urban areas, optimally utilise USAF, and adapt aggregation based schemes to the convergence era (Hyde-Clarke, 2006: 151; Kariuki, 2009: 150).

<u>2012 ICT Policy Review</u>

The limited success of early reform initiatives to adapt to the convergence of telecommunications, thereby ineffectively promoting the digital inclusion of under-served communities along the urban periphery, triggered the release of a Department of Communications Framing Paper in 2013 to initiate an ICT policy review process currently ongoing (Department of Communication, 2014: 9). Though this 2013 Paper prescribes the re-orientation of policy towards development along a rights-based approach, it does so without targeting any one particular marginalised group in South Africa (Department of Communications, 2014: 9). It does however specifically underscore the right of all South Africans to "benefit equitably from the ability of the communications sector to facilitate social development and improve the quality of life of individuals" (Department of Communications, 2014: 9).

This approach is aligned with the 2012 NDP 2030, premier national policy in South Africa, which envisions ICT as the foundation for the "development of a dynamic and connected information society…that is more inclusive and prosperous", given its overall aim of eliminating headcount poverty and reducing inequality by 2030 (NPC, 2013: 190; Tibane, & Lentsoane, 2016: 5). However, despite highlighting the importance of targeting "underserviced areas and marginalised communities" for the reduction of digital and spatial inequalities, the NDP outlines only a broad timeline of objectives for the market as a whole (NPC, 2013: 193). This is reflected through targets of 100 percent broadband penetration by 2020, the development of a comprehensive e-strategy, as well as the demand-based goal of ensuring the usefulness of ICT for developmental outcomes with particular reference to needs of the rural poor (NPC, 2013: 194-196). In prescribing both ICT supply and demand-based interventions to this end, the NDP particularly highlights the importance of ensuring access to Internet services "at a cost and quality at least equal to South Africa's main peers and competitors" (NDP, 2013; 190).

The 2013 National Integrated ICT Policy Green Paper, as a review of preceding ICT policy reform, underscored the importance of Internet service costs by highlighting the ineffectiveness of previous policies to reduce broadband prices (Department of Communications, 2014: 43). Maintaining the urban-rural divide discourse of the NDP however, recommendations advised by the Green Paper predominantly relate to competition, ICASA reform and the broader extension of existing urban broadband infrastructure to rural areas. Despite its adoption of the rights-based approach in the 2013 Framing paper, rather than ensuring the effectiveness of demand-based polices, the most notable outcome of the Green Paper is the realisation of its prescribed national broadband policy (Department of Communications, 2014: 7-42).

The 2013 "South Africa Connect: Creating Opportunity, Ensuring Inclusion" (SA Connect) represents not only the first national broadband policy initiative in South Africa, but the first ICT policy to explicitly adopt a citizen-centric approach under the Policy review (Department of Communications, 2013: 5). Consequently, SA Connect is the first policy initiative that acknowledges the existence of "urban areas with high population densities that remain unserved" where "insufficient infrastructure competition" exists (Department of Communications, 2013: 24). In addition to pursuing the NDP broadband target with of an average download speed of 100 mbps by 2030, SA Connect subsequently targets a more extensive "infrastructure reach" into both urban and rural areas (Department of Communications, 2013: 11-40). This is encapsulated in its four-pronged strategy to strengthen the regulator's implementation capacity, deploy FPW "at points of connection," establish an open access wholesale fibre and wireless broadband, and promote digital skills (Department of Communications, 2013: 4-6). Although FPW initiatives have yet to extend into the urban sprawl, SA Connect notably provided the basis for the separation of Telkom activities to extend greater broadband access to Internet service providers (ISP) via its 'Openserve' wholesale division (Gillwald et al, 2016: 30).

By incorporating the ideas of both SA Connect and the 2013 Green Paper, the 2016 National Integrated ICT Policy White Paper consequently represents the national "overarching policy framework for the transformation of South Africa into an inclusive and innovative digital and knowledge society" (DPTS, 2016: 3). In replacing the White Papers on Telecommunications (1996) and Postal Services (1998), the 2016 White Paper serves to explicitly outline how Government will realise its ICT ambitions by placing convergence "at the heart" of its multi-stakeholder and user-centric approach (DPTS, 2016: 2). Despite reinforcing the need for both supply and demand intervention however, as outlined by SA Connect, the 2016 White Paper faces critical drawbacks of failing to both develop a discourse on the potential digital inequality within unserved urban communities, as well as practical plans for the 'infrastructure reach' envisioned by SA Connect (Gillwald et al, 2016: 29).

It is therefore within the context of these policy developments and policy gaps in the 2016 White Paper, as well as the 2016 State directive targeted at ICASA to reduce the high cost of broadband "as one of the primary factors hampering South Africa's competitiveness," that the role and contribution of ICT to the development of the urban poor will be assessed in the current analysis (Republic of South Africa, 2016: 11).

5. Conceptual framework

Development and wellbeing

In support of evidence-based policy, the contribution ICT makes towards the lives of the urban poor is understood within this thesis in terms of its ability to facilitate enhanced wellbeing. Using its heterodox conceptualisation by Amartya Sen, this state of wellbeing is defined as the expansion or "active exercise of freedom" (Sen, 1985: 44). It relates to the idea that in order for individuals to live the lives they desire, they must not only have the agency to actively pursue it, but the opportunity to choose how that life is defined (Sen, 1985: 39-44). Specifically, Sen's "valuable states of being" are not only tied with passive "beings and doings" but rather with the ability of individuals to effectively combine and leverage these states as capabilities in ways which are strategic and conducive to actively achieving a desired outcome (Sen, 1985: 38). Combined with the freedom of choice to decide how available capabilities may translate into opportunities, the contribution of ICT to wellbeing is intimately defined by the link between the Internet as a "medium of choice par excellence" and the capabilities it engenders (Gigler, 2011: 6; Kleine, 2011: 125). This conceptualisation consequently emphasises the "effective use" of ICT towards meaningfully accomplishing developmental goals; where the value of ICT is not simply in its provision, but rather how it is used to strengthen capabilities (Gurstein, 2003: 6; McNamara, 2003: 18).

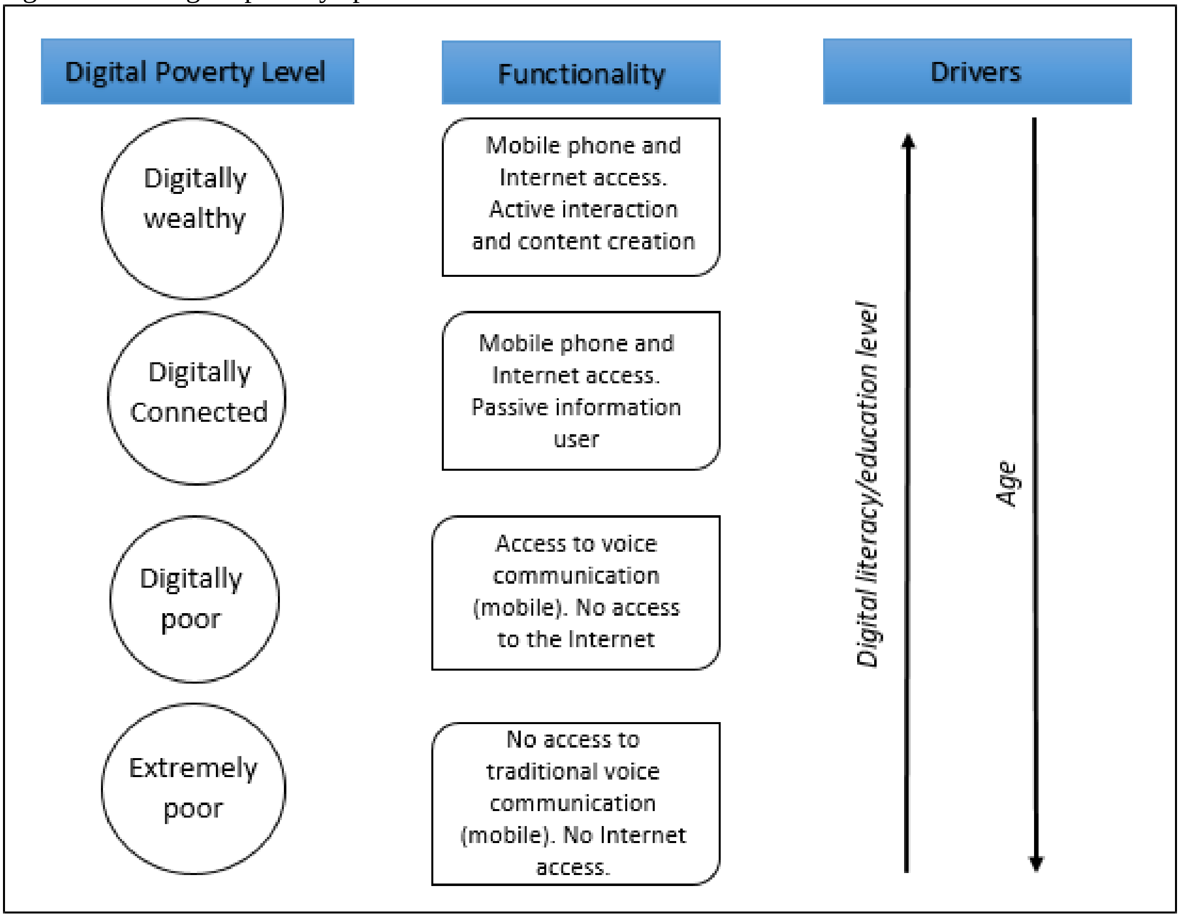
Given this, and drawing on Sen (1985), the optimal contribution of ICT towards wellbeing is defined in terms of its strengthening of three core capabilities. These include *social capabilities* with reference to the capability to associate and effectively communicate with existing social networks, as well as foster new connections which may be leveraged for both social and economic inclusion (Sen, 1985: 31). In turn, *economic* capabilities are additionally observed as vital in terms of having the ability to combine "beings and doings" in ways which are conducive to generating income and wealth necessary to live a free life (Sen, 1985: 33-41). *Human* capabilities are additionally highlighted as essential to the achievement of broader freedoms. By encompassing the capability to maintain good health, it acts as a necessary prerequisite for "a person's ability to choose the life she/he values," and acquire both knowledge and learning (Kleine, 2011: 123). In doing so, it further empowers individuals to pursue opportunities and actively participate in increasingly knowledge-based economies (Sen, 1985: 31).

Digital Poverty Framework

Roxana Barrantes's (2010) Digital Poverty Framework (DPF), is used and updated to take into account the multi-functionality of convergence technology, to operationalise the ideas of Sen (1985) and analyse ICTs in terms of their use towards enabling strengthen capabilities. The DPF crucially extends the analysis of ICT supply in placing greater emphasis on its demand and effective usage as opposed to the typical "have and have-nots" discourse associated with the digital divide, (Barrantes, 2007: 33). Although recognising the importance of ICT access as a necessary prerequisite to use, the predominant focus of the DPF "is not on any type of information or communication per se, but rather on data that can be stored, made available, used and consumed by digital media" (Barrantes, 2010: 3). The extent to which ICT contributes towards the capabilities of the poor to enhance their wellbeing is therefore reflected in how it is used to "broaden the equipment's functionality" (Barrantes, 2007: 33).

Hence, the Framework adopted within this paper defines digitally poor individuals as those who are unable to extract the relevant information and communication dividends from digital technologies for improved wellbeing (Barrantes, 2007: 33). The DPF recognises however that due to the personal nature of ICT access and usage the digitally poor cannot only be classified by economic status or supply constraints, but also by the severity of limited demand. As a result, the DPF views digital poverty on a spectrum in Figure 5.1 from supply (bottom), to higher order demand constraints, which inhibit optimal gains from available ICT. Economically marginalised urban individuals, due to their proximity

Figure 5. 1 – Digital poverty spectrum



Source: Adapted from Barrantes (2007, 2010)

to various sources of Internet and their substantial adoption of Smartphones, are consequently conceptualised as existing closer to the latter constraint than the former (Barrantes, 2007: 34).

Following the hypothesis of the urban poor as more demand constrained in ICT, the DPF hypothesizes four main determinants which may explain constrained use and the placement of the urban poor along the digital poverty spectrum in Figure 5.1 (Barrantes, 2007: 34-35):

1. <u>Education</u>

With human capital conceptualised as a prominent driver of ICT demand, education is hypothesised as a primary determinant for its optimisation. According to the DPF, the higher the education level attained by the urban poor, the lower the likelihood of being digitally poor and the greater the chances of using ICT meaningfully to extract digital dividends (Barrantes, 2010: 35). This is supported by the understanding that the more educated individuals are, the more likely they are to be both aware of and motivated to extract gains from ICT usage (Van Dijk, 2006: 227; Milek et al, 2011).

2. Age

The second main determinant hypothesised is age. From extant literature and arguments made by Millward (2003), age is hypothesised to be positively associated with the likelihood of being digital poor. The further DPF argues that this relationship is explained as consequence of inadequate digital literacy and practical exposure to modern ICT.

3. ICT supply

In terms of functionality, available ICT infrastructure is conceived as the third key determinant for digital poverty given the recognition of its necessary, but insufficient requirement for retrieving digital dividends. More specifically, in light of the prominence of convergence technology, the ownership of more traditional mobile phones and ICT are positively related with digital poverty. The Internet, and access to more sophisticated forms of Smart technology, are conversely positively associated with the satisfaction of ICT demand and meaningful ICT usage.

4. Functionality of ICT

Lastly, the degree of functionality accomplished via ICT is hypothesised as a prime indication of how intensely ICT is demanded and used in expanding capabilities. It is this last characteristic which distinguishes optimal ICT usage from its sub-optimal form. According to Barrantes (2010: 4), this underscores the difference in ICT use from "the mere reception of information" to its full interaction and contribution towards digital content.

This distinction can be further understood as the difference between **passive** and **active** ICT use. Taken from Montague and Xu (2012: 703), passive users are defined as those who receive more information than they contribute towards. Rather than taking advantage of the enhanced functionality of digital technologies, passive users restrict themselves to basic interactions with ICT such as those associated with the traditional delivery-based functions of radios and telephones. As a result, passive users are associated with Internet services which demand no input, are text-based, and do not allow interaction between multiple users or service provider (Lee et al, 2005: 279).

In contrast, active users of ICT are those who not only receive information, but actively engage, contribute, request, receive and modify content in ways which optimally leverage opportunities into expanded capabilities (Lee et al, 2005: 275). As opposed to restricting use to information-delivery based services, active users use digital technologies to interact with governments, engage in e-commerce, share and modify content across networks, develop social connections, shop online, and enhance overall capabilities associated with living freely (Barrantes, 2007: 35; Lee et al, 2005: 279).

Given the above, active users further differ from passive users in the **frequency** of their use (Howard et al, 2001: 393). Specifically, the more active or frequent ICT applications are used, the more intensely choices from digital services are capitalized upon, and the greater the contribution of ICTs to the lives of individuals (Howard et al, 2001: 393). Since active users are assumed to use ICT more frequently than passive users, the DPF consequently conceptualises active users to have a greater appreciation not only of ICT, but also of its role towards wellbeing. It is only when ICT is actively used in both meaningful and frequent ways, that ICT has the most potential to improve the wellbeing and freedoms of individuals.

Degrees of digital poverty

Given these characteristics, the DPF spectrum of digital poverty is defined according to the four broad categories depicted in Figure 5.1.

According to the diagram, **extremely digitally poor** individuals are those either without access to ICT, or the ability to optimally use ICT in an active capacity (Barrantes, 2010: 4). When access is provided to extremely digitally poor individuals, its use is typically passive.

Digitally poor individuals refer to those who may have access to digital technology but limited in usage due to a "lack of supply or human capital limitations, such as lower levels of education, a higher degree of illiteracy, or advanced age" (Barrantes, 2007: 35; Barrantes, 2008: 4). The digitally poor are thus assumed to be non-Internet users.

The **digitally connected** and **wealthy** however possess both access to ICT hardware as well as use of the Internet, though in different capacities (Barrantes, 2007: 35-36). **Digitally connected** users are distinguished as passive users who vary in frequency of use. According to Barrantes (2010: 4), this implies that their Internet usage "substitute[s] for traditional types of information consumption or communicating in general, instead of changing the way people interact with information providers." Although digitally connected individuals are capable of benefiting from Internet access, their sub-optimal use inhibits the significant strengthening of capabilities. The **digitally wealthy** however are active users in terms of both type of usage and frequency. These individuals critically possess the knowledge to optimally transform available choices online into enhanced wellbeing offline. In applying the DPF to the current analysis, the proportion of digitally wealthy individuals among the urban poor is perceived to constitute the extent to which ICT contributes towards their wellbeing.

6. Methodology

Method appropriateness

In order to estimate the DPF of the urban poor, a quantitative approach is applied as per the methodology adopted by Barrantes (2007, 2010). This method diverges from the popular qualitative or mixed method approaches typically utilised within the literature for assessing the effect of ICT on livelihoods or wellbeing (Attwood et al, 2014; Bowora & Chazovachii, 2010; Chigona et al, 2016; Duncombe, 2007; Miller et al, 2005; Fisher et al, 2015; McNamara, 2008; Waema & Miroro, 2014; Agüero et al, 2014; Crandall et al, 2012; Sife et al, 2010).

Although useful, findings produced from these studies are inadequate to generalise across wider populations and thus inform national policy (Rahman & Akter, 2010: 5). In addition, the use of relatively small sample sizes has often implied a lack of comparable, robust, quality data to sufficiently analyse the role of ICT, to a degree of statistical significance, on development (Souter et al, 2005: 21). These limitations may be overcome however by adopting a quantitative approach, backed by nationally representative survey data.

Data Sample

Data used to support this analysis is taken from the cross-sectional 2017 RIA "After Access" Household, Individual and Informal Business survey. Although undertaken in countries from Latin America and Asia, this survey reflects the only nationally representative supply and demand-side survey of its kind in Africa (Gillwald et al, 2012: 38). The African surveys were conducted between April and September 2017 across nine African countries, and utilised both structured questionnaires and focus groups to identify constraints to both ICT access and use (RIA, 2017).

This took place with a particular focus on mobile phones, computers/laptops, and various forms of Internet (RIA, 2017). Further key areas investigated by the survey include the frequency of hardware and specific mobile application use, digital literacy, employment-creation, mobile money transactions, social media engagement, affordability and various other barriers which allow for a disaggregation of findings along urban and rural geographic locations, in addition to gender, age and education. This research will only be analysing the South African data.

Survey design

The "After Access" survey was conducted based on a random sampling design using clustering and single stage stratification between May and August 2017 (RIA, 2012: 1). The 2011 Statistics South

Africa Census Master Frame was used as the sampling frame for the survey instead of the Small Area Layers (SAL) frame due to time and cost considerations (RIA 2017: 14). Enumerator areas (EA) taken from this frame were subsequently divided into urban and rural (farms, smallholdings and traditional residences) geographic locations, and each sampled for stratification using probability proportional to size (PPS) (RIA, 2012: 1). Based on a clustering of 24 households per EA, 30 rural and 45 Urban EAs were sampled (RIA, 2017: 14). For each urban and rural EA, final sampling was conducted using PPS separately (RIA, 2017: 14).

For the given geographic sample, data were collected from two electronic listings created for all households and businesses, both of which were subject to real time geographic checks (RIA, 2017). These listings formed the sampling frame for simple random sampling of households, and subsequently, the simple random sampling of one individual per household. Randomly selected individuals within this survey, 15 years or older, were defined as adults " who lived and ate with the household for at least six months including those who were not within the household at the time of the survey and were expected to be absent from the household for less than six months" (RIA, 2012: 3). In order to limit selection bias and ensure consistency with the composition of the true national population, 60 percent of the sample reflected the oversampling of urban households and individuals, with 40 percent constituting the undersampling of their rural counterparts (SACN, 2016: 19; RIA, 2012: 2). This yielded a target of 720 rural and 1080 urban households (RIA, 2017: 14). In reality, taking into account clustering effects and the true dispersion of EAs nationwide, this method produced a final sample size of 1815 households comprising of 740 rural and 1075 urban households/individuals. Although only 1771 households and individuals were uniquely identified, this reflected the likelihood of surveyors incorrectly recording households rather than inconsistencies within the sample selection itself. This is indicated by the absence of any missing observation units within the sample due to the application of a random replacement methodology when households from particular EAs were unavailable (RIA, 2017: 16).

Survey weights

To ensure national representivity, sample weights were applied to the data when analysed using the statistical software programme, Stata 15. Based on the simple random sampling (SRS) of final households and individuals, the construction of inverse selection probability weights differed from formulations based on probability proportional to size sampling (RIA, 2017: 16). This methodology produced EA selection probability weights equal to the target number of EAs per strata divided by the given EA (RIA, 2017: 16). Using these, household and individual inverse selection probability weights were further derived to "gross up the data to national level when applied" (RIA, 2017: 10). These were constructed with the critical application of design weights to compensate for the "over-sampling of urban EAs and under-sampling of rural EAs" (RIA, 2017: 11). With final adjusted households weights applied, rural and urban households were scaled up from 740 and 1075, to 5 million and 12 million respectively. Individually, this represents 14 million rural dwellers and 26 million urban dwellers. In total, this suggests an underestimation of the official 2017 population by 16.5 million according to the Stats SA estimate of 56.5 million (StatsSA, 2017(b): 2). This is primarily as a result of the RIA individual-based survey design which, in line with the International Telecommunications Union[1] indicator collection guidelines, is the basis for mobile phone access and use – while fixed communications is measured at the household level. The census and annual community survey collect data at the household level only and extrapolate for the entire population, and while the household measures are drawn from the same census sample frame, the RIA individual survey measures mobile phone access of only those who are 15 years and older (as does the census). This also avoids having to get parental clearance for younger users who make up a relatively small percentage of total users. When the survey presents results on mobile usage therefore it reflects only those people in the population only 15 years and older (40 million people). Further slight variations may derive from the RIA weights being based on the 2011 census data not the 2017 population estimates of StatsSA.

Missing observations

Prior to an analysis of the data, a test for item non-responses was conducted to determine whether missing observations were present in the sample, and if those existing could be ignored. This was achieved using Little's MCAR test to distinguish whether existing missing responses were missing completely at random (MCAR), or missing at random (MAR) (Li, 2013: 795). Following the definition of MCAR as the assumption that "the missingness of the data is independent of both the observed and the unobserved data," the null hypothesis of the MCAR test for "no differences between the means of different missing-value patterns" was rejected at the 5% significance level using the likelihood-ratio statistic (Li, 2013: 795-796).

Failing to reject the null hypothesis, this test indicated the likelihood of non-responses for variables such as "mobile phone type," "Internet use," age and race to be MAR and ignorable once taken into account within the model. This was achieved through recognising the correlation between missing items and negative responses for prior qualifying questions such as mobile phone type and Internet use. As a result, item non-responses for these variables were either recoded as zero for binary variables such as Internet use, or left as missing when validated by no phone ownership in the case of mobile

[1] See https://www.itu.int/en/ITU-D/Statistics/Pages/definitions/default.aspx , particularly pages 38 to 41.

phone type. Although the number of missing observations for age were found to be negligible, more than 10 percent of the unit responses for race were found missing. Surveyed as a last minute addition to the original questionnaire, these missing values reflected the inability of surveyors to reconnect with respondents following the initial roll-out of the survey according to the survey and data base annotations. Rather than exclude this variable from the analysis, missing race values were proxied by language spoken as a typical reflection of their self-identified race (Brown and Licker, 2003: 7).

Defining a poverty line

A poverty line was established to distinguish between poor and non-poor groups for the given sample. Within poverty analyses literature, the criteria for the selection of this line has been subject to a significant degree of contentiousness (Donohue & Biggs, 2015: 392; Jazani & Khatavakhotan, 2011: 344). Despite criticisms for the bluntness of absolute poverty lines, the concept of "the bottom of the pyramid" (BoP) is adopted as the prevailing measure to differentiate between poor and non-poor individuals in accordance with previous methodologies in ICT analyses (De Silva et al, 2008; Crandall et al, 2012; Stork et al, 2013; Kaplinsky, 2011 & Gillwald et al, 2012). Initially popularised by C.K Prahalad and Stuart Hart, the concept of BoP refers to the existence of a four tier "world economic pyramid" in which billions of "aspiring poor" reside at its base as not simply potential consumers but as "actively engaged" producers of wealth (Prahalad & Hart, 2002: 1; Prahalad, 2010: 27). As a result, the particular applicability of the BoP concept to ICT and development stems from its identification of the poor as both willing and price discriminating individuals, capable of capitalising on resources to overcome exclusion (Prahalad & Hart, 2002: 2-14).

Given conceptualisation of poverty, consistent with the methodology adopted by both Crandall et al (2012) and Gillwald et al (2012) in their ICT analysis of the BoP, this paper adopts the South African lower bound poverty line (LBPL) as its welfare indicator to identify the BoP (NPC, 2012: 9). In doing so, it represents individuals who "do not have command over enough resources to consume or purchase both adequate food and non-food items and are therefore forced to sacrifice food to obtain essential non-food items" (StatsSA, 2011: 1). Given its additional utilisation by the NDP as a benchmark for poverty alleviation, this poverty line further serves as both a key policy indicator as well as a measurement for the severity of opportunity costs endured by the poor in using ICT (NPC, 2012: 363).

The LBPL is defined at R501 or less per capita per month in accordance with rebased figures produced by the 2010/2011 StatsSA National Income and Expenditure survey (StatsSA, 2011: 10). At a national level, this equates to 37 percent of the population in South Africa, and when converted using 2011

PPP, amounts to $105 per-person-per-month (StatsSA, 2011: 10)[2]. In the absence of a formal national urban and rural poverty line, this LBPL is applied and adjusted for 2017 prices using the national headline consumer price index (CPI) published by StatsSA. Defined as the average CPI for all urban and rural areas, the LBPL is adjusted according to the mid-point month in which CPI data for 2017 was collected (StatsSA, 2017 (a): 8). Utilising the CPI for April 2017, this produces an inflation-adjusted LBPL of R758 per person per month, and identifies all individuals with a monthly income of R758 or less as part of the BoP[3]. The BoP is measured for rural residents in addition to those from urban areas to allow for comparison.

DPF construction - Definitions

Randomly selected adults from each household were chosen as units of analysis for the DPF. This is consistent with International Telecommunication Union (ITU) indicator definitions which identify mobile phones as primarily for individual use (and fixed lines for household use) (International Telecommunication Union, n.d). In addition to its use by Barrantes (2010: 6), this identification further draws on the personal nature of both wellbeing, and the use of ICT in achieving individual goals or "preference orderings" (Barrantes, 2007: 37; Sen, 1985: 171; Wang, 2015: 19; Gurstein, 2003: 6).

Given the above, ICT itself is defined as technology capable of not only delivering information and enabling communication, but also electronically reusing, repurposing, manipulating and reorganising content (McNamara, 2003: 13). For the purposes of this study, ICT is interpreted and analysed as constituted by mobile phones and the Internet. The term ICT is consequently used interchangeably with these technologies.

Users of ICT are assumed to be synonymous with self-reported ownership and defined as dichotomous variables. Users of mobile phones are proxied by respondents who answered in the affirmative to the binary question, "Do you own a mobile phone?" Although the practice of mobile phone sharing is recognised, this question is neither directly asked in the survey nor considered pertinent to the study due to its decreasing relevance in South Africa (Aker & Mbiti, 2010: 212; Gillwald et al, 2012: 47). Internet users are further identified as those who self-reported in the affirmative to the binary question, "Have you ever used the Internet?" Although this answer required a certain level of digital literacy by

[2] This figure is below the recently adjusted international poverty line of $1.90 per day (Cruz et al, 2015: 1).

[3] For comparability, average monthly individual income and expenditure were additionally adjusted for inflation according to the CPI of the mid-point month during which the RIA survey was taken. Using the CPI for June did not produce significantly different results relative to the application of April CPI. This is due to the marginal differences in monthly CPI for 2017.

respondents understand the definition of "the Internet," surveyors were explicitly requested to explain its meaning in order to minimise measurement error.

Digital poverty categories

DPF categories are developed to account for both the access and use of ICT in terms of meaningful functionality. In defining the latter for each category, active and passive use is determined using survey questions relating to mobile phone application (m-app) usage as opposed to general Internet usage. This allows for a more precise measurement of how mobile phones are used and to what extent "data-hungry" applications are actively leveraged to build capabilities. In doing so, the digitally poor are assumed to be all owners of basic mobile phone without Internet functionality or access to m-apps.

Mobile applications used to distinguish between active and passive users are defined in Table 6.1. In accordance with the DPF outlined in Chapter Five, active applications (*active_mapps*) refer to those associated with the development of capabilities essential to an enhanced wellbeing i.e. economic, social and human capabilities. Passive applications (*passive_mapps*) are conversely less associated with development and more geared towards information consumption. Each m-app is left unweighted to avoid imposing normative judgements on the value of m-apps for given capabilities. Since each mobile application was surveyed and coded along a 4-point Likert scale ranging from 1 to 4 based on frequency of use, all active and passive applications used at least once by "connected" DPF categories are disaggregated into user frequency binary variables in terms of occasional (1), weekly (2), daily (3), or zero (4) usage.

Following these classifications, five categories of the DPF are created as individual dummy variables and subsequently grouped into a single categorical variable based on the following definitions:

1. ***Extremely digitally poor*** are those respondents who report neither ownership of a mobile phone (*m.phone = 1"yes"; 0="no"*) nor to have ever used the Internet (*webuse=1"yes"; 0='no"*).

$$X.Digtally\ poor = m.phone\ (= 0) + webuse\ (= 0) \tag{1}$$

2. ***Digitally poor*** are those respondents who report to own a basic (*model*=non-Internet enabled=1) mobile phone, but to never have used the Internet.

$$Digtally\ poor = m.phone\ (= 1) + model(= 1) + \ webuse\ (= 0) \tag{2}$$

3. ***Passively connected*** are those respondents who report both ownership of an Internet-enabled (*model*= Internet enabled= 2 "Feature" or 3 'Smartphone") mobile phone and use the Internet, but in a strictly passive way. This implies the occasional to daily use of at least one information-receiving based mobile application, and no use of any active applications.

$$P.Connected = m.phone\ (=1) + model(>1) + \ webuse\ (=1) + \ passive\_mapps(<4) + \ active\_mapps = 4) \quad (3)$$

4. ***Mildly active*** are those respondents who report both Internet-enabled mobile phone ownership and active use of the Internet. These respondents make use of designated active applications weekly or occasionally. This low level of active usage implies the sub-optimal extraction of digital dividends relative to the digitally wealthy.

$$M.Connected = m.phone\ (=1) + model(>1) + \ webuse\ (=1) + \ active\_mapp(<3) \quad (4)$$

5. ***Digitally wealthy*** are those respondents who report both Internet-enabled (feature or Smart) mobile phone ownership and active use of the Internet on a daily basis. This frequency is based on its conventional definition within ICT adoption literature (Kania-Lundholm & Torres, 2015: 29; Singer et al, 2012; 1; Montague & Xu, 2012: 702; Howard et al, 2001: 383).

$$W.Connected = m.phone\ (=1) + model(>1) + \ webuse\ (=1) + \ active\_mapp(=3) \quad (5)$$

Table 6. 1 - Passive versus active use

Internet use type	Mobile phone application
Passive use	
	Informational:
	Use of news apps (local news, national headlines, technology announcements, sport)
	Use of weather apps (local forecasts, natural disaster updates)
	Use of search tools (directions, phone numbers, recipes, etc)
	Entertainment:
	Use of game apps (puzzles, charades, etc.)
	Use of entertainment apps (movie trailers, celebrity gossip, radio station guides)
	Text-based:
	Use of voice or messaging apps (whatsapp, skype, viper, line, talkray, telegram, facebook messenger))
Active use	
	Economic:
	Use of business apps (calculate, convert, translate, etc)
	Use of trading apps (selling and buying online)
	Use of transport apps (public transportation info, taxis, uber)
	Social:
	Use of social networking apps (facebook, whatsapp, instagram, snapchat, twitter, linkedin, line)
	Use of dating apps (Tinder etc)
	Human:
	Use of educational apps (dictionary, learning tools)
	Use of health apps

Source: Author’s own

DPF Analysis

The DPF is measured for both urban and rural BoP, in addition to the overall national population to serve as initial comparisons, when testing hypotheses posed in Stata 15. The DPF for the urban BoP is further contextualised through its characterisation via cross-tabulations. This achieved through an assessment of both the urban BoP's access profile in terms of hardware, Internet sources and mobile related expenditure; in addition to individual characteristics such as demography (gender, education, employment status, age, Race) and average monthly income.

To determine the statistical significance of characteristics for each DPF category of the urban BoP, measures of association between categorical variables are tested using the chi-squared test of association. This is substituted for Fischer's exact test when expected cell frequency counts fall below 5.Statistical significance is defined for cross-tabulations when the null hypothesis (H_0) of independence or no association between categories of digital poverty and contextual characteristics is rejected. In the case of continuous variables, measures of association are calculated using a test of mean independence (t-test) based on the fulfilment of its assumptions of normality, equal variances and SRS. If the assumption of standard error equality failed, tests were performed using unequal variances. If the assumption of normality was breached, as in the case of the distribution of data expenditure as a proportion of mobile expenditure, the non-parametric Mann-Whitney two-sample test was conducted to test for independence in the medians (Wild & Seber, 2011: 4). The Gamma measure of association was used in the case of ordinal characteristics. As an asymmetric measurement, Gamma measures the degree of monotonicity between variables under the same null hypothesis as the chi-squared test of association (Agresti, 2002: 59). For all measurements utilised, the null hypothesis is rejected for variables returning values of alpha (α) less than 0.05, thus implying the existence of a relationship between DPF categories and given characteristics which is statistically significant rather than by chance.

7. Data Analysis

Descriptive statistics

According to Table 7.1, nearly 40 percent of the weighted sample, or 15 million adults, are found to reside at the BoP. This finding matches the latest LBPL poverty headcount estimated produced by StatsSA for the national population in 2015 (StatsSA, 2017(a): 14). By disaggregating the weighted BoP sample further by geographic location, a relatively larger proportion of the BoP is found to reside within urban areas by 53 percent compared to 40 percent among rural areas. At a national level this further implies that the urban BoP accounts for 21 percent of the sample population relative 15 percent by the rural BoP.

Table 7. 1 - Bottom of the Pyramid segmentation

	National	BOP	Urban BOP	Rural BOP
Average monthly income per capita (constant R)	3639	220	194	255
n (% of n) (m)	40	15 (36%)	8 (21%)	6 (15%)

Authors own calculations. Results are weighted.
Source: 2017 "After Access" RIA household and Individual ICT access and use survey

Despite the use of inverse PPS weights to compensate for urban oversampling, this finding distinctly differs from 2015 national estimates produced by StatsSA in which the rural poor are found to dominate this poverty criteria by 65 percent (StatsSA, 2017(a): 72). This indicates that although the survey may accurately reflect the geographic composition of the country, the rural poor remain under-represented according to the BoP criteria used. This is observed given the real average monthly income of R255 for rural individuals - an estimate R61 higher than the urban BoP real average monthly per capita income and R35 higher than the overall BoP average of R220 per capita. Given the inability to verify BoP status using household income from the current data, it is possible that the urban BoP may comprise more of "poor" individuals who are classified as dependents on household income, such as students, than within the rural BoP.

To further understand the composition of the sample BoP, Table 7.2 highlights the existence of broad similarities between BoP and national households in terms of demography. Though rural households tend to host more occupants, clear trends exist across households with the majority of households owned and with access to energy via the national main-line grid. This mirrors national findings for improvements in access to main-line electricity supply for 84 percent of the population in 2017 (StatsSA, 2018: 32). This is in stark contrast to water access in which nearly 44 percent of urban BoP households report to be without any source of water at all. This lack of water access is higher than the 27% of the total household sample that report no water access, and contradictory to the findings of the 2016 StatSA Community Survey that cite only 10% of metropolitan households without access (StatsSA, 2016:4). These discrepancies are however likely due to the inability of aggregate figures to accurately identity unequal service delivery to urban and rural BOP households given that no national statistical publications currently exist to measure these inequalities.

Beyond service delivery, additional key household trends include secondary education as the highest level within households, most of which have no migrant family, speak isiXhosa or isiZulu as their

Table 7. 2 - Household descriptive statistics

% of n	Rural BOP	Urban BOP	National
Household size			
1	8,5	14,8	14,6
2	13,8	17,4	18,7
3	20,6	17,5	17,6
4	17,5	20,8	18,1
5	8,9	10,5	11,7
6	9,6	5,8	8,1
7-11 members	19,6	12,4	10,4
12 or more	1,5	0,8	0,8
Home ownership			
Own	79,7	67,6	73,6
rent	3,1	18,7	14,3
occupy for free	17,2	13,7	12,2
Access to water			
Yes -yard	53,6	22,9	33,4
Yes -house	39,0	33,6	39,5
No	7,4	43,5	27,1
Access to electricity			
Main electricity grid	84,2	86,5	88,9
Generator	0,8	0,5	1,0
Solar	3,1	0,6	1,1
No	8,0	9,4	6,6
Other	3,9	3,1	2,5
Highest level of household education			
Primary	1,4	1,1	2,2
Secondary	13,5	7,9	12,2
Tertiary	76,0	67,4	61,2
None	9,1	23,7	24,4
Main household language			
Afrikaans	15,7	5,6	11,8
English	0,0	7,8	9,6
isiNdebele	2,2	4,2	2,7
isiXhosa	9,7	16,5	16,7
isiZulu	39,0	31,4	29,0
Northern Sotho	9,9	5,1	6,7
Sesotho	3,1	14,3	8,2
siSwazi	5,3	0,8	2,1
Tsonga	3,8	3,1	3,2
Tswana	8,4	3,7	4,6
Venda	2,6	3,9	3,0
Other	0,4	3,6	2,4
Migrant family			
Yes	96,7	93,9	93,6
No	3,3	6,1	6,5
Province			
Eastern Cape	9,5	8,8	11,7
Free State	1,4	8,9	4,4
Gauteng	0,0	28,4	17,6
KwaZulu-Natal	44,9	20,9	26,0
Limpopo	14,6	5,3	8,2
Mpumalanga	9,2	11,4	8,8
North West	9,6	1,9	4,0
Northern Cape	10,9	0,2	3,7
Western Cape	0,0	14,2	15,6

Authors own calculations. Results are weighted. Source: 2017 “After Access” RIA household and Individual ICT access and use survey

Table 7. 3 - Individual descriptive statistics

% of n*	Rural BoP	Urban BoP	National
Age			
15-24	49,0	51,7	25,6
25 – 34	24,0	25,5	22,9
35 – 44	11,9	10,8	17,2
45 – 54	6,5	4,7	12,7
55 – 64	6,5	5,5	12,4
65yrs and above	2,2	1,4	9,2
Gender			
Female	57,6	55,1	54,9
Male	42,4	44,9	45,1
Race			
African	89,1	86,4	79,8
White	1,2	0,9	2,1
Coloured	9,6	1,0	4,4
Asian/Indian	0,0	0,0	0,0
Other	0,0	0,1	0,1
Marital status			
Married	13,3	13,8	32,0
Single	82,3	79,4	56,8
Widow	3,1	2,0	6,4
Divorced	0,5	1,7	2,6
Years of education			
1-7yrs	13,5	11,3	16,8
8-12yrs	66,5	75,6	58,0
13-20yrs	10,5	11,6	17,4
21 or more years	0,3	0,4	1,5
None	9,3	1,1	6,3
Economic Activity			
Employment	5,4	5,3	26,6
Strict unemployment	34,8	37,6	23,0
Flexible unemployment	10,4	4,6	8,3
Self-employed	1,1	0,9	5,0
Student	35,8	41,0	17,8
Unpaid housework	10,0	6,2	8,6
Retired	2,6	4,5	10,8
Banked			
Yes	29,0	41,6	56,9
Use of someone else's	0,8	6,5	3,2
No	70,2	51,9	39,9
Hours spent with interest groups			
0-6hrs	90,8	91,3	92,5
7-12hrs	5,1	7,8	4,9
13-24hrs	3,6	0,9	2,2
25 hrs+	0,6	0,0	0,4

Authors own calculations.
Results are weighted. Source: 2017 “After Access” RIA household and Individual ICT access and use survey

main language, and predominantly reside in large urban provinces such as Gauteng (28 percent), KwaZulu-Natal (21 percent) and the Western Cape (14 percent).

At the individual level, Table 7.3 finds urban BoP adults broadly reflective of trends at both the rural and national level. Specifically, the majority of urban poor respondents appear to be between the ages of 15 and 24 years old, predominantly African, single and with a slightly larger proportion of females. Reflecting South Africa's youth bulge on aggregate, and among the BoP, 76 percent of poor urban respondents in the sample hold between 8 and 12 years of education, and 41 percent claim studying as their main form of economic (in)activity (StatsSA, 2017(a): 29). Although the former remains true at the national level, wage employment dominates student activity as the main form of economic activity for the national population. This implies a clear distinction between true wage-based poverty at a national level, and the poverty experienced at the urban BoP which may simply reflect an economic dependence by the urban poor on household income. Furthermore, it may imply a key differentiation between urban BoP individuals and the rest of the population regarding both ICT access and use. The youthfulness of the urban BoP sample is further highlighted by finding 7 percent of this this group to bank via another account, and to only physically socialise between 0 and 12 hours with interest groups.

To identify the relationship between BoP status and ICT supply, Table 7.4 provides an overview of ICT access by the urban and rural BoP relative to the national level. Although households at national level are found to have the greatest access to ICT with an average mean of 0.17, a bias in access is found towards urban BoP households relative to its rural counterpart. Despite displaying less significant associations with ICT overall, the urban bias in ICT access among the BoP appears explained by nearly 30 percent of households reporting access to the Internet, 12 percent reporting ownership of at least one tablet, and 16 percent reporting a positive statistically significant association with at least one laptop at the 5 percent significance level. Interestingly, both BoP groups indicate that more than 40 percent of household Internet stem from "other" sources.

Table 7. 4 - Access digital divides

n (millions)	**Rural BOP**			**Urban BOP**			**National**		
	n	Col (%)	Mean	n	Col (%)	Mean	n	Col (%)	Mean
Household									
Telephone	0.03	1,4	0,01***	0.1	4,0	0,0	1.3	7,9	0,1
PC	0.04	2,0	0,02***	0.2	7,2	0,1	1.4	8,1	0,1
More than 1 PC	0	0		0	0,0		0.1	0,5	
Laptop			$0,1^{+++}$			0,2			0,2
1	0.09	4,6		0.5	15,6		2.2	13,3	
2	0.01	0,5		0.07	2,1		0.1	2,8	
3	0	0		0.05	0,2		0.1	0,5	
4 or more	0	0		0	0,0		0.002	17,0	
Tablet			$0,1^{+++}$			0,2			0,2
1	0.1	6,1		0.4	12,1		2.0	12,3	

2	0.03	0,2		0.06	1,7		0.3	2,0	
More than 2	0	0		0	0		0.1	0.53	
Internet access	0.1	4,8	0,1***	0.4	11,6	**0,1**	1.9	11,2	**0,1**
ADSL	0.01	12,2		0.1	29,8		0.7	37,6	
Dongle	0.01	14.0		0.1	34,4		0.7	35,5	
Fibre	0.005	5,4		0.02	5,3		0.04	2,1	
Other	0,0	68,5		0.0	40,3		0,0	35,6	
Total average			0,06			0,16			0,17
<u>Individual</u>									
PC	0.4	6,5	0,1***	0.7	8,2	0,1	5.6	14,0	0,1
Mobile phone	0.5	79,2	0,8*	0.7	82,0	0,8	33.7	83,8	0,8
Mobile phone type									
Basic	2.1	43,3		1.6	22,9		12.2	36,1	
Feature	0.5	10,2		0.8	10,9		2.8	8,4	
Smartphone	2.4	46,4		4.6	66,2		18.7	55,5	
Mobile phone contract			0,9			0,9			0,9
Contract	0.1	1,7		0.02	3,0		2.9	8,7	
Prepaid	4.8	98,3		6.7	97,1		31.0	91,3	
Internet use	2.9	46,7	0,5*	0.5	62,8	0,6***	20.0	49,7	0,5
Mobile Internet	2.5	87,6	0,4	4.9	93,0	0,6***	18.5	92, 2	0,5
PC Internet	0.8	27,8	0,1***	0.2	35,5	0,2	9.2	45,8	0,2
Free Public Wi-Fi	0.5	17,0	0,1***	0.3	51,7	0,3***	8.7	43,0	0,2
Total			0,44			0,51			0,49
Monthly mobile expenditure (real R)			36,9 ^{xxx}			62,2^{xxx}			137,43
Mobile expenditure as a proportion of monthly income			0,17^{xxx}			0,28^{xxx}			0,09
Data costs as a proportion of monthly mobile expenditure			0,34			0,49^{xxx}			0,38

Authors own calculations. Results are weighted.
*p<0,05; **p<0,01; ***p<0,001. $^{+}$p<0,05; $^{++}$p<0,01; $^{+++}$p<0,001
Measures of association between dichotomous nominal variables were calculated using the Chi-Squared statistic (*). Where cells included joint frequencies of less than 5, Fischer's exact measure of association was used. Gamma measure of association (+) used for ordinal dependent variables. Statistical significance was determined for each test against the null hypothesis of independence between variables when p<0,05; p<0.01 and p<0,001. A difference of means test (ttest) (^{x}) was used between continuous income and expenditure variables against the null hypothesis of independence of means between distributions.
Source: 2017 "After Access" RIA household and Individual IC access and use survey

In contrast to the household digital divide, urban poor respondents are found to have greater access to ICT on average (PC, mobile phone, Internet use) relative to both poor rural respondents and national respondents in Table 7.4. With nearly 80 percent of individuals in each category reporting mobile phone ownership, this urban bias among the poor appears to be derived from over 60 percent of the urban poor reporting Internet usage relative to only 50 percent at the rural and national level. Given the statistical significance of the association between Internet and the urban BoP at the 1 percent level, a unique relationship between this group and the Information Society may exist. This is reinforced by the substantial propensity of the urban poor to own Smart phones (66 percent) and to utilise mobile Internet (93 percent). FPW is additionally identified as a strong contributor to the relatively high connectivity of the urban poor due to its usage by nearly 52 percent of the urban BoP sample.

Aside from FPW, the urban poor consequently appear to be dependent on mobile broadband to service their Internet needs due to their low ownership of desktop computers and PC broadband, relative to the national population. Smartphones therefore appear to not only compensate for low levels of tele-density (4 percent) experienced by the urban poor, but to also act as a primary portal to the Internet (Stork et al, 2013: 34). The critical importance of Smartphones to the urban poor is underscored by their dedication of nearly 30 percent of their monthly income towards mobile expenditure, and nearly 50 percent thereof towards data purchases. This allocation is more than triple the amount sacrificed at the individual level.

Table 7. 5 – Digital poverty in South Africa

Thousands	**Rural BOP**			**Urban BOP**			**National**		
	n	Col %	Diff %	n	Col %	Diff %	n	Col %	Diff %
Extremely digital poor	840	18,1	18,1	1009	16,2	16,2	4973	15,8	15,8
Digitally poor	1764	38,0	19,9	1162	18,7	2,5	10630	33,8	18,0
Passive	19	4,1	-33,8	86	1,4	-17,3	560	1,8	-32,0
Mildly active	1656	35,6	31,5	3175	51,0	49,6	11875	37,7	35,9
Digitally wealthy	194	4,2	-31,5	799	12,8	-38,1	3445	10,9	-26,8
Total	4475	100		6231	100		31484	100	

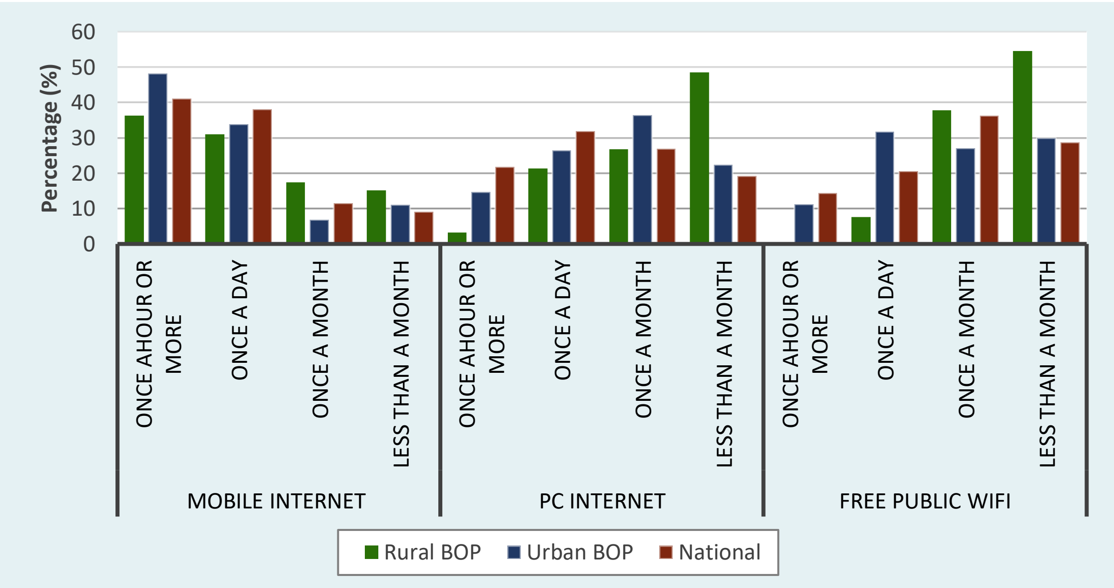
Authors own calculations. Results are weighted.
Source: 2017 "After Access" RIA household and Individual ICT access and use survey

Digital Poverty Framework

Table 7.5 outlines findings for the DPF when applied to all segments of the population. Results indicate that, across all segments, the majority of respondents are primarily concentrated among the digitally poor and mildly active. This breakdown replicates similar findings produced by Barrantes (2010) for the Peruvian population. For the urban BoP in particular however, findings indicate that over 60 percent of respondents own Internet-enabled mobile phones and actively leverage these devices for developmental gains. However, given that 51 percent of the urban BoP only engage in active use occasionally, it is apparent that this extraction is less than optimal with fewer than 13 percent reporting daily active use of capability-enhancing m-apps.

Results from Table 7.5 further highlight however, that although the majority of the urban poor may be sub-optimal Smartphone users, their likelihood of active use is greater than that observed at the national level. With passive users found to account for only 1.4 percent of those with Internet-enabled phones, the urban poor are found to comprise of more mildly active and digitally wealthy respondents than at the national level by nearly 35 percent and 17 percent respectively.

Figure 7. 1 – Type of Internet access



Authors own calculations. Results are weighted.
Source: 2017 "After Access" RIA household and Individual ICT access and use survey

Findings from Figure 7.1 further indicate the substantial use of mobile broadband to support the mobile phone usage of the urban poor on an hourly basis for almost 50 percent of the sample. Given the predominant sub-optimal usage of the urban poor however, this finding also highlights the current inability of mobile broadband alone to sufficiently support optimal ICT usage for this sub-sample. Instead, mobile broadband may be supporting the existence of digital inequality among the urban poor. The extent of digital inequality is reflected by the 32 percent gap between the digitally poor and mildly active, and 38 percent gap between mildly and daily active users gaps among the urban poor.

Developmental outcomes

In order to assess the quality of digital dividends extracted by the urban poor in terms of capabilities, Table 7.6 indicates the strength of the correlation between DPF categories and capability-enhancing mobile applications which were identified in Chapter six. According to Table 7.6, due to its weak

Table 7. 6 - Correlations between mobile applications and DPF categories

	Passive user	Mildly active	Digitally wealthy
Passive Apps			
Games	-0,03	0,44	0,18
Entertainment	-0,07	0,47	0,18
News	-0,07	0,43	0,21
Searches	-0,08	0,47	0,25
Weather	0,07	0,43	0,17
Messaging	0,06	0,54	0,19
Active Apps			
Social Media		0,79	0,30
Transport		0,20	0,13
Business		0,24	0,20
Education		0,56	0,32
Ecommerce		0,23	0,24
Health		0,29	0,24
Dating		0,24	0,27

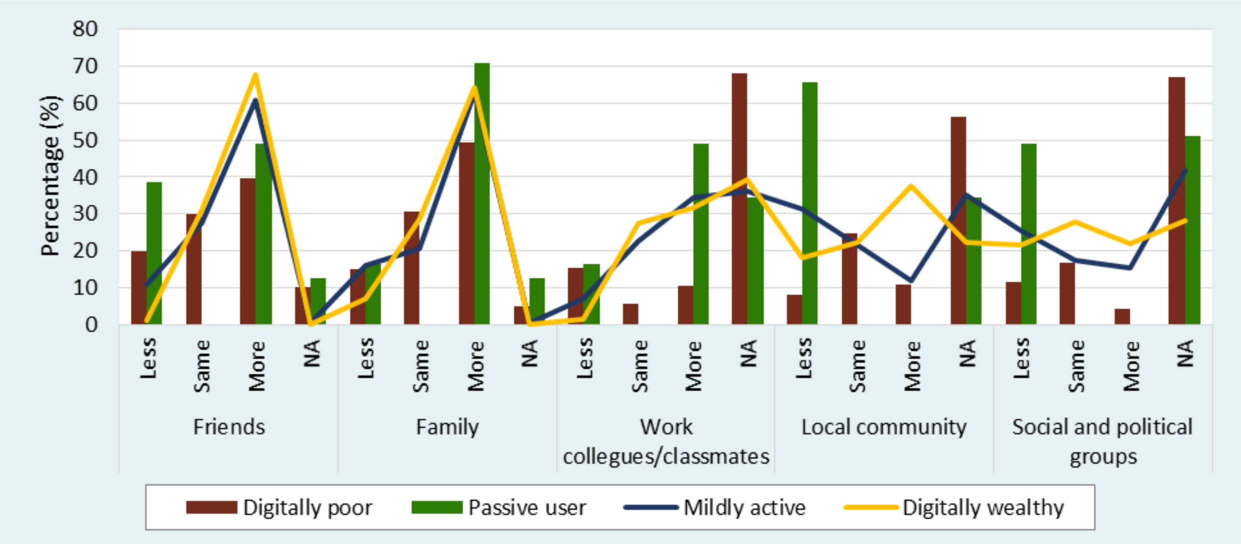
Authors own calculations. Results are weighted.
A Phi correlation coefficient is a measure of association for a Chi-squared distribution between two nominal binary variables. This statistic ranges from 0 to 1, with large values associated with stronger relationships, and smaller values indicative of weaker associations. Since this measure is symmetric, neither the direction of the relationship nor its significance can be determined. This coefficient is preferred when variables are neither continuous nor capable of being ranked.
Source: 2017 "After Access" RIA household and Individual IC access and use survey

presence in the urban BoP sample, very weak or non-existent correlations below 0.1 are observed between designated passive applications and passive Internet-enabled mobile phone users. In contrast, for the same set of applications, mildly active users are observed to be most correlated, though weakly, with messaging applications with a correlation coefficient of 0.5. For active capability-orientated applications, mildly active users display the strongest and most positive correlation with social media. Second to social capital, educational applications are additionally found to be positively correlated with mildly active users.

The significance of this outcome is further underlined by finding educational applications to be the strongest application associated with ICT use by the digitally wealthy. Given this, in addition to its strong correlations with social media, dating applications, and e-commerce and health applications with a correlation coefficient of 0.24, a distinct link between digital wealth and enhanced capabilities is observed. Although these findings fail to diminish gains by the mildly active, it does allude to the reversal of digital priorities when optimal ICT use is possible and opportunities for enhanced freedom are less inhibited.

Beyond capabilities directly attributable to the Internet, Figures 7.2 and 7.3 further highlight differences in developmental outcomes for respondents by DPF categories. Figure 7.2 plots the attitudinal responses of respondents regarding how mobile phones have affected contact with existing relationships. Findings indicate that the digitally poor consider mobile phones to be more essential in improving contact with family and friends, than strengthening ties with colleagues, the community and interest groups. Except for improved contact with work colleagues and kin, passive users are found to

Figure 7. 2 – Existing social capital gains from mobile phones



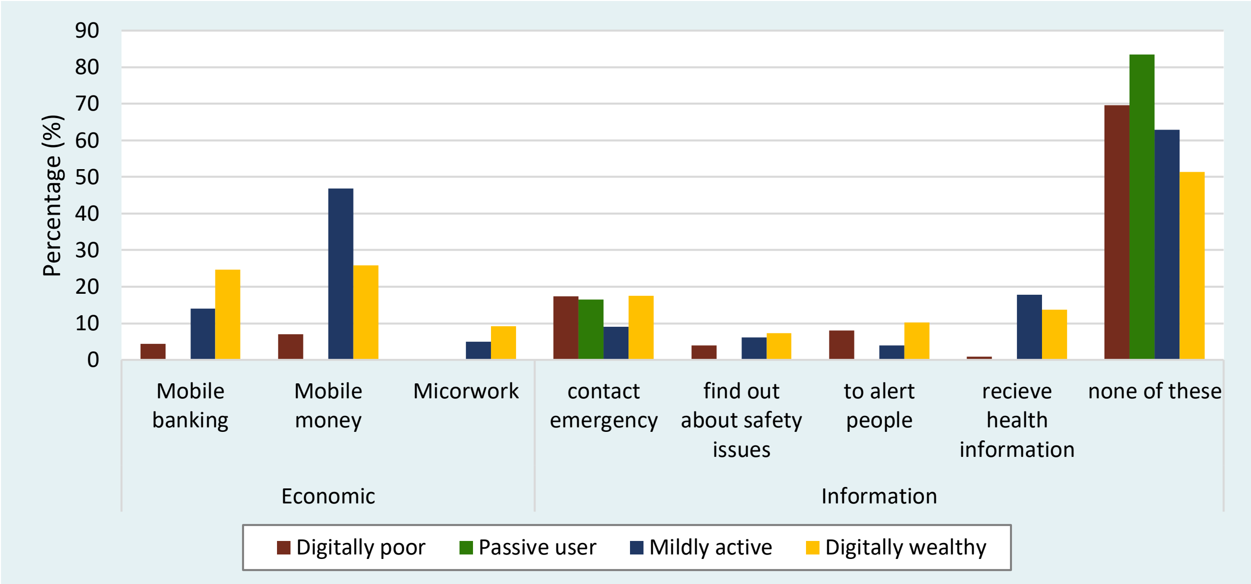
Authors own calculations. Results are weighted.
Source: 2017 "After Access" RIA household and Individual ICT access and use survey

negatively associate mobile phones with interest groups. The mildly active and digitally wealthy are additionally observed to substantially associate mobile phones within improved communication with friends and family. Key differences however appear between these active users in their divergent attitudes towards contact with the local community and interest groups, of which the digitally wealthy appear more positive towards. This may imply that socio-economic and political inclusion are more important incentives for active use of ICT by the digitally wealthy, relative to the mildly active.

Differences between DPF categories are further identified in information gains in Figure 7.3. Despite all categories reporting less than 20 percent in the affirmative to receiving or broadcasting safety and health related information, the digitally wealthy are found least averse to using their mobile phones for this purpose. This bias in meaningful ICT use is further extended to economic inclusion in terms of economic opportunities. More specifically, while nearly 50 percent of mildly active respondents indicated their use of mobile money, digitally wealthy respondents appear to gain more in terms of mobile banking and digital micro-employment[4].

[4] According to the Rockefeller Foundation (2013) digital micro-employment, or "digital jobs," are defined as "any short-term or permanent positions that use information technology to deliver a product or service… [which are] in the formal sector."

Figure 7. 3 – Economic and Informational ICT gain



Authors own calculations. Results are weighted.
Source: 2017 "After Access" RIA household and Individual ICT access and use survey

Characteristics of DPF user categories

Table 7.7 illustrates key characteristic differences between users of different DPF categories which may explain differences in digital inclusion within the urban BoP. The strength of statistically significant measures of associations between user characteristics and the DPF is detailed in appendix Table 12.1. Regarding ICT frequency of use, Table 7.7 highlights that in contrast to the digitally poor and passive, the mildly active and digitally wealthy are found more likely to use mobile Internet once a day and per hour respectively. This is likely linked to the propensity of these users to own Smartphones rather than entry-level feature phones or basic mobile phones. Furthermore, while the use of mobile Internet by 58 percent of the mildly active sample is statistically significantly, fixed-line Internet and FPW once a month are found to be stronger alternatives to mobile broadband for the digitally wealthy.

In terms of human capital-related demographics, over half of the mildly active and digitally wealthy sub-samples are found concentrated among 15-24 year olds, who possess between 8 and 12 years of education, and come from households in which secondary education is the highest level attained. Human capital variables are significant predictors for all categories of DPF at the 0.1 percent significance level, excluding those passive. However, although the statistical significance of student activity may characterise mildly active and digitally wealthy users, it also may present a potential bias in how these users engage with ICT.

Table 7. 7 - DPF categories

Urban BoP	Extremely digital poor		Digitally poor		Passive		Mildly active		Digitally wealthy	
	n	Col%	n	Col %	n	Col %	n	Col %	n	Col %
ICT infrastructure										
Mobile phone										
Basic phone			1162	100	0	0,0	0	0,0	0	0,00
Feature phone			0	0	14	16,5	211	6,7	60	7,6
Smartphone			0	0	72	83,5	2964	93,4	738	92,4
Mobile Internet										
Once an hour or more					0	0	1843	58,0	301	37,7
Once a day					19	21,9	1192	37,5	327	40,9
Once a month					42	49,1	53	1,7	86	10,7
Less than once a month					25	29,0	56	1,8	46	5,7
Never					0	0	31	1,0	40	5,0
PC Internet										
Once an hour or more					11	12,5	185	5,8	81	10,1
Once a day					0	0,0	256	8,1	148	18,5
Once a month					0	0,0	262	8,3	296	37,0
Less than once a m					19	21,9	176	5,5	50	6,3
Never					56	65,7	2297	72,4	224	28,1
FPW										
Once an hour or more					0	0	14	4,3	71	8,9
Once a day					0	0	393	12,4	226	28,3
Once a month					0	0	734	23,1	237	29,7
Less than once a m					19	21,9	283	8,9	114	14,2
Never					67	78,1	1629	51,3	151	18,9
Telephone	0	0	29	5	18	49,1	46	4,0	17	5,5
Individual PC	20	2,01	49	4,2	11	12,5	358	11,3	197	24,7
Human capital demographics										
Age										
15-24 years	459	45,5	258	23,0	0	0,0	2279	71,8	484	60,6
25 - 34 years	268	26,6	36	31,9	19	21,9	670	21,1	26	32,0
35 - 44 years	138	13,7	168	14,9	14	16,5	173	5,4	41	5,1
45 - 54 years	77	7,6	128	11,4	0	0,0	4	1,2	18	2,3
55 - 64 years	36	3,5	163	14,5	42	49,1	0	0	0	0
65years and above	31	3,1	49	4,3	11	12,5	16	0,5	0	0
Years of Education										
1-7	276	27,3	354	30,5	14	16,5	198	6,2	1	1,8
8-12	706	70	745	64,2	61	71,0	2496	78,6	582	72,9
13-20	0	0	26	2,3	11	12,5	48	15,2	202	25,3
21 or more	0	0	8	0,7	0	0,0	0	0	0	0
None	27	2,7	29	2,5	0	0,0	0	0	0	0
Maximum household education										
Primary	68	14,7	83	14.1	0	0	33	2,9	0	0
Secondary	360	76,8	491	83.1	18	50,9	688	60,0	194	64,5
Tertiary	14	3,1	17	2,8	18	49,1	426	37,2	107	35,5
None	25	5,4	0	0	0	0	0	0	0	0
Race										
African	934	94,5	1069	92	33	38,4	2556	87,5	687	86
Coloured	27	2,8	0	0,0	0	0,0	57	2,0	0	0
White	0	0,0	54	4,6	0	0,0	2	0,6	0	0

Indian/Asian	0	0,0	0	0,0	0	0,0	0	0,0	0	0
Other	0	0,0	4	0,4	0	0,0	0	0,0	0	0
Refuse	27	2,8	4	3,0	53	61,6	291	10,0	112	14
Gender										
Male	456	45,2	607	52,2	72	83,5	1592	50,2	258	32,3
Female	553	54,8	556	47,8	14	16,5	1583	49,9	541	67,7
Economic Employment										
Employed	26	2,6	82	7,1	14	16,5	158	5,0	85	10,7
Strict unemployment	429	42,5	519	44,7	19	21,9	1025	32,3	216	27,1
Flex unemployment	85	8,4	103	8,9	0	0,0	120	3,8	18	2,3
Student	368	36,5	23	19,9	0	0,0	1734	54,6	357	44,7
Self-employed	13	1,2	46	4,0	0	0,0	0	0,0	2	2,0
Unpaid housework	35	3,5	102	8,8	0	0,0	122	3,8	107	13,4
Retired	54	5,3	78	6,7	53	61,6	16	0,5	0	0,0
Average monthly income	135,8		180,6		49,6		209,9		227,1	
Proportion spent on mobile expenditure			0,4		0,0		0,2		0,3	
Proportion of mobile expenditure spent on data			0,1***		0,2		0,7***		0,6*	

Authors own calculations. Results are weighted.
Measures of association between dichotomous nominal variables were calculated using the Chi-Squared statistic. Where cells included joint frequencies of less than 5, Fischer’s exact measure of association was used. Gamma measure of association used for ordinal dependent variables. A difference of means test (t-test)(*) was used between continuous income and expenditure variables against the null hypothesis of independence of means between distributions. Statistical significance for all measures of association is determined against the null hypothesis of independence between variables when p<0,05; p<0.01 and p<0,001.
Source: 2017 “After Access” RIA household and Individual ICT access and use survey

For the extreme and digitally poor in comparison, strict unemployment is the dominant form of economic (in)activity and reflects a statistically significant Chi-squared association with each of these categories at the 1 percent significance level. Demographic findings indicate that all DPF groups are dominated by the African racial group. Gender further appears uniquely associated with DPF categories, with more females dominating in categories which are the digitally poorest and the wealthiest. This may be explained by the existence of a high degree of unevenness in digital skills among females at the urban BoP (Deen-Swarray et al, 2012: 29). This therefore directly confirms the potential of digital inequality to exacerbate existing inequalities in a vicious cycle (Servon & Nelson, 2001).

In terms of economic poverty, relative to the mildly active and digitally wealthy, the extremely and digitally poor are observed to receive the lowest average monthly income of R136 and R181, respectively. Although the digitally wealthy receive an average monthly income marginally greater than the mildly active by R17, it suggests a positive relationship between average income, active ICT usage, and developmental gains. The dominant allocation by the digitally poor of 40 percent of their average monthly income towards mobile expenditure further highlights the substantial ICT demand of these individuals despite their lack of Internet connectivity and vulnerability to the extractive effect of mobile pricing. This effect is notably found to increase by active usage for the urban BoP, with the digitally wealthy found to allocate at least 30 percent of their average monthly income towards extracting optimal digital dividends.

Critically, despite their sub-optimal usage, it is the mildly active who are found to dedicate the largest proportion (66 percent) of their mobile expenditure to mobile data specifically, an association found to be statistically significant at the 1 percent level according to a two-sample t-test.. The digitally wealthy, in comparison, only allocate 58 percent of mobile expenditure to data. This difference may reflect the wider availability of Internet alternatives for the digitally wealthy relative to the mildly active who are found significantly more dependent on mobile broadband for hourly-to-daily Internet use in Table 7.7.

8. Econometric model

Generalised Ordered Logit model

To identify the probability of achieving a given level of the DPF, as well as its associated determinants, an econometric model is estimated. However, due to the ordinal structure of the DPF dependent variable, typical assumptions required for a linear regression model are violated. Specifically, while the assumption of equal distances between intervals may be appropriate for model applications using continuous or interval dependent variables, it is not the case for ordinal variables which may be ranked with either unknown or unequal distances between categories (Long & Freese, 2001: 137). Furthermore, due to its inability to predict numeric values, ordinal dependent variables fail to meet the criteria necessary for Ordinary Least Square methods to be used in determining the line of best fit (Burn & Burn, 2008).

As a result, a generalised ordered logit model (GOLM) is utilised to estimate an ordinal regression model (ORM). As an extension of the standard ordered logit, the GOLM is defined as a non-linear probability model for all real values between zero and one (Long & Freese, 2012: 141). Given its ordinal procedure, the GOLM estimates the probability of being beyond a certain category of the outcome variable, relative to being at or below that specific category or group of categories (Liu & Koirala, 2012: 244).

Given this, a non-linear log transformed GOLM model is defined by the following probability function:

$$P(Y_i > j) = g(XB_j) = \frac{\exp(\alpha_j + \beta_j X_i)}{1 + [\exp(\alpha_j + \beta_j X_i)]}, j = 1,2, \ldots . M - 1 \quad (6)$$

where Y_i is defined as ordinal outcome variable for M categories; α_j is the intercept assumed to be zero, β_j is the logit regression coefficient for a given *j* category for the *i*-th subject, conditional on a X_i vector of explanatory variables. Underlining this equation, are the probabilities of Y_i assuming any level of M.

These probabilities are given by:

$$P\ (Yi = 1|\ X)\ =\ 1\ -\ g(\beta_j X_i) \quad (7)$$

$$P\ (Yi =\ j|\ X)\ =\ g(X_i\beta_j - 1) -\ g(\beta_j X_i) \qquad j = 2, \ldots, M\ -\ 1 \quad (8)$$

$$P\ (Yi = M\ |X) =\ g(\beta_{M-1} X_i) \quad (9)$$

For an outcome variable with more than two categories, equations (7)-(9) effectively describe the GOLM as a series of binary logistic regressions in which M categories are combined and contrasted against higher succeeding *j* levels. This is performed in order to measure how the cumulative logit probability ($P(Y_i > j)$) of a *j* level of Y_i occurring, changes for a given change in an independent variable (x_i), holding all else constant (Williams, 2006: 59; Long & Freese, 2001: 137). For a dependent variable with four categories, this implies the estimation of three sets of regression estimates based on three equations simultaneously run with M-1 as the last cumulative probability necessarily equal to one (Williams, 2016: 11; Grilli & Rampichini, 2014: 4510). Given its use of a logit-link function, the method of Maximum Likelihood Estimation is evidently used in which "the probability of classifying the observed data into the appropriate category" is maximised through an iterative procedure of increasing the log-likelihood until differences between iterations are sufficiently small (Burn & Burn, 2012). When this occurs, convergence of the model is achieved (Burn & Burn, 2012).

GOLM properties

One of the leading features and assumptions of the GOLM, which has garnered it increasing favour over common ordered logits by analysts, is its relative flexibility to the parallel lines or proportional odds (PO) assumption of ORMs (Williams, 2006, 2016). This is defined as the assumption that all beta coefficients across separate logit regressions should be equal, thus implying a constant log-odd probability of each *j* level of the outcome variable occurring for a given change in any covariate (Williams, 2016: 9). However, rather than risking the exclusion of dynamic asymmetrical relationships, the GOLM is capable of adjusting to fit a more flexible partial proportional odds model

(PPO) (Williams, 2016: 15). This allows for "some of the beta coefficients [to be] the same for all values of *j*, while others can differ" (Williams, 2016: 11).

Further ORM assumptions which are upheld by the GOLM include the ordinal nature of the dependent variable in terms of category ranking in ascending order (Lani, 2010). This implies setting the most superior level as the highest. The GOLM further assumes the cumulative probability of each category occurring with $P(Y_i = 1)$ to possess very little or zero multicollinearity between covariates, the linearity of independent variables and log odds, and a sufficiently large sample size suitable for MLE which ensure between 10 and 30 observations per parameter (Lani, 2010). For robustness, White-Huber standard errors are utilised to account for the usage of sample weights when working with complex survey data.

Model estimation

Give its advantages as a more parsimonious and less restrictive version of the standard GOLM, a constrained PPO model is estimated according to the following adjusted equation (6):

$$P(Y_i > j) = \frac{\exp\left(\alpha_j + \beta 1X1_i + B2_jX2_i + \beta 3X3_i + B4_jX4_i + \beta 5X5_i + \beta 6X6_i + \beta 7X7_i + \beta 8X8_i\right)}{1 + \left[\exp[\![\left(\alpha_j + \beta 1X1_i + B2_jX2_i + \beta 3X3_i + B4_jX4_i + \beta 5X5_i + \beta 6X6_i + \beta 7X7_i + \beta 8X8_i\right)]\!]\right]}, \quad j = 1,2,3, M-1 \tag{10}$$

$$ln(Y_i > j) = \alpha_j + \left(\beta 1X1_i + B2_jX2_i + \beta 3X3_i + B4_jX4_i + \beta 5X5_i + \beta 6X6_i + \beta 7X7_i + \beta 8X8_i\right) \tag{11}$$

where Y_i is defined as the re-categorised DPF ordinal outcome variable for M (4) categories to enhance its power (1=Extremely digitally poor, 2=Digitally poor, 3=Passive-to-mildly digitally active, 4=Digitally wealthy); α_j is the intercept and β_j is the logit regression coefficient for a given *j* category for the *i*-th subject where the *j* category is only specified when explanatory variable X_i is allowed to change for various outcomes of the dependent variable.

As outlined in Table 8.1, eight key explanatory variables are estimated by the GOLM.

Due to the DPF hypothesis for the positive relationship between human capital indicators and ICT usage via greater digital literacy and awareness, **years of education (*B1*)** attained is included as a primary variable of interest (Barrantes, 2010: 9). **Age (*B2$_j$*)** is additionally controlled for to test the DPF hypothesis that the "younger you are, the more probable it is that you are familiar with and use ICTs" (Barrantes, 2010: 9). By finding age to violate the PO assumption, it is estimated to vary by *j* category. As an additional individual descriptor of human capital, **gender (*B3*)** is controlled for to account for its hypothesised negative influence on optimal ICT use (Obayelu & Ogunlade, 2006; May, 2010; Sinha & Hyma, 2013; ITU, 2016; World Bank, 2016; Chair, 2017). **Home language spoken (*B4*$_j$)** is included given the hypothesised negative relationship between the indigenous home language of individuals and their digital usage as a function of digital literacy (Sinha & Hyma, 2013)[5]. This variable additionally serves as a proxy for race within the current model to account for the potential impact of Apartheid legacies on ICT access and usage (Brown & Licker, 2003: 6)[6]. Following its violation of the PO assumption, home language is additionally estimated to vary by *j* category.

To cater for potential household inter-generational spillover effects, the **highest education level attained by any household member (*B5*)** is included in the model. This follows the hypothesis that "the higher the [household] educational level, the more likely it is for the household to be digitally wealthy since there may be spillover effects from one member to another" (Barrantes, 2010: 10). However, given the high correlation between this variable and individual level education, household education was restricted to the maximum of secondary education as a level with the greatest variation for the urban BoP sub-sample. **Household size (*B6*)** is additionally included in the model given the assumption that the larger the household, the greater the probability of being digitally wealthy due to the likelihood of being taught ICT skills by family members (Barrantes, 2010: 10).

To account for economic poverty as a hypothesised main determinant for digital wealth, membership of the economically active population **(EAP) (*B7*)** is controlled for as a binary variable. This follows the assumption that being economically active is positively related with digital wealth as a reflection of one's income and ability to afford both ICT access and usage (Kularski & Moller, 2012). This however implies that economic inactivity, such as being a student, is negatively related with digital wealth. Although this is expected to be proven false, the age covariate is likely to capture this effect. Beyond its own value, EAP is further included to proxy the influence of individual monthly income which could not be included in the model due to its endogeneity to the sample selection.

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[5] African languages refers to the summation of 9 official African languages recognised in South African as spoken by various tribes across the country.

[6] Race was not able to be included in the model due to its high collinearity with language spoken and all education variables pertinent to the model.

Table 8. 1- Generalised Ordered Logit model variable description

Variable	Description	Expected sign
Dependent variable		
Digital poverty level	Ordinal categorical variable. Values from 1 to 4, where: 1="Extremely digitally poor", 2="Digitally poor", 3="Passive to occasionally active", 4="Digitally wealthy"	
Independent variables		
Years of education	Continuous variable. Ranges from 0 to 30.	+
Age	Continuous variable. Ranges from 15 to 80.	+
Gender	Dichotomous variable. Value of 1 = female; 0 = male	-
Language spoken	Nominal categorical variable. Value of 1 = Afrikaans (base), 2= English, 3= African language	+
Household secondary level education	Dichotomous variable. Value 1 = maximum level of education in the household is secondary, 0= maximum household education level is not secondary	+
Membership of EAP	Dichotomous variable. Value of 1 = formal employed, or job-seeking unemployed, or self-employed; 0 = economically inactive (student, retired, disabled, housewives).	+
Household size	Continuous variable. 1-25.	+
Hours spent with interest group	Continuous variable. 1-45	+

Source: Authors own

Lastly, an indicator for hours spent with **interest groups (*B8*)** is included in the model. This is based on the popular hypothesis which argues that the more socially or politically connected individuals are, the greater their demand for regular communication and coordination (Barrantes, 2010; Wang, 2015; Manacorda & Tesei, 2016).

<u>Marginal effects</u>

Following the fulfilment of GOLM assumptions for the above covariates, the marginal change in predicted probabilities per category is further derived post-estimation to ease the interpretation of predicted cumulative log-odd probabilities.

These marginal effects can be defined as:

$$\frac{\partial P(Y=j|X)}{\partial x_k} = P(y = m \mid x, x_k = x_e) - P(y = m \mid x, x_k = x_s) = \beta_k \quad (12)$$

For a discrete unit change in $x_k$from its start value (x_s) to end value (x_e), this implies the change in the predicted probability of j outcome by $\frac{\partial P(Y=j|X)}{\partial x_k}$, holding all else constant (Long & Freese, 2001: 163). For a non-binary or continuous changes inx_k, this implies the unit change in the predicted probability of j outcome in a similar fashion, but centred at the mean.

Model Results

Following the failure of the ordered logit model to satisfy the parallel lines assumption for the given set of covariates, findings for the PPO adjusted GOLM indicated the rectification of this[7]. This was achieved using Williams (2006) "gologit2" command in Stata15, and applying the "autofit" option to estimate a PPO model[8]. To enhance the robustness of findings and account for any potential underestimation of the predicted probabilities, two regression models were run for the same set of explanatory variables, but with the omission of students from the sample in the second regression model. Estimated cumulative predicted probabilities by the GOLM, for both specifications, can be viewed in Appendix Table 12.1. The marginal effects of these estimated predicted probabilities can however be viewed in Table 8.2.

Based on 234 observations in the initial model (with students), and 164 without students, this implied the need to relax the PO assumption for age and main language spoken given their observed differential effects across j outcomes. Following the implementation of these constraints, both models were found statistically significant at the 1 percent significant level for a Wald Chi-Square test statistic of 984.97 and 390.34, with and without students, respectively. Additional assumptions of the GOLM were met through the achievement of minimal multicollinearity according a mean Variance Inflation Factor of 1.10 for both models, and statistical significance of individual Wald tests for the independence of each covariate.

Following the convergence of the initial PPO model, the predicted probabilities of being in each category of the outcome variable, conditional on their predictors, were estimated and plotted in

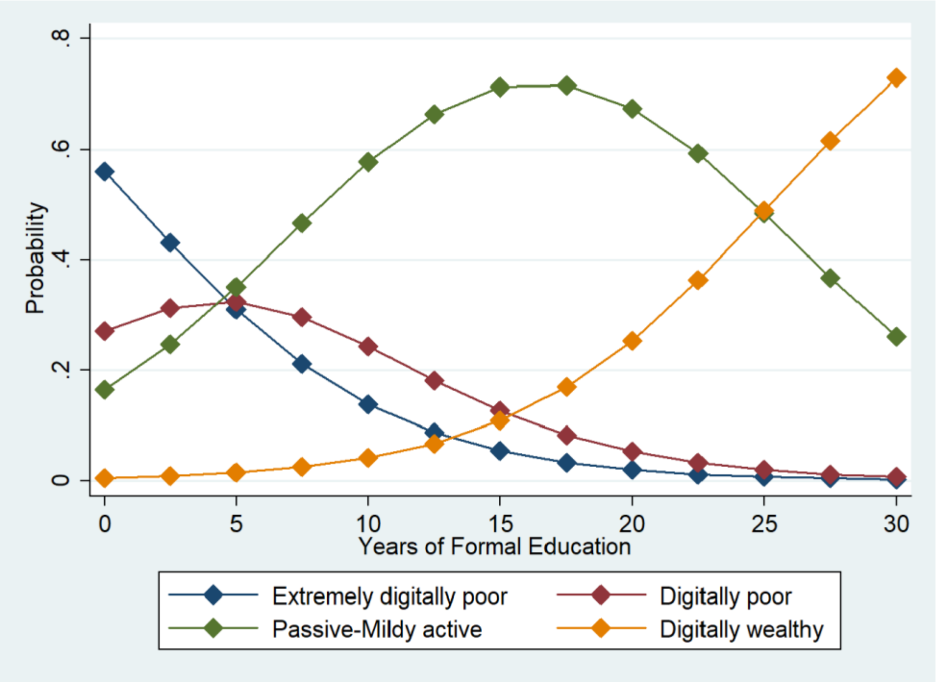
[7] Regression output for executed ordered logit regression models is available upon request.

[8] The autofit option is a stepwise procedure "to identify [independent] variables where proportionality constraints should be relaxed" (Williams, 2016: 19). The significance level (α) of 0.05 was chosen for this procedure due to its appropriateness for relatively smaller sample sizes where a lower value of α implies the rejection of the PO assumption with greater difficulty (Williams, 2006: 66-79).

Appendix Figure 12.1. According to this figure, the predicted probability of the urban poor being extremely digitally poor are 13 percent, 23 percent for being digitally poor, 59 percent for being mildly active and a low of 5 percent for being digitally wealthy. Notably, the probabilities of being at the lower end of the spectrum increase following the exclusion of students, and decrease the probability of being at the upper end. This affirms the upward bias presented by students in the model. However, similar to both models, key covariates appear to affect outcomes of the dependent variable differentially in both magnitude and direction.

For key human capital covariates, the average marginal effect of years of education is found to be both economically and statistically significant at the 1 percent significance level at each outcome level. Although an additional year of education is associated with the average marginal effect of lowering the probability of belonging to either the extreme or digitally poor category by 2.3 and 2.5 percent, the direction of this average marginal effect reverses for the mildly active and digitally wealthy with an associated 3.9 percent and 0.9 percent increase in their predicted probability respectively, holding all else constant. These GOLM trends in predicted probability for years of education are further illustrated in Figure 8.2. According to the figure, both the probability of digital wealth and extreme digital poverty decrease and increase steeply with education, respectively. The predicted probability of being mildly active alternatively peaks between 15-20 years of education before intersecting with the probability of becoming digitally wealthy. These trends notably persist when students are excluded from the model.

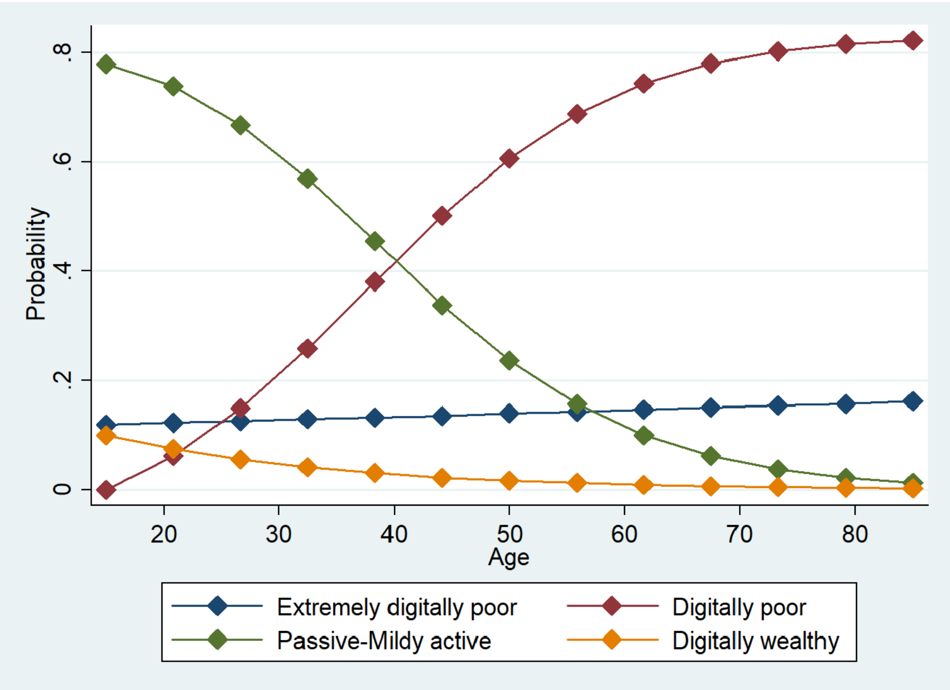
Figure 8. 1 - Estimated probability of DPF category by education (with students)



Authors own calculations.
Source: 2017 "After Access" RIA household and Individual ICT access and use survey

Inclusive of students, an additional year of age is associated with the increase in the average marginal effect on the predicted probability of lower DPF categories, and a decrease in predicted probability for higher DPF outcomes. This association is statistically significant at the 1 percent level for all categories of the DPF above extreme digital poverty. In terms of magnitude however, age appears to have the average marginal effect of increasing the predicted probability of being digitally poor by 2 percent, relative to its reduction by 1.8 percent for the predicted probability of being mildly active. These marginal effects persist in both magnitude and direction when students are excluded from the model. Validating a key hypothesis of the DPF, Figure 8.2 additionally underlines the proportional and inversely proportional relationship between age and the predicted probability of being digitally poor and mildly active, respectively. In comparison, the positive and negative effects on the predicted probability of extreme digital poverty and digital wealth respectively are found notably more subdued according to Figure 8.2.

Figure 8. 2 - Estimated probability of DPF category by age (with students)



Authors own calculations.
Source: 2017 “After Access” RIA household and Individual ICT access and use survey

Table 8. 2 - Marginal effects of GOLM predicted probabilities

	With students				Without students			
	Extremely digitally poor	Digitally poor	Digitally connected	Digitally wealthy	Extremely digitally poor	Digitally poor	Digitally connected	Digitally wealthy
Membership of EAP	0.019	0.020	-0.032	-0.007	0.011	0.009	-0.019	-0.002
	(0.031)	(0.033)	(0.053)	(0.012)	(0.050)	(0.042)	(0.082)	(0.010)
Years of education	-0.023***	-0.025***	0.039***	0.009***	-0.028***	-0.023**	0.046***	0.005**
	(0.007)	(0.008)	(0.011)	(0.002)	(0.008)	(0.010)	(0.014)	(0.002)
Female	-0.077**	-0.078**	0.127**	0.028**	-0.081*	-0.063	0.129*	0.016
	(0.034)	(0.036)	(0.055)	(0.013)	(0.047)	(0.041)	(0.075)	(0.011)
Age	0.001	0.020***	-0.018***	-0.002***	0.001	0.020***	-0.019***	-0.002***
	(0.002)	(0.004)	(0.004)	(0.001)	(0.002)	(0.004)	(0.004)	(0.001)
Household size	-0.007	-0.007	0.011	0.003	-0.006	-0.005	0.010	0.001
	(0.007)	(0.008)	(0.011)	(0.003)	(0.009)	(0.008)	(0.015)	(0.002)
Max secondary level of household education	0.030	0.253***	-0.291***	0.007	0.037	0.330***	-0.353***	-0.014
	(0.046)	(0.063)	(0.071)	(0.019)	(0.064)	(0.079)	(0.082)	(0.020)
Hours spent with interest group	-0.004	-0.004	0.007	0.002	-0.006	-0.005	0.010	0.001
	(0.004)	(0.004)	(0.007)	(0.002)	(0.006)	(0.005)	(0.009)	(0.001)
English home language	-0.103	-0.097	-0.789***	0.989***	-0.093	-0.109	-0.789***	0.991***
	(0.082)	(0.166)	(0.184)	(0.003)	(0.137)	(0.261)	(0.290)	(0.004)
Indigenous African home language	-0.029	0.192	-0.448**	0.285***	-0.020	0.161	-0.278	0.137***
	(0.155)	(0.193)	(0.176)	(0.057)	(0.182)	(0.266)	(0.258)	(0.050)
N = 234					N=164			
Wald chi2(17) = 984.79					Wald chi2(17) = 390.34			
Prob >chi2=0.0000					Prob >chi2=0.0000			
Pseudo R2=0.2213					Pseudo R2=0.2048			

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
Categorical dependent variable with 1 as extremely digitally poor, 2 as digitally poor, 3 as the combination between passive and mildly active, and 4 as digitally wealthy. Membership of Economically active population (1= employed, unemployed or self-employed; 0= student, retired, discouraged unemployed, unpaid housework, disabled), female (1=female; 0=male) and secondary household education (1=maximum secondary education; 0= not secondary as maximum level of education) are dichotomous variables. Years of education, age, household size and hours spent with interest groups are continuous variables. Home language is a categorical variable with 1= Afrikaans (base), 2=English, 3 =African languages.

For households with secondary highest level of education, correct signs are predicted for all probabilities except for digital wealth. As opposed to additively decreasing the predicted probability of digital wealth, membership of a household with only secondary education is associated with its additive increase by 0.7 percentage points. Beyond this, secondary level household education is found economically and statistically significant at the 1 percent level for being digitally poor and mildly active. This reflects the association of an additive increase and decrease in the predicted probability of being digitally poor by 25.3 percentage points, and 29.1 percentage points, respectively. Although the direction and significance of this association persists when students are excluded, the effect becomes marginally larger in magnitude.

For main languages spoken, English as one's home language is found to display the correct sign relative to the base category of Afrikaans for all categories except mildly active in which an additive decrease of 79 percentage points is observed for its predicted probability rather than an increase. Irrespective, this association is found to be both economically and statistically significant as in its positive additive association with digital wealth at the 1 percent level. These associations remain constant when students are excluded.

Noticeably however, while speaking English relative to Afrikaans is negatively associated with the predicted probability of being on the lower end of the DPF spectrum as expected, this proves to be the opposite for African languages with regards to the predicted probability of being digitally poor. This remains true when students are excluded. Furthermore, although expectedly associated with an additive decrease in the predicted probability of being mildly active by 44.8 percentage points at the 5 percent significant level, an additive increase is unexpectedly found for being digitally wealthy when speaking an African language relative to the base category. In addition to being associated with its additive increase in predicated probability by 28.5 percentage points, this association is further observed to be statistically significant at the 1 percent significance level holding all else constant. These effects however do appear to become smaller in magnitude when students are excluded.

In line with associations of other key covariates, being female relative to male is found to be a statistically significant predictor for all outcomes of the dependent variable at the 5 percent level, but in different directions for the lower and upper half of the DPF. Being female is associated with the additive decrease in the probability of being extreme and digitally poor by 7.7 and 7.8 percentage points respectively, and with the additive increase in probability by 12.7 and 2.8 percentage points for mild and digital wealth respectively holding all else constant.

Although the direction of these effect persist with the exclusion of the students, the size of both its economic and statistical significance is weakened.

For the influence of economic poverty in the absence of monthly income, membership of the EAP is found to be neither statistically nor economically significant. However, EAP is associated with the additive increase in the predicted probability of being on the lower end of the DPF spectrum, and with the additive decrease in the probability of being at the upper end by 3.2 and 0.7 percentage points for mildly active and digital wealth respectively, holding all else constant. Although this association may be attributed to the influence of students as non-EA participants; the same insignificant, yet weaker, trend persists when this group is removed. This may suggest that more frequent active ICT usage may not be solely dependent on economic status, but perhaps simply the ability of non-EAP respondents to spend more time online. Similar conclusions may be drawn for the relationship between age and active use.

To supplement the information provided by EAP for the importance of affordability, Table 8.3 outlines the barriers to optimal ICT usage as self-reported by urban BoP respondents within each DPF category. Findings indicate that the largest constraint to (any) mobile phone usage for the digitally poor and passive user is the cost of airtime by at least 50 percent. This remains true irrespective of whether students are included or excluded. Although this constraint holds for the mildly active and digitally wealthy, the negative influence of data expenditure on mobile usage begins to take precedence for these groups. Interestingly, although this constraint remains the largest barrier to mobile phone usage, irrespective of whether students are excluded or not, its negative influence is considered much greater for a larger proportion among the digitally wealthy than its sub-optimal counterparts. This suggests that the digitally wealthy may be more price-discriminating relative to the mildly active who appear to report additional obstacles to optimal use such as coverage, battery life and "other."

This is further underscored by the mildly active reporting a lack of time as the second largest barrier to optimal Internet use on any device, second only to its lack of affordability as the dominant obstacle. This holds for the digitally wealthy and becomes an even larger constraint when students are excluded from the sample. Given these results, it can therefore be seen that although ICT may enable gains in capabilities for the urban poor, the cost of doing so online presents not only a significant barrier to its optimal extraction, but a potentially destabilising influence on poverty alleviation in light of substantial opportunity costs.

Table 8. 3 – Self-reported constraints to optimal ICT usage by DPF category

	Digitally poor		Passive		Mildly active		Digitally wealthy	
	With student	No student	With student	No student	With student	No student	With student	No student
Mobile phone usage constraints (% of n)								
Friends and family do not have mobile	7,1	8,9	0,0	0,0	0,0	0,0	0,0	0,0
Cost of airtime	**52,7**	**51,5**	**65,7**	**65,7**	19,3	13,3	19,1	9,1
Cost of data	4,9	3,7	21,9	21,9	**39,9**	**46,2**	**46,2**	**47,1**
Coverage	0,0	0,0	0,0	0,0	2,4	2,3	0,0	0,0
Battery life	0,0	0,0	0,0	0,0	13,4	6,7	3,9	3,6
Lack of content	0,2	0,3	0,0	0,0	1,5	0,0	0,0	0,0
My mobile phone is a distraction	6,3	4,5	0,0	0,0	1,9	0,0	6,2	9,4
security	0,0	0,0	0,0	0,0	4,6	4,7	0,0	0,0
NA	24,6	26,0	12,5	12,5	13,9	22,7	23,5	28,5
Other	4,2	5,2	0,0	0,0	3,2	4,1	1,3	2,3
Total (n)	1162	931	86	86	3175	1441	799	442
Internet constraints (% of n)								
No interest			**49,1**	**49,1**	3,8	6,7	7,1	6,2
Slow Internet			0	0,0	0,0	8,9	**13,4**	**19,5**
Too expensive			**21,9**	**21,9**	**21,9**	**47,9**	**33,9**	**44,9**
No one to contact			0	0,0	0,0	3,4	3,3	0,0
Privacy			0,0	0,0	0,5	1,1	0,0	0,0
Virus concerns			0	0,0	0,0	0,7	1,6	2,0
Restricted			0,0	0,0	2,0	2,0	0,0	0,0
Lack of time			**16,6**	**16,6**	**8,4**	**10,8**	10,8	19,5
Difficult to use			0	0,0	0,0	0,5	1,1	3,8
None			12,5	12,5	18,4	18,2	10,1	11,4
Other			0,0	0,0	5,6	9,9	1,9	3,4
Total (n)			86	86	3175	1441	799	442

Authors own calculations. Results are weighted.
Source: 2017 "After Access" RIA household and Individual ICT access and use survey

9. Discussion

ICT beneficiaries at the urban BoP

This thesis aims to assess the extent to which the urban poor of South Africa have been able to both access and utilise ICT for their improved wellbeing in the context of an ICT policy which seems ill-informed and inconsiderate of their digital inclusion. From the supply point of view, findings from the 2017 RIA "After Access" survey evidently suggest that the urban poor are in fact best placed within the ICT market to benefit from the Information Society, given their significant ownership of Smartphones and access to the Internet. However, while this stated level of mobile penetration reflects and replicates trends observed at the national level by both the current study and StatsSA, the substantial dependency of the urban poor on mobile broadband and FPW for Internet connectivity, is distinct (StatsSA, 2018: 51). Although this dependency is underlined by their willingness to dedicate nearly 30 percent of their average monthly income towards mobile-functionality, it also serves to highlight the significant demand of these individuals to be digitally included.

Unlike the rural poor who may face more pressing deprivations than digital exclusion, this desire for connectivity by the urban poor may represent an essential basic need for survival within a modern urban economy where the Internet has become "…the default medium for anyone wishing to provide information, to perform transactions, [or] … create civic engagement" (Warren, 2007: 385). This could therefore suggest that although greater broadband "infrastructure reach" may be required throughout the country, its potential to stimulate developmental gains is greatest among marginalised urban areas where both its demand and need is significantly high (Department of Communications, 2013: 20).

(In)effective ICT usage and its implications

Despite this demand for connectivity and ICT however, findings from the applied Digital Poverty Framework critically refute the assumption that access to ICT has been sufficient for the extraction of optimal developmental gains by the urban poor (McNamara, 2003: 5; Van Dijk, 2006: 229). Specifically, only 12 percent of the urban BoP sample are found to optimally use their Internet-enabled phones on a daily basis, while more than half are conversely found to be sub-optimal users. This therefore suggests that despite the relative ubiquity of Internet-enabled mobile phones among the urban poor, their potential usefulness as tools for empowerment and wellbeing, have largely been unrealized (McNamara, 2003). These findings appear to critically support postulations made by Odendaal (2011b) and Graham (2002) on the potential of ICT to perpetuate or exacerbate existing within-group inequalities. Notably this is in spite of the substantial presence of 15-24 year old students within the sample and the upward bias they present to both daily and occasional-weekly usage of capability-driven m-apps. This implies a critical deviation from previous findings within the literature which attest to the characterisation of youthful groups as active online participants and intense mobile phone users (Kreutzer, 2009; Waema & Miroro, 2014). However, by locating this group within the urban BoP context, it serves to highlight not only the current severity of digital exclusion experienced by this sample in terms usage intensity, but to also the flawed understanding of South African policymakers in regarding digital exclusion as a function predominantly of geographic infrastructure.

The implications of this digital exclusion among the urban poor (as well as the flawed South African policies which appear to have contributed towards this exclusion) can be seen in the distinctions in the type of opportunities capitalized upon by optimal versus sub-optimal users. Specifically, as found in the literature (Hellström & & Tröften, 2010; Barberousse et al, 2009; Gikenye and Ocholla, 2010; Chair, 2017), although both types of users are found to utilise their Internet-enabled mobile phones predominantly for social media this usage-pattern is observed more in sub-optimal users as opposed to the digitally wealthy who significantly also place value on educational m-apps. Although the intensity of social media usage may be subject to a certain degree of under-estimation due to respondents fear of appearing addicted to m-apps, this difference in frequency matches the divergence observed in attitudes held by users towards mobile devices (Molony, 2009; Sey, 2011). This is illustrated by the finding that the digitally wealthy value their Internet-enabled mobile phones both for the strengthening of social ties, typically associated with upward social mobility in the literature, as well as for the active capitalisation of digital micro-employment opportunities (Molony, 2010; Carmody, 2012; Johnson & Thakur, 2015). In contrast, sub-optimal users are found to place value more on strengthening existing ties with friends and family, and to derive gains from mobile money than from digitally facilitated employment.

Thus, although both users are found capable of using their mobile devices to strengthen their capabilities and agency, it is the digitally wealthy who are found to be most likely to take advantage of opportunities which enable meaningful and frequent participation within the digital society and economy (Johnson & Thakur, 2015: 17). Although it is possible for these differences in developmental outcomes to arise from unobserved differences in motivation which may be unrelated to issues of awareness, they nonetheless affirm the existence of demand barriers which inhibit the ability of the urban poor to use available ICT to derive optimal digital dividends (Gillwald, 2017; Heeks, 2010; van Dijk and Hacker, 2003).

The persistence of demand barriers

The barriers found in this study are not only consistent with the broad "beyond access" literature, but also suggest their structural entrenchment within the ICT ecosystem of South Africa.

Given the plethora of evidence substantiating the vital role of human capital in ICT diffusion and usage literature, the finding of human capital as both a significant obstacle and determinant for optimal use within the urban poor sample, is unsurprising (Ojo et al, 2012; Kularski & Moller, 2012; May, 2010; Mutula, 2004). Moreover, in agreement with the DPF hypothesis, the positive association between years of education and the predicted probability of digital wealth underscores the perennial and critical need for a certain amount of education to be attained as a necessary prerequisite for the development of useful digital skills (Kularski & Moller, 2012: 8). As a result of this precondition, the particular association between the digitally wealthy and educational m-apps further highlights the potential for a virtuous cycle in human capital to take place. However, by finding 15 years of formal education to be a tipping point between optimal and sub-optimal active use, it may further suggest an inadequacy in the quality of secondary education received by current sample in terms of its ability to foster effective digital literacy (Manyika et al, 2013: 24). This assertion is supported by evidence within the literature of the historically low quality of education provided by schools along the urban periphery in South Africa following the legacy of Apartheid (Mutula, 2004). This likely explains the positive influence of intergenerational education on the probability of optimal ICT usage, in addition to its relation to income (Servon & Nelson, 2001: 280). Accounting for this intergenerational influence, these findings therefore signal the critical role of improved digital skills in policy for the effective utilisation of ICT.

This importance of education however further ties in with regression findings for the inverse relationship between age and digital wealth, a relationship which not only affirms the DPF hypothesis, but also a larger array of "beyond access" literature (Barrantes, 2007, 2010; Millward, 2003; Kularski & Moller, 2012; May, 2010; Wang, 2015; Ussher, 2015). Interestingly however, the prominence of disinterest and time-consumption as major self-reported barriers by sub-optimal users, even when students are excluded from the sample, highlights a possible alternative explanation for age as a factor beyond digital literacy. Specifically, although age and education may interdependently foster effective ICT usage, motivation as an unobservable product of age, may present an even greater influence over mobile phone functionality (Van Dijk & Hacker, 2003: 319).

Given that older respondents may likely self-select to being outsiders of the Digital Age irrespective of education attained, this may suggest that although formal education may be a crucial component for digital awareness for the urban poor, the possession of a positive attitude may be even more crucial for active and meaningful ICT engagement (van Dijk & Hacker, 2003: 319). According to regression findings, this is especially pertinent for respondents 40 years and above. While this is in contrast with previous arguments within the literature for age to directly predict optimal ICT usage, it additionally serves to explain the digital wealth of the marginalised urban youth within the sample who may be more incentivised and available to take advantage of known digital opportunities, such as those for youth unemployment, in the face of socio-economic hurdles in South Africa (Kania-Lundholm & Torres, 2015; Kreutzer, 2009; Waema & Miroro, 2014).

The aforementioned notwithstanding however, one of the most significant and policy-relevant findings produced by the current analysis, is evidence for the severity of mobile broadband pricing as a major barrier to satisfying the ICT demand of the mobile Internet-dependent urban poor. Consequently, this paper supports the well-asserted risk of ICT being extractive to the economic wellbeing of the poor across the developing world (Miller et al, 2005; Chigona et al, 2009; Carmody, 2012; Crandell et al, 2012; Chair, 2017). This is based on findings of the willingness of the digitally wealthy to not only dedicate nearly 30 percent of their average monthly income to mobile expenditure, in spite of their low economic status, but to incur an opportunity cost sufficiently greater than the "standard reference of two percent to three percent of income spent in developed economies" (Gillwald, 2017: 2).

Although this finding is inclusive of students whose contribution to household consumption would be limited, information from Table 8.2 in Chapter 8 critically confirm the severity of high mobile data costs as an inhibitor to optimal mobile phone and Internet usage. Cognisant of the potential influence of self-reported measurement bias in these results, the information nevertheless serves to highlight that while the ubiquity of Smartphones among the urban poor may have eliminated physical digital divides, broadband affordability-gaps threaten their effectiveness in promoting digital inclusion and wellbeing (Townsend, 2015: 10). This is further underscored by the finding that mobile broadband expenditure accounts for 70 percent and 60 percent of total mobile expenditure for the digital wealthy and mildly active or sub-optimal user, respectively.

In light of this observed dependency on mobile broadband by the urban poor and the potential for its cost to undermine the value of digital dividends extracted, these findings affirm the argument by Gillwald (2017: 1) that “broadband can no longer be seen as a supply-side infrastructural issue alone,” but rather a critical component of optimising ICT demand and usage. To this end, the price of mobile broadband, and the complaints thereof by urban BoP respondents, both serve to highlight the insufficient progress of current policy directives to influence mobile broadband prices and promote greater competition within the MNO market on prepaid products beyond those which are voice-based and promotional (Mothobi, 2017: 11).

In terms of alternatives to mobile broadband however, the relative under-utilisation of FPW by the urban poor further highlights the inability of these initiatives to fully realise their designed aims to expand infrastructure and reduce mobile traffic (Geerdts et al, 2016; Chair, 2017). Although this may reflect the unique limitations faced by provincial FPW programmes to be more widely available and of more reliable quality along urban peripheries, the current level of FPW usage by the urban poor serves to critically underlines the broader inefficiency of the national ICT policy to effectively include the urban poor to the developmental gains of the Information society through effective interventions (Odendaal, 2008; Chigona et al, 2016; Geerdts et al, 2016).

Policy recommendations

In order to make progress in alleviating the above demand barriers and achieving goals of the NDP, a clear need exists for more concerted effort by national ICT policy to rectify its tendency to disproportionally emphasise supply-side measures, and to target the optimisation of ICT demand in ways which are both sustainable and innovative (Brown & Brown, 2008: 120). More importantly, in order for the urban poor to feel the effects of reform, the narrative of policy discourse and its implementation must be adjusted to specifically target the needs of marginalised urban communities. To inform this process of policy reform, the following recommendations are provided which may not only encourage greater digital dividends to be reaped by the urban poor, but also facilitate the inclusivity of the ICT sector as a whole.

1. Digital literacy learning in schools

Findings of this paper, show that a clear need exists for policy to actively promote and prioritise the development of digital skills within poor urban schools which regularly struggle to equip students with skills necessary to gainfully participate within the digital economy (Mutula, 2004; Jain, 2006; Chair, 2017). Although this need for digital literacy intervention is acknowledged by SA Connect under its pillar of "Digital Opportunity," its active realisation in national frameworks and practice have been notably absent (Department of Communications, 2013:6). This is indicative of the slow realisation by policymakers that while the aggregation of computers are vital as key prerequisites for the teaching of digital literacy in schools, in the digital age, it is the ability to utilise digital technology effectively which is most essential (Gillwald et al, 2012; Gillwald, 2017). As a result, a strong need exists for national policy to promote digital literacy learning within poor urban schools which not only equips students with the ability to search and receive information on fixed computers, but to also create and leverage digital content in ways which develop capabilities and skills required by the digital economy. Greater awareness of the usefulness of ICT for broader knowledge and learning may also be created by incorporating digital literacy into traditional classrooms, as opposed to stand-alone computer courses (Manyika et al, 2013:19; Gillwald, 2017: 13).

2. Improve local content of digital literacy and m-apps

In order to support this proposal however, findings for the importance of language within the regression analysis suggests the need to promote digital content which is local and tailored to the needs of the poor. Although recent findings by Chair (2017) challenge the relevance of this aspect for South Africans in general, this may not necessarily be the case for poor urban students and job-seekers who are highly motivated to engage with interactive online content but are less likely to be primarily English speakers (Kreutzer, 2009: 26; Odendaal, 2011b: 156).

Given that Internet search engines such as Google have already made inroads in improving instant translations, the key to satisfying local ICT demand may involve local innovations in m-apps targeted towards delivering content tailored to the needs of digitally connected South Africans with English as a second or third language (Gillwald, 2017: 14). Although these m-apps could trigger greater developmental gains in areas such as in digital micro-employment, greater public-private partnerships should be promoted by Government to lower the high cost of innovation in South Africa and generate broader awareness of useful m-apps (Manyika et al, 2013: 33). This would notably encourage more intensive usage of capability-driven m-apps by the urban youth, and youth in general, who demand more online participation than other segments of the population (Waema & Miroro: 2014: 117).

3. *Improve mobile broadband affordability*

The success of these initiatives critically depend however on the ability of the poor to utilise these increasing "data-hungry" applications without being inhibited by significant opportunity costs (Geerdts et al, 2016: 14). Given the dependency of the urban poor and overall BoP on mobile broadband, it is therefore critical that national Government addresses its affordability (Gillwald, 2017: 5). This may be achieved through a rebalancing of the institutionally weak and inefficient ICT sector (Gillwald et al, 2012: 4). Specifically, given the negative influence of the uncompetitive market structure on mobile data pricing, reform should take place through activating the broader release of broadcaster frequency spectrum to MNOs, unbundling infrastructure-sharing bottlenecks, and ensuring greater competition within the MNO market (Department of Telecommunications and Postal Services, 2016: 67; Gillwald et al, 2016: 31). However, given that the responsibility of these specific reforms fall under the mandate of the regulator, a reform of ICAASA's capabilities may additionally be required in order to improve the efficiency of the ICT sector (Gillwald et al, 2012: 4).

4. *Expand Free Public Wi-Fi nationally within marginalised urban communities*

Given its use at least once a day by the urban poor, current estimates of FPW supply support the need for its broader expansion nationally, but specifically targeted along urban fringes in line with SA Connect objectives (Department of Communications, 2013: 5). Although FPW may not yet be capable of acting as a substitute for costly mobile broadband, it may assist in significantly reducing the dependency of the urban poor on mobile broadband as its quality and coverage improves (Hodge, 2017; Geerdts et al, 2016:100). As a result, the sensitivity of the urban poor to persistently high mobile data prices may be additionally reduced (Geerdts et al, 2016: 3). The achievement of these results however, will depend not only on the substantive progress in policy frameworks to develop "Open Access" broadband, but also on provision which is user-centric and matches the demands of the urban poor in terms of availability, quality and ease of use (Department of Telecommunications and Postal Services, 2013: 65; Geerdts et al, 2016: 100).

10. Limitations

Due to the dynamic relationship between ICT and development, the scope of the current study was restricted in a number ways.

In defining the urban poor as the subject of analysis, one of the first limitations encountered by this study was the inability to analyse ICT based on various standards and depths of poverty. Although this level of detailed analysis would have provided rich insight into the relationship between ICT and poverty, this approach would have proven too cumbersome for the scope of this thesis. As a result, this analysis was restricted to using a single absolute poverty line to define its poor population, and therefore risked including individuals, such as students, who may only have been impoverished as a result of their dependency on household income. In the absence of household income, it was not possible to verify this for the current analysis. To provide a more thorough insight into how ICT is used for the development of the poor, and at what cost, future analyses should therefore take into account various income sources, poverty line standards and depths of poverty experienced by individuals.

Furthermore, in attempting to understand the nuances of mobile phone usage, the construction of the DPF within the current analysis depended significantly on self-reported data on the frequency with which various m-apps were utilised. However, given the potential for individuals to either over- or under-estimate their usage due to some unobserved motivation, such as perceptions of addiction, it is possible that this derivation of digital poverty introduced omitted variable bias into the analysis (Woolridge, 2013: 86). Although this bias was inevitable and less significant for cross-tabulation data analysis, greater efforts were made to account for its influence on regression findings by removing students from the model. Given the inability to identify a proxy for motivation, the construction of future DP frameworks should seek to utilise MNO activity data as a substitute for survey data. This may provide a more accurate depiction of mobile phone usage.

Another limitation encountered by this thesis relates to its inability to econometrically assess the influence of affordability on the digital poverty of the urban poor. This arose from the fact that although the RIA national sample was nationally representative and randomly sampled, the determination of the urban BoP was not. As a result, although the application of sample weights minimised the potential for sample bias, the utilisation of a poverty line prohibited the inclusion of income-based covariates within the econometric analysis. To replicate or improve on these results in the future, data-sets explicitly collected for poor urban populations should be utilised to avoid this constraint on results. In doing so, not only could a larger representative sample be collected, but also it would enable the control of more covariates such as race and provinces.

The scope of this thesis was also unable to incorporate a valuable analysis on the cost-saving strategies employed by the urban poor to reduce their vulnerability to high mobile data costs. This imposed the limitation on this study in not taking into account whether and how the urban poor use multiple SIM cards to benefit from different promotional packages across various MNO networks, as well as possibly to utilise zero-rated services to relieve cost pressures when using specific “data hungry” m-apps. Although an inclusion of these products would not have affected calculations for the opportunity costs endured by the urban BoP sample, they may have added insight into measuring the effectiveness of current MNO initiatives to reduce affordability barriers.

11. Conclusion

Since the end of Apartheid in 1994, South African national policy has aimed to ensure universal access of ICT to previously disadvantaged communities in order to promote their development and achieve an overall socio-economic transformation of the economy (DPTS, 2016: 6). Within the modern digital era, this aim has been underscored by the 2012 National Development Plan through its commitment to ensure that by 2030, “ICT will underpin the development of a dynamic and connected information society….that is more inclusive and prosperous” (NPC, 2012: 190). The achievement of this goal by the State has often depended however on the implicit assumption that if a critical mass of ICT infrastructure or penetration is achieved, the marginalised poor would automatically be empowered to derive optimal developmental gains from this degree of access. This assumption by policymakers has been especially applied to individuals residing within urban areas, given their increasing adoption of Smartphones and exposure to an expanding network of broadband services.

However, in light of increasing urban inequality and “the urbanisation of poverty” in South Africa, this thesis finds that contrary to the prevailing assumptions of national policy, the substantial ownership of Smartphones among urban residents at the Bottom of the Economic Pyramid (BoP) has not been sufficient to promote optimal developmental outcomes for their improved wellbeing (SACN, 2016: 142-157). Using Roxana Barrantes’ Digital Poverty Framework (2010), this conclusion is supported through finding that only 12 percent of the urban BoP are capable of actively using their Internet-enabled mobile phone on a daily basis in capability-driven ways. This outcome implies that despite the ability of all Smartphones owners to leverage their devices for strengthening social capital, economic inclusion and knowledge - the optimality of these returns in terms of quality and quantity is predicted with only a 5 percent probability. These results consequently suggest that despite the relative ubiquity of Smartphones among the urban BoP, their ability to effectively use these devices for developmental gains has been subject a significant degree of inequality.

By accounting for the potentially confounding effect of students on the urban BoP sample, the analysis within this thesis finds digital literacy, negative perceptions, and the costs associated with mobile access and broadband services to be key demand barriers in driving this observed digital inequality. However, given the observed willingness of the urban BoP sample to dedicate up 30 percent of their monthly per capita incomes towards mobile expenditure on average, the latter barrier is found particularly extractive and inhibiting to their digital inclusion. This is notably reinforced by finding the urban BoP to be critically dependent on mobile broadband, with sub-optimal Smartphone users allocating nearly 70 percent of their mobile expenditure to mobile data costs in the absence of greater access to the same Internet alternatives which are enjoyed by optimal Smartphone users at home or work.

In order to reduce the digital inequality experienced by the urban BoP and optimise the potential of Smartphones as turnkeys for development and opportunity, these results consequently advocate for the substantive reform of national ICT initiatives to effectively target the amelioration of demand barriers experienced by the urban BoP. In line with the framework established by the 2013 National Broadband policy, these should include interventions targeted at not only improving digital literacy learning in schools, but also the reduction of mobile broadband prices and the expanded availability of Internet alternatives, such as Free Public Wi-Fi, along the poor urban periphery. In doing so, national Government may assist in not only limiting the entrenchment of digital inequality within its poor urban marginalised communities, but also in empowering its citizens to effectively utilise their available ICTs as tools for improved wellbeing at reduced opportunity costs.

To further inform these reform efforts, as well as to reduce the paucity of research on urban digital inequality, results from this thesis highlight a number of areas which warrant further research. These include a deeper analysis of gender inequalities in Smartphone usage towards development, as well as how poor urban youth utilise Free Public Wifi and the costs they incur to do so (both in terms of time and money). Further evaluation on the broader availability and use of Free Public Wifi in peri-urban areas, in terms of access, quality and cost, should additionally be conducted to evaluate the success of this initiative in effectively optimising its potential as a cost-saving strategy for the remote and under-served urban sprawl. This research should specifically aim to produce quantitative and robust indicators of Wi-Fi related gains in order to contribute towards evidence-based policy and precisely targeted State programmes.

12. Appendix

Table 12. 1 – DPF user characteristics

Urban BoP	Extremely digital poor		Digitally poor		Passive		Mildly active		Digitally wealthy	
	n	Col %	n	Col %	n	Col %	n	Col %	n	Col %
ICT infrastructure										
Mobile phone										
Basic phone			1162	100	0	0,0	0	0,0	0	0,00
Feature phone			0	0	14	16,5	211	6,7	60	7,6
Smartphone			0	0	72	83,5	2964	93,4	738	92,4
n/Chi-squared			44/174,5***		4/2,1		119/1167***		28/16,9***	
Mobile Internet										
Once an hour or more					0	0	1843	58,0	301	37,7
Once a day					19	21,9	1192	37,5	327	40,9
Once a month					42	49,1	53	1,7	86	10,7
Less than once a month					25	29,0	56	1,8	46	5,7
Never					0	0	31	1,0	40	5,0
n/Gamma					3/0,7^{+++}		110/-0,8^{+++}		27/-0,1	
PC Internet										
Once an hour or more					11	12,5	185	5,8	81	10,1
Once a day					0	0,0	256	8,1	148	18,5
Once a month					0	0,0	262	8,3	296	37,0
Less than once a m					19	21,9	176	5,5	50	6,3
Never					56	65,7	2297	72,4	224	28,1
n/Gamma					3/-0,1		109/-0,1		28/-0,5^{+++}	
FPW										
Once an hour or more					0	0	14	4,3	71	8,9
Once a day					0	0	393	12,4	226	28,3
Once a month					0	0	734	23,1	237	29,7
Less than once a m					19	21,9	283	8,9	114	14,2
Never					67	78,1	1629	51,3	151	18,9
n/Gamma					3/0,6^{+}		110/-0,3^{++}		27/-0,5^{+++}	
Telephone	0	0	29	5	18	49,1	46	4,0	17	5,5
n/Chi-squared	0/0,8		3/0,0		2/14,6*		3/0,6		2/0,0	
Individual PC	20	2,01	49	4,2	11	12,5	358	11,3	197	24,7
n/Chi-squared	1/3,2		2/3,7		0/0,8		14/16,4***		7/10,3**	
Human capital demographics										
Age										
15-24 years	459	45,5	258	23,0	0	0,0	2279	71,8	484	60,6
25 - 34 years	268	26,6	36	31,9	19	21,9	670	21,1	26	32,0
35 - 44 years	138	13,7	168	14,9	14	16,5	173	5,4	41	5,1
45 - 54 years	77	7,6	128	11,4	0	0,0	4	1,2	18	2,3
55 - 64 years	36	3,5	163	14,5	42	49,1	0	0	0	0
65years and above	31	3,1	49	4,3	11	12,5	16	0,5	0	0
n/Gamma	37/0,3^{++}		43/0,5^{+++}		4/0,7^{+++}		120/ -7,8^{+++}		31/ -0,4^{+++}	
Years of Education										
1-7	276	27,3	354	30,5	14	16,5	198	6,2	1	1,8
8-12	706	70	745	64,2	61	71,0	2496	78,6	582	72,9

Urban BoP	Extremely digital poor		Digitally poor		Passive		Mildly active		Digitally wealthy	
	n	Col %	n	Col %	n	Col %	n	Col %	n	Col %
13-20	0	0	26	2,3	11	12,5	48	15,2	202	25,3
21 or more	0	0	8	0,7	0	0,0	0	0	0	0
None	27	2,7	29	2,5	0	0,0	0	0	0	0
n/Gamma	38/-0,7^{+++}		43/-0,5^{+++}		3/0,0		119/0,5^{+++}		31/0,4^{+++}	
Maximum household education										
Primary	68	14,7	83	14.1	0	0	33	2,9	0	0
Secondary	360	76,8	491	83.1	18	50,9	688	60,0	194	64,5
Tertiary	14	3,1	17	2,8	18	49,1	426	37,2	107	35,5
None	25	5,4	0	0	0	0	0	0	0	0
n/Gamma	41/-0,7^{+++}		55/-0,6^{+++}		4/ 0,5		104/0,7^{+++}		28/0,4^{+++}	
Race										
African	934	94,5	1069	92	33	38,4	2556	87,5	687	86
Coloured	27	2,8	0	0,0	0	0,0	57	2,0	0	0
White	0	0,0	54	4,6	0	0,0	2	0,6	0	0
Indian/Asian	0	0,0	0	0,0	0	0,0	0	0,0	0	0
Other	0	0,0	4	0,4	0	0,0	0	0,0	0	0
Refuse	27	2,8	4	3,0	53	61,6	291	10,0	112	14
n/Chi-squared	38/45		44/ 12,4*		3/ 6,7		112/10,7*		30/5,3	
Gender										
Male	456	45,2	607	52,2	72	83,5	1592	50,2	258	32,3
Female	553	54,8	556	47,8	14	16,5	1583	49,9	541	67,7
n/Chi-squared	38/4,0*		44/3,5		4/1,6		120/4,2*		30/ 0,9	
Economic										
Employment										
Employed	26	2,6	82	7,1	14	16,5	158	5,0	85	10,7
Strict unemployment	429	42,5	519	44,7	19	21,9	1025	32,3	216	27,1
Flex unemployment	85	8,4	103	8,9	0	0,0	120	3,8	18	2,3
Student	368	36,5	23	19,9	0	0,0	1734	54,6	357	44,7
Self-employed	13	1,2	46	4,0	0	0,0	0	0,0	2	2,0
Unpaid housework	35	3,5	102	8,8	0	0,0	122	3,8	107	13,4
Retired	54	5,3	78	6,7	53	61,6	16	0,5	0	0,0
n/Chi-squared	37/8,9		45/21,3**		4/17,7**		121/33,8***		30/12,7*	
Average monthly income	135,8		180,6		49,6		209,9		227,1	
Proportion spent on mobile expenditure			0,4		0,0		0,2		0,3	
Proportion of mobile expenditure spent on data			0,1 ^{xxx}		0,2		0,7^{xxx}		0,6^{x}	

Authors own calculations. Results are weighted.

*p<0,05; **p<0,01; ***p<0,001. $^{+}$p<0,05; $^{++}$p<0,01; $^{+++}$p<0,001

Measures of association between dichotomous nominal variables were calculated using the Chi-Squared statistic (*). Where cells included joint frequencies of less than 5, Fischer's exact measure of association was used. Gamma measure of association (+) used for ordinal dependent variables. Statistical significance was determined for each test against the null hypothesis of independence between variables when p<0,05; p<0.01 and p<0,001. A difference of means test (ttest) (^{x}) was used between continuous income and expenditure variables against the null hypothesis of independence of means between distributions.

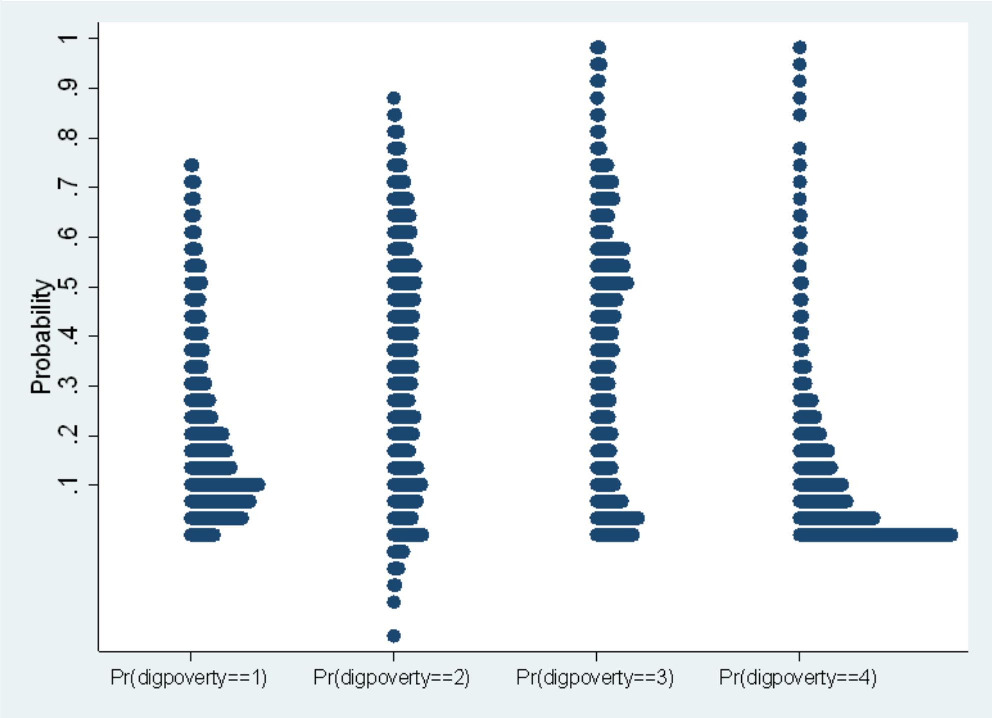
Source: 2017 "After Access" RIA household and Individual IC access and use survey

Table 12. 2 - GOLM cumulative predicted probabilities (with and without students)

	With students			Without students		
	Extremely digitally poor	Digitally poor	Passive Mildly active	Extremely digitally poor	Digitally poor	Passive Mildly active
Membership of EAP	-0.169	-0.169	-0.169	-0.084	-0.084	-0.084
	(0.279)	(0.279)	(0.279)	(0.370)	(0.370)	(0.370)
Years of education	0.207***	0.207***	0.207***	0.207***	0.207***	0.207***
	(0.053)	(0.053)	(0.053)	(0.061)	(0.061)	(0.061)
Female	0.672**	0.672**	0.672**	0.585*	0.585*	0.585*
	(0.287)	(0.287)	(0.287)	(0.346)	(0.346)	(0.346)
Age	-0.005	-0.088***	-0.053***	-0.007	-0.083***	-0.070**
	(0.015)	(0.015)	(0.019)	(0.016)	(0.019)	(0.032)
Household size	0.059	0.059	0.059	0.047	0.047	0.047
	(0.061)	(0.061)	(0.061)	(0.067)	(0.067)	(0.067)
Max secondary level of household education	-0.280	-1.335***	0.163	-0.276	-1.544***	-0.474
	(0.439)	(0.358)	(0.477)	(0.503)	(0.375)	(0.609)
Hours spent with interest group	0.037	0.037	0.037	0.045	0.045	0.045
	(0.036)	(0.036)	(0.036)	(0.042)	(0.042)	(0.042)
English home language	1.342	1.006	13.159***	0.859	0.824	12.807***
	(1.633)	(1.126)	(0.698)	(1.668)	(1.253)	(1.109)
Indigenous African home language	0.242	-0.774	11.927***	0.139	-0.567	10.938***
	(1.228)	(0.895)	(0.484)	(1.244)	(1.046)	(0.727)
Constant	-0.817	1.965	-15.484***	-0.663	1.728	-13.661***
	(1.676)	(1.398)	(1.025)	(1.767)	(1.735)	(1.631)
N	234	234	234	164	164	164
Wald chi2(17) = 984.79				Wald chi2(17) = 390.34		
Prob>chi2=0.0000				Prob >chi2=0.0000		
Pseudo R2=0.2213				Pseudo R2=0.2048		

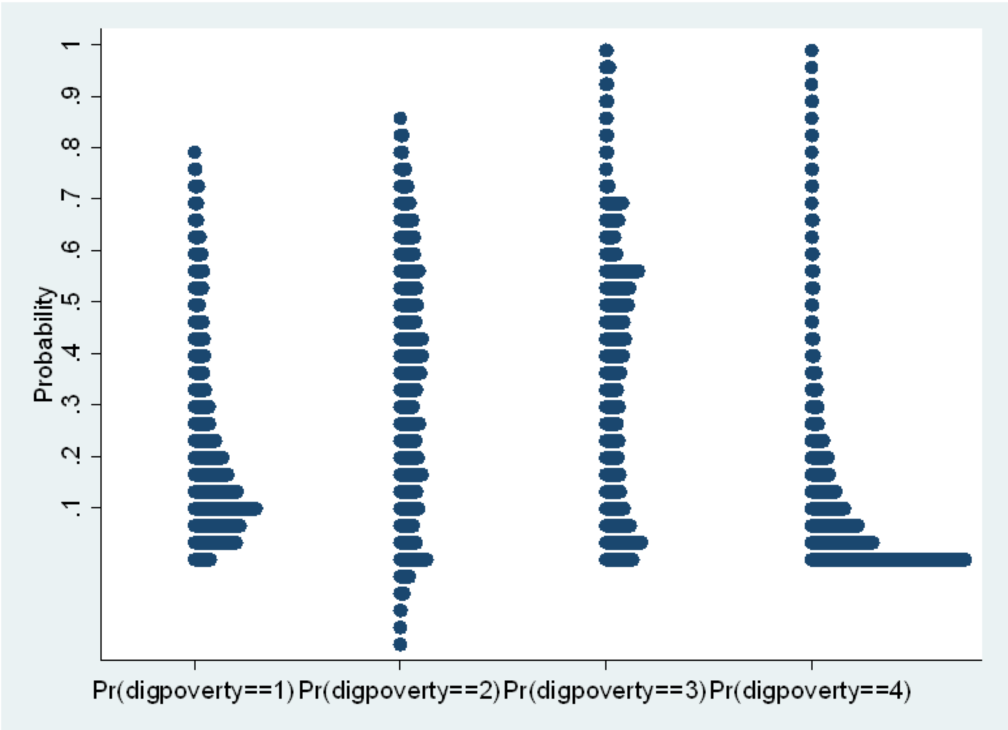
Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
Categorical dependent variable with 1 as extremely digitally poor, 2 as digitally poor, 3 as the combination between passive and mildly active, and 4 as digitally wealthy. Membership of Economically active population (1= employed, unemployed or self-employed; 0= student, retired, discouraged unemployed, unpaid housework, disabled) and female (1=female; 0=male) ae dichotomous variables. Real monthly income, years of education, age, household size, household years of education and hours spent with interest groups are continuous variables. Home language is a categorical variable with 1= Afrikaans (base), 2=English, 3 =African languages.

Figure 12. 1 - GOLM predicted probabilities per DPF (with students)



Authors own calculations. Results are weighted.
Source: 2017 "After Access" RIA household and Individual ICT access and use survey

Figure 12. 2 - GOLM predicted probabilities per DPF (without students)



Authors own calculations. Results are weighted.
Source: 2017 "After Access" RIA household and Individual ICT access and use survey

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