The impact of line quality and product attributes on fixed line penetration

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Households are disconnecting from fixed lines in large numbers in South Africa, where the number of mobile subscriptions dwarfs the number of fixed line subscriptions. One possible explanation for the disconnection of fixed lines (and uptake of mobile) is the poor quality of fixed line infrastructure, and the lack of broadband-enabled switches. The quality of fixed line infrastructure matters for broadband services: long loop lengths result in slow internet speeds as a result of the attenuation (weakening) of signal as the length of the copper line between a Telkom exchange and a residence grows. In order to test whether the quality of landline affects a household's choice of broadband service, a unique variable for the quality of fixed line broadband in South Africa is developed by calculating the distances between Telkom exchanges and residences. This allows us to assess whether consumers that have replaced fixed lines with mobile services tend to be further away from local exchanges. The dataset to be used will also allow us to test whether the availability of ADSL causes more customers to choose to have a landline. This analysis is possible by combining geographic location information on households in the the National Income Dynamics Study (NIDS), a panel household survey of over 7,000 households conducted in 2008, 2010/2011, 2012 and 2014, and Telkom switches in the broadbandstats.co.za database. The data will be analysed using a binary choice model, comparing results for waves 2 and 3 of NIDS. NIDS allows for a range of household characteristics to be held constant, including household size, internet spend and income. The outcomes of this research have important policy implications: to the extent that landline disconnections are the result of poor quality and the lack of ADSL (rather than the availability of substitutes, such as mobile), then the regulator ought to intervene by introducing competition for the supply of fixed line services through open network access policies, including local loop unbundling.

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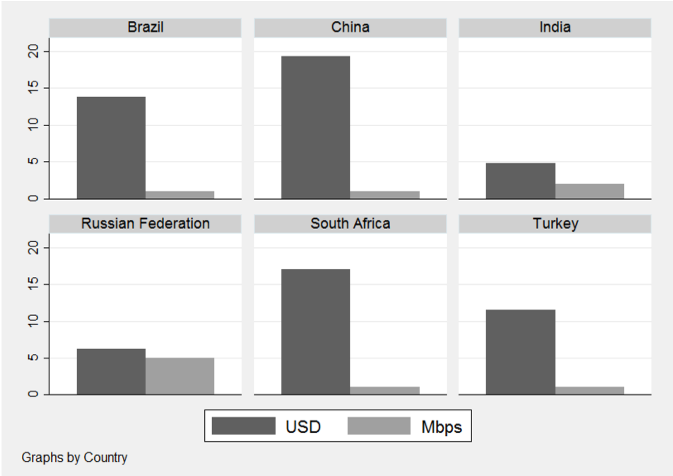
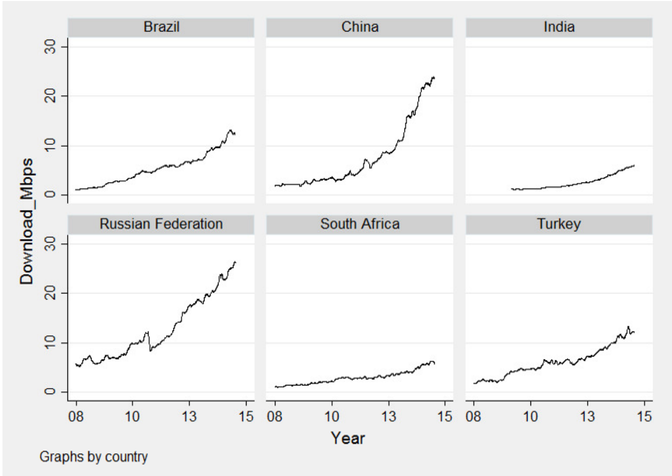


(a) Speeds (Mbps) and prices (USD), 2013

Source: Analysis of ITU (2014) data.



(b) Broadband speeds (Mbps, 2008-2015)

Source: Analysis of Ookla (2015) data.

Figure 1: Broadband speeds and prices in South Africa, Brazil, China, India, Russia and Turkey

1 Introduction and motivation

The costs to communicate in South Africa are high, particularly in respect of broadband services (see, for example, Bonakele *et al*, 2014) . SA has very high broadband prices relative to its developing/middle income country peers, for services that have relatively slow speeds (see Figure 1a). Relative to developed countries, SA performs even more poorly.

Moreover, SA is falling behind its developing and middle income country peers in respect of broadband speeds: While India was the slowest of the above group of countries historically, India has now caught up to South Africa (see Figure 1b). Speeds in SA are growing much more slowly than they are in Russia, Brazil, China and Turkey.

There is growing pressure to reduce these costs, both from Parliament[1] and from the Independent Communications Authority of South Africa (ICASA)[2].

Local Loop Unbundling (LLU), a remedy typically used to address market power in markets for fixed lines, is one of the remedies being considered by ICASA in order to address the high costs to communicate (ICASA, 2014b). LLU is a remedy imposed on fixed line incumbents in the European Union and elsewhere, and is intended to facilitate services-based competition via a 'ladder of investment', whereby new entrants use existing infrastructure initially and progressively build out their own infrastructure (Cave, 2006a).[3]

However, households are disconnecting from fixed lines in large numbers in South Africa, and the number of mobile subscriptions dwarfs the number of fixed line subscriptions (see, for example, Bonakele *et al*, 2014). There is therefore some doubt as to whether ICASA ought to implement LLU. To the extent that quality of fixed lines matters to consumers, landline disconnections might be the result of poor quality rather than fixed to mobile substitution. The quality of fixed line infrastructure matters particularly for broadband services: long loop lengths result in slow internet speeds and poor customer experience.

The main research question addressed here is: do fixed lines still matter in South Africa, given the significantly larger number of mobile subscriptions? Related to this question are two further questions: (1) Does ADSL availability make choosing a fixed line more likely? (2) Does the quality of the fixed line affect landline (and mobile) choice?

[1]See, for one example among many, the Parliamentary Portfolio Committee on Communications' hearings on the 'cost to communicate' in South Africa, held in July 2013.

[2]See, for example, ICASA's cost to communicate programme (ICASA, 2013).

[3]Unbundling of the local loop is a regulatory process which allows several internet service providers to use the incumbent fixed line network's copper lines to customers in order to drive innovation, lower prices and offer consumers and businesses a variety of access options for ICT services. The local loop is the copper line between the fixed line operator's nearest point of network aggregation (usually a local exchange or switch) and the end-customer's premises.

These questions will be addressed by measuring the impact of ADSL (broadband) availability and the quality of fixed line broadband services on household choices of fixed lines (the first contribution). This will be undertaken by the development of a unique dataset on broadband availability and quality, combining the National Income Dynamics Survey (NIDS) and data on Telkom switches (provided by broadbandstats.co.za). There is limited research on the impact of broadband availability and quality on the demand for fixed lines.

The rest of this paper is structured as follows: first, a brief review of the existing literature is provided. This is followed by a discussion on the data and methodology to be used. Results are then presented, followed by a concluding section.

2 Previous research on fixed line penetration and quality

There is relatively little work on the impact of line quality (through its impact on broadband speeds) and the availability of broadband on fixed line penetration. There is nonetheless a considerable literature on fixed to mobile substitution. Vogelsang (2010) provides a useful review of this literature. Hamilton (2003), for example, evaluates the determinants of fixed line penetration across 23 African countries between 1985 and 1997. The study measured the impact of mobile penetration (subscriptions / population * 1000), GDP per capita, institutional factors (using the International Country Risk Guide), economic freedom, democracy, extent of urbanisation and trade on fixed line penetration (measure in two ways: fixed telephone lines supplied / population, and demand for fixed telephone lines / population). Hamilton (2003) finds that mobile penetration is positively associated with fixed line penetration for most specifications of her model, which supports the hypothesis that mobile networks and fixed line networks are complements (rather than substitutes). This might be because greater competition from mobile operators induces fixed operators to invest in their networks and improve the quality of their services, which in turn causes fixed line networks to expand. She finds however considerable variability in her results over time (she finds much stronger complementarity in 1987 than she does in 1997) and between countries. She also finds some evidence of substitutability between fixed lines and mobile phones as penetration of mobile phones grows.

This study inevitably runs the risk of pooling observations from countries with widely divergent regulatory systems and consumer tastes.[4] While Hamilton (2003) controls for these problems using fixed effects for each country, and then separately using fixed effects for different regions, it is not clear that pooling very different countries in the first place makes sense. A further problem that arises in cross-country studies in developing countries is endogeneity between the uptake of fixed lines and mobile broadband where the government owns the incumbent fixed line operator and also makes policy for the mobile sector (Hamilton, 2003). In many developing countries in Africa for example, the fixed line operators tend to be state owned and report to the Minister responsible for telecommunications. The fixed line operator might therefore be in a position to influence the number of mobile subscriptions. This means that the number of mobile subscriptions and the number of fixed lines might be jointly determined. Ordinary least squares would attribute changes in fixed line subscriptions to mobile subscriptions when in fact the two are jointly set by a third party, the government. Accordingly, mobile penetration would be correlated with the error terms in the regression model. An instrumental variable approach presents one possible solution to this problem, and involves finding an alternative variable that is correlated with the mobile phone penetration variable but is not correlated with the error terms in the regression model. The author used this approach, using the percentage share of private participation in the economy (private credit extension as a percentage of GDP) as a proxy for the extent of mobile penetration.

The existing literature on the demand for telecommunications services is largely consistent with Hamilton's (2003) results, and suggests that households largely view fixed and mobile voice services as substitutes, though the literature is not conclusive (Vogelsang, 2010). The inconclusive nature of the literature is partly due to the fact that finding high quality price data for different countries is difficult given the complexities of telecommunications prices (installation, access and usage prices) and service qualities (such as high speed broadband vs. low speed and the variety of mobile services that are bundled with tradition mobile voice

[4]The Hamilton (2003) study pools a large group of heterogenous countries, from Arabic speaking North African countries to French speaking West African and English speaking Southern African countries. There are significant differences between these countries. For example, French speaking West Africa has a very different administrative law system to the common law system employed in English-speaking Southern African countries.

services). Furthermore, significantly different results for fixed to mobile substitution (FMS) arise depending on the basket of fixed and mobile services included in the analysis. While fixed and mobile voice services may be substitutes for some households, once fixed line broadband is included in the customer choice set fixed and mobile services become complements rather than substitutes (Grzybowski & Verboven, 2014).

An additional feature of the literature is that supply side considerations are not taken into account: developed countries have existing fixed line networks that are largely depreciated, while developing countries do not (Vogelsang, 2010).[5] Fixed lines may be more expensive in developing countries as a result of this, which might lead to greater FMS. The relatively limited research on fixed to mobile substitution in developing countries leaves this question open to be tested.

There is a nascent literature on the impact of LLU on broadband speeds (broadband quality). Nardotto, Valletti and Verboven (2012) analysed broadband penetration and broadband quality across more than 4,265 UK local exchanges, assessing the effect of where new entrants use LLU lines at those exchanges and where the incumbent, BT, provides services directly to customers or provides services indirectly to customers via third parties using a service called Bitstream access.[6] Their main findings were that LLU does not have an impact on broadband penetration but it does have an impact on broadband quality, as new entrants try to differentiate themselves from the incumbent through broadband speed offerings.[7] This paper does not take into account the physical properties of the fixed line infrastructure and focuses rather, from a quality perspective, on broadband speeds. Furthermore, the paper deals with the impact of LLU, rather than on fixed line penetration *per se*.

A problem that arose in of the impact of LLU in terms of broadband penetration and quality was that there was endogeneity between explanatory variables. Nardoto *et al* (2013) used average income levels and new entrants using LLU at Local Exchanges (LEs) as explanatory variables to assess the impact of LLU on broadband penetration and broadband quality. However in 2005, for example, LEs that were served by an LLU new entrant had higher broadband penetration. LLU new entrants were likely to target high income consumers and businesses that were more likely to take up broadband in the first place. The authors solved this endogeneity problem by using a system GMM approach, and using lagged differences of the explanatory variables as instruments for the endogenous variables, following Blundell and Bond (1998) and Blundell *et al*(2000).

Grzybowski and Verboven (2014) assess the impact of broadband on the uptake of fixed lines, in estimating demand for broadband and voice services among 160,363 households in 27 EU countries between 2005 and 2011 using a discrete choice model.[8] The authors find that the services are perceived as substitutes over time on average but that there is significant heterogeneity between countries, and the extent of substitutability is a relatively recent phenomenon. For example, they find that while fixed and mobile services may be substitutes in Central and Eastern European countries including Romania, Lithuania and the Czech Republic, these services are weak complements in Sweden, the Netherlands and Malta. At the same time, the demand for each type of service is independent in the UK, Luxembourg and Slovenia. Including fixed line broadband in their analysis introduces greater complementarity between fixed and mobile services. The authors find that the introduction of fixed line broadband has slowed FMS. [9]

[5] Vogelsang (2010) finds that relatively little work in this area has been undertaken. FMS might be taking place due to falling costs for mobile networks, which means that mobile operators can reduce their prices and cause customers to switch away from fixed line networks. Relative price reductions for mobile services might arise from cost reductions arising from technical progress and/or economies of scale and scope andor greater competition. Mobile networks are significantly cheaper to build than the replacement cost of fixed line networks. The fixed costs of fixed line networks in developed countries have largely been recovered already, and they are therefore regulated at incremental cost, which makes them relatively cheap. Fixed line networks are still being built in developing countries, however, and their costs may be higher. Therefore, while mobile networks might not be significantly cheaper than fixed networks in developed countries, there may be significant differences in costs between fixed and mobile networks in developing countries.

[6] The data was evaluated over 17 periods.

[7] The authors further examined the impact of inter-modal competition from cable broadband providers. Inter-modal competition between cable and DSL has a positive impact on both broadband penetration and on innovation.

[8] The authors used household survey data (the Eurobarometer) and price data from Teligen. Prices used were composite price bundles for services, including usage and access charges.

[9] They further find that fixed and mobile services offered by the incumbent are viewed as complements rather than substitutes. Instead of assessing whether mobile voice and fixed voice services are substitutes by themselves, their model allows households to choose bundles of fixed voice and mobile voice services, as well as choose different providers including incumbent and competitor fixed or mobile providers. The model is further extended for households to choose between different types of internet, including

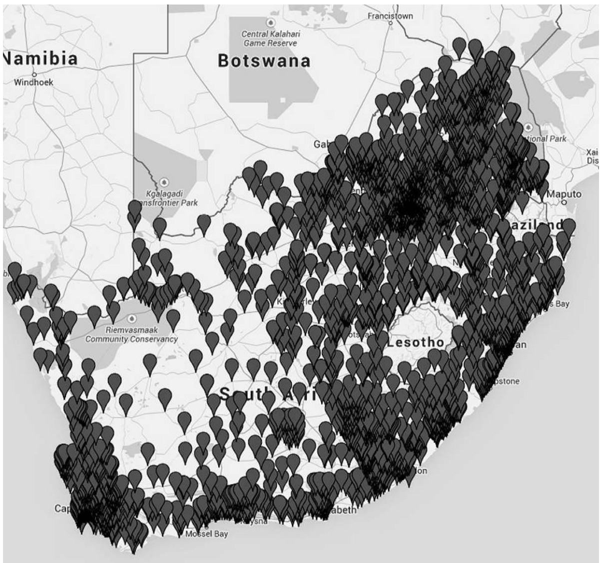


Figure 2: Telkom switches

Analysis of broadbandstats.co.za, 2013

Grzybowski & Verboven (2014), similar to Hamilton (2003) (discussed above), run the risk of pooling countries with widely divergent regulatory frameworks.[10]

These papers, however, do not address how line quality and the availability of broadband, affects the uptake of fixed lines. This paper contributes to the debate on fixed to mobile substitution, by addressing the impact of fixed line quality, and the availability of broadband, on fixed line penetration in a single country (South Africa).

3 Data and methodology

3.1 Data

3.1.1 Overview

First, a variable for the quality of fixed line broadband in South Africa is developed by calculating the distance from Telkom exchanges to customer premises in order to assess whether consumers that have replaced fixed with mobile tend to be further away from local exchanges (which gives rise to poorer quality broadband). The key principle that this analysis rests on is the attenuation (weakening) of signal as the length of the copper line grows.[11] This reduces the signal to noise ratio, which reduces the line speed experienced by consumers. This is illustrated, for example, on figure 3.

Secondly, the broadbandstats.co.za dataset records ADSL speed upgrades of Telkom switches over time. This information is linked to National Income Dynamics Survey (NIDS) data on the locations of households, in order to be able to assess whether households whose nearest switch received an upgrade are more likely to choose to have fixed line internet.

DSL, dial-up, mobile broadband, cable, other (including satellite, wifi, etc.) and no internet.

[10]The Grzybowski &Verboven (2014) paper pools a number of countries with widely divergent institutional frameworks. The UK, for example, has seen tremendous uptake in LLU lines at least in part due the functional separation imposed on BT, the fixed line incumbent there (see Cave, 2006). This has led to highly competitive outcomes resulting in high quality for fixed line broadband in the UK (see, for example, Nardotto *et al*, 2013) which may have the effect of limiting fixed to mobile substitution. This is in contrast to countries that are in transition in Eastern Europe that are more likely to have weaker institutions and therefore less competitive fixed line sectors.

[11]The quality of the broadband connection is also affected by interference from other signals travelling across the same medium (crosstalk). These factors can be assessed in terms of the Shannon Limit, which provides a theoretical maximum data rate possible over a communications channel, calculated using the signal to noise ratio on that communications channel.

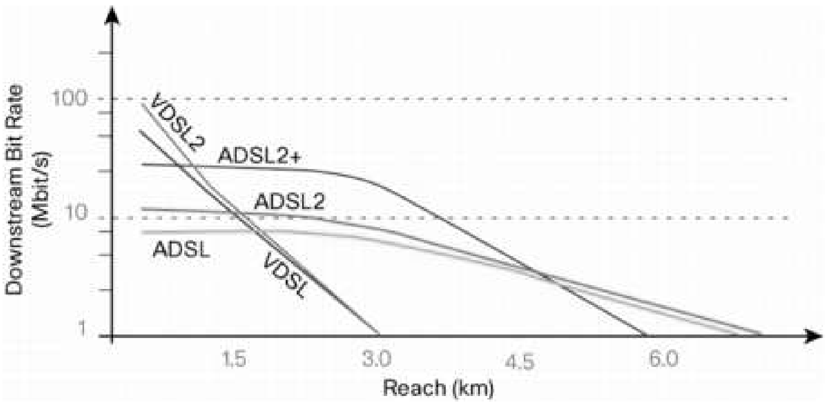
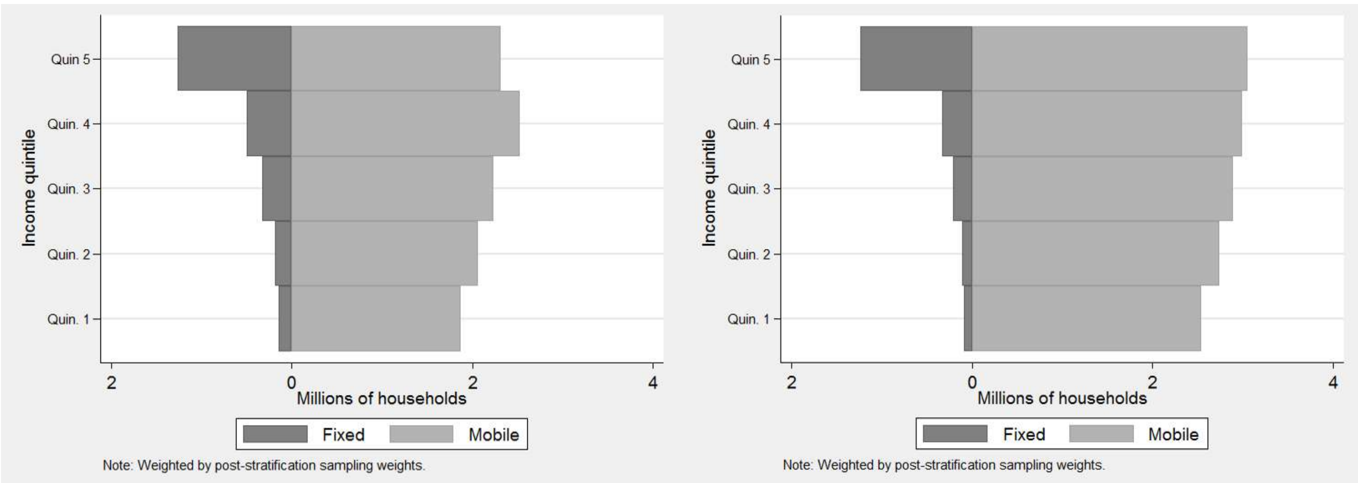


Figure 3: ADSL maximum speeds and distances

Cisco, 2009



(a) Wave 2, 2011 **(b) Wave 3, 2012**

Figure 4: Income distribution of fixed and mobile access (NIDS)

3.1.2 National income dynamics survey (NIDS)

NIDS is a national panel data study on households, and includes more than 20,000 individual observations in each of four waves (the fourth wave is forthcoming this year, 2015). The broadbandstats.co.za dataset covers the period 2011-2013, corresponding to NIDS waves 2 and 3.

In wave 2 (2010/2011), fixed line penetration among households sampled was 10.8% (17%, using weighted results) and cellphone ownership was 77% (82% using the weighted sample) over the same period. In Wave 3 (2012), fixed line penetration among households sampled decreased to 7.5% (12% using the weighted sample). At the same time, cellphone ownership increased to 90% (88.7% using the weighted sample). Access to fixed lines had become even more skewed relative to access to cellphones by 2012 (see Figure 4b).

Of the approximately 819 households sampled in Wave 2 (2010/2011) of the NIDS survey that had a fixed line telephone, only 388 (47% of the sample) had a fixed line telephone in Wave 3 (2012) (see Table 1).

This suggests that a considerable proportion of households are switching away from fixed lines. In order to determine the causes of this, it is important to understand whether those households disconnected their landlines for reasons unrelated to changes in consumer preferences, including income, geographic location (moving to a location where landlines are not available) and changes in household size (larger households may have a preference for landlines). The NIDS dataset allows for the control of all of these variables.

		Wave 3			
		Yes-W	**Yes-NW**	**No**	**Total**
Wave 2	**Yes-W**	388.0	29.0	402.0	819.0
	Yes-NW	28.0	19.0	165.0	212.0
	No	191.0	94.0	8,106.0	8,391.0
	Total	607.0	142.0	8,673.0	9,422.0

Table 1: Households with landlines between NIDS waves 2 and 3

A further variable that should be controlled for is variability in broadband quality. NIDS does not directly ask whether the household's fixed line is being used for broadband services. Nonetheless, there are a number of proxies for this including household expenditure on landlines (spend over a certain voice usage average might indicate broadband use) and NIDS contains questions about internet expenditure separately to expenditure on 'mobile experiences' and separately to expenditure on telephone expenses. While the questionnaire allows for internet to be included in telephone expenses, the questionnaire implies that internet expenditure on mobile phones is captured separately.

In order to use fixed line broadband in South Africa, a landline in working order is required. While consumers may cease to use their landline to make voice calls due to ownership of a mobile phone, broadband may be slowing fixed to mobile substitution (which would be consistent with Grzybowski & Verboven's (2014) findings, discussed above in section 2).

3.1.3 Data on locations of and maximum speeds at local exchanges

Broadband quality depends on distance between local exchanges and households: the greater the distance, the lower quality (discussed above in section 3.1.1). Households are also only able to achieve the maximum speed available at their local switch, which varies across switches. The locations and maximum speeds of local switches are available for 2011 and 2012 from the broadbandstats.co.za dataset, which is a website that collates maximum speeds and the locations of Telkom switches throughout South Africa (mapped on figure 2).

Furthermore, there are $4,339$ unique switches (each of which connects to an individual exchange) that have geolocation information (longditude and latitude co-ordinates) in the dataset. Of these switches, $2,376$ were enabled for ADSL at the end of wave 2 (April 2011).[12] $2,483$ were ADSL enabled by May 2012 (almost halfway through NIDS wave 3). The uptake of fixed lines in ADSL enabled areas will be compared with those where ADSL is not available. This will be analysed separately to, and combined with, the impact of line length (discussed next).

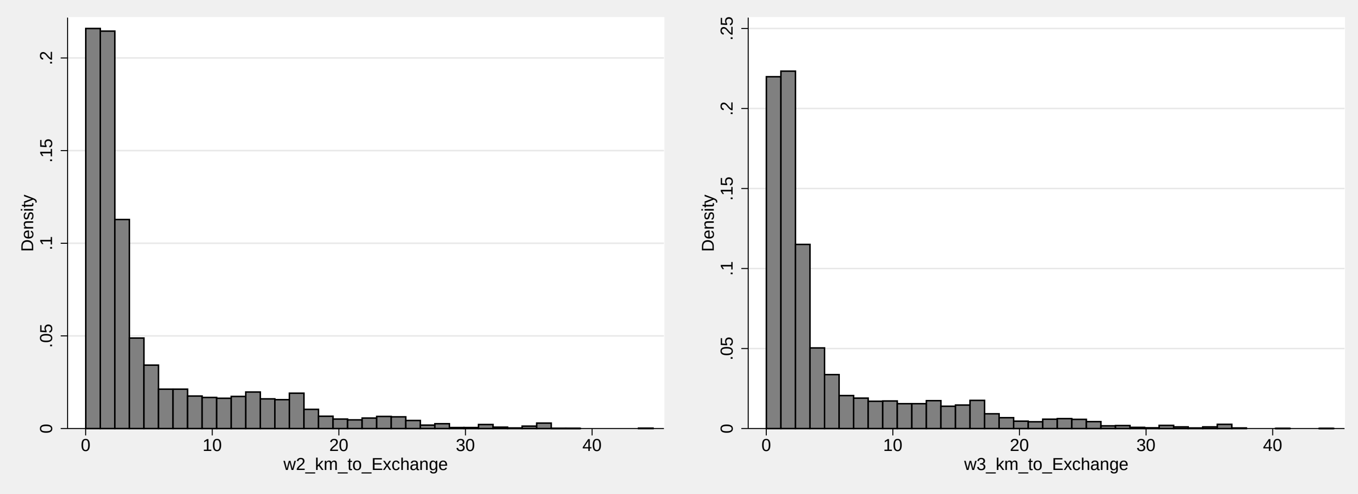
3.2 Methodology

3.2.1 Developing the line quality variable

The quality variable will be developed using the geodetic distances between Telkom's switches (from the broadbandstats.co.za dataset) and NIDS survey respondent households using a Stata package called 'geonear', developed by Robert Picard. Geonear calculates the geodetic distance between an observation of a variable (such as household location) and the nearest observation of another variable (such as the location of a Telkom switch).[13] The initial results of this variable calculation show considerable variability in distances among the data, and this variability is relatively stable over time: approximately 20% of households are located 1km and 2kms from the nearest Telkom switch (see Figure 5).

[12] NIDS interviews in wave 2 were conducted in two phases: Phase 1 was conducted between May 2010 and 9 May 2011. An additional 383 households were interviewed from June 2011 during the course of phase 2. The latter will be dropped from the NIDS sample for this analysis.

[13] The geodetic distance is calculated, according to Picard, as "'the length of the shortest curve between two points along the surface of a mathematical model of the earth"'.



(a) 2011 **(b) 2012**

Figure 5: Distribution of distances to nearest Telkom switch (NIDS)

3.2.2 OLS, logit and probit choice models

A reduced form binary choice model will be used to test the determinants of whether households choose a landline or do not, and choose a cellphone or do not. There are, broadly speaking, three approaches to assessing binary choice models: linear probability, the probit model (assumes that the probability distribution is normal) and the logit model (largely for mathematical convenience) (see, for example, Greene (2010)). The linear probability distribution will be estimated using ordinary Least Squares (OLS), and logit and probit models will be estimated using maximum likelihood. The linear probability model not commonly used, other than as a comparator for other models, due to the fact that it cannot be constrained to give results over the interval $0-1$. The probit model is only correct to the extent that household choices of landlines are normally distributed.[14]

The main idea is to assess the impact of ADSL availability and line quality on the variable of interest, in this case choice of telecommunications technology (fixed line or mobile). The choice of fixed line will also depend on a number of other variables, including household income, household size, race, gender and home ownership (following, for example, Madden & Coble-Neal (2005).

$$y_{it} = \beta_1 + \beta_2 EN + \beta_3 DIS + \beta_4 SPEND + \beta_5 INC + \beta_6 SIZ + \varepsilon_{it} \tag{3}$$

Where $y_{it} = 1$ if the household chooses a fixed line (and in the second specification, chooses a mobile), EN takes the value 1 when the nearest switch is enabled for ADSL, INC is household income, SIZ is household size, $SPEND$ is household spend on its internet access and DIS is the geodetic distance between the household and the exchange. The model will be estimated for waves 2 and 3 of NIDS.

The EN variable captures the effect of ADSL availability on fixed line penetration. The quality of the fixed line is captured by the distance variable, DIS. The average line distance appears as though households

[14] If data was available, a difference in difference approach could have been explored, following for example Dale & Krueger's (2002) work on the returns to education. The main idea is to assess the impact of a treatment (upgrade of maximum available speed) on the variable of interest, in this case choice of broadband technology (whether a fixed line was chosen or not). In its most basic form, the model to be estimated will be as follows (see, for example, Greene (2012)):

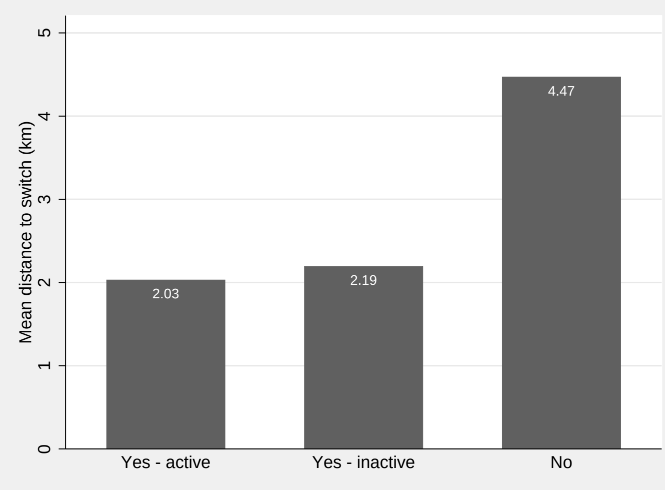
$$y_{it} = \beta_1 + \beta_2 T_t + \beta_3 D_i + B_4 T_t \times D_i + \varepsilon_{it} \tag{1}$$

Where $y_{it} = 1$ if the household chooses a fixed line, T_t takes the value 0 for wave 1 of NIDS and 1 for wave 2, D_i is the treatment variable. There will be two separate analyses for two separate treatment effects: the switch being upgraded to be able to handle ADSL, and the exchange being upgraded from less than 10Mbps to 10Mbps. For each treatment effect, D_i will take the value 1, and 0 otherwise.

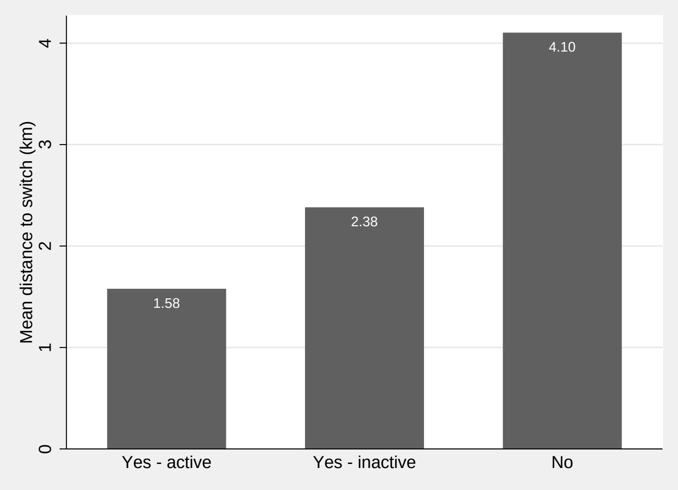
The impact of broadband speed upgrades is the difference in difference estimator, given by:

$$[(y_{i2}|D_i = 1) - (y_{i1}|D_i = 1)$$

]-[(y$_{i2}|D_i = 0) - (y_{i1}|D_i = 0)] = \beta_4(2)$



(a) NIDS wave 2 (2011)



(b) NIDS wave 3 (2012)

Figure 6: Average distance to nearest Telkom switch, by choice of landline

that have a working fixed line are close to Telkom switches (see Figure 6).

The high average distance for households that responded ‘no’ likely reflects the fact that Telkom landlines are not available to a large proportion of households in South Africa: there are approximately 3m landlines that connect households in South Africa[15], and approximately 15m households (Statistics South Africa, 2012). The other variables above (including income, race and ownership) will be used to control for the fact that landlines are not available to many households.

4 Results

4.1 Choice of landline

The results of the initial regressions for waves 2 and 3 of NIDS are shown on tables 2 and 3. The results are strikingly different for the two waves. In the second wave, households near to ADSL enabled switches are significantly more likely to choose a fixed line. Similarly, households that are farther away from exchanges are less likely to take up a fixed line (though having ADSL be enabled has a stronger effect). This result is robust to the choice probability distribution selected (linear, normal and logit).

Higher internet spend means the household is more likely to have a fixed line. However, household size is negatively related to the propensity to take up a fixed line. This is surprising: we would expect that larger households would have a greater demand for broadband.

In the third wave, these results largely fall away: we cannot reject the null hypothesis that the explanatory variables have no relationship with household choice of fixed line.

There may be endogeneity between the income and ADSL enabled variables. This is because Telkom might have decided to upgrade its switches to have ADSL in areas where incomes are higher.

There is also likely to be a relationship between household size and income (poorer households are larger in South Africa), and between internet spend and income (wealthier households are likely to spend more).

4.2 Choice of cellphone

The estimation results for choice of cellphone are shown on table 4. Household spend and Household income do not predict whether a household is likely to have a cellphone. Distance to the Telkom switch does predict this but in the opposite way that it would be expected to: being closer to a switch causes consumers to be more likely to choose a mobile phone. This likely has more to do with the fact that wealthier consumers

[15]At the peak of Telkom’s fixed line network reach, Telkom provided approximately 5.5m lines, slightly more than half of which served residential households (see Telkom annual reports, 1999/2000 and 2000/2001). The number of fixed lines in service began to decline after 2000.

Table 2: Estimation results: Household choice of landline, Wave 2

Variable	OLS	Probit	Logit
	(Std. Err.)	(Std. Err.)	(Std. Err.)
EN	0.036*	0.154*	0.230*
	(0.014)	(0.060)	(0.112)
DIS	-0.005**	-0.047**	-0.093**
	(0.002)	(0.016)	(0.033)
SPEND	0.001**	0.003**	0.004**
	(0.000)	(0.000)	(0.001)
INC	0.000**	0.000**	0.000**
	(0.000)	(0.000)	(0.000)
SIZ	-0.006**	-0.028**	-0.061**
	(0.002)	(0.011)	(0.020)
Intercept	0.157**	-0.966**	-1.645**
	(0.017)	(0.076)	(0.141)

Significance levels : † : 10% ∗ : 5% ∗∗ : 1%

Table 3: Estimation results : Household choice of landline, Wave 3

Variable	OLS	Probit	Logit
	(Std. Err.)	(Std. Err.)	(Std. Err.)
EN	0.236	0.570	0.988
	(0.169)	(0.507)	(0.888)
DIS	-0.013	-0.041	-0.075
	(0.048)	(0.125)	(0.220)
SPEND	0.000†	0.002*	0.004*
	(0.000)	(0.001)	(0.002)
INC	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)
SIZ	-0.030	-0.072	-0.128
	(0.032)	(0.086)	(0.153)
Intercept	0.203	-1.004†	-1.700†
	(0.196)	(0.580)	(1.005)

Significance levels : † : 10% ∗ : 5% ∗∗ : 1%

are more likely to have a cellphone and be close to a Telkom switch. This means that there is a measure of endogeneity between the locations of switches and the locations of higher income households. This does not rule out fixed and mobile services being complements.

Table 4: Estimation results: Household choice of cellphone, Wave 2

Variable	OLS (Std. Err.)	Probit (Std. Err.)	Logit (Std. Err.)
DIS	-0.017**	-0.061**	-0.098**
	(0.005)	(0.020)	(0.033)
SPEND	0.000	0.001†	0.003
	(0.000)	(0.001)	(0.002)
INC	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)
SIZ	0.014**	0.063**	0.112**
	(0.003)	(0.014)	(0.026)
Intercept	0.797**	0.790**	1.267**
	(0.018)	(0.074)	(0.134)

Significance levels : † : 10% ∗ : 5% ∗∗ : 1% height

4.3 Difference in Difference approach (upgrades of switches between waves 2 and 3)

The difference in difference approach holds time and location constant, and measures the impact of an upgrade of Telkom switches. Unfortunately, very few households in the NIDS sample were located close to switches that received upgrades between waves 2 and 3 of NIDS (154 households in total). Only 8 households, where the local switch was upgraded to 10Mbps, did not have a fixed line in Wave 2 and subscribed for one in Wave 3.

The result of this is that the Difference in Difference estimators are not statistically significant (see Table 6).

The implication of this is that only a small proportion of switches are being upgraded to ADSL over time. Out of the 4,338 switches in the broadbandstats.co.za database, only 731 were enabled for speeds of 10Mbps or more by July 2013. Only 180 switches were upgraded between Waves 2 and 3 of NIDS. While it might be the case that highest available internet speed has no impact on choice of fixed line, it is also possible that the very low investment into higher speeds by Telkom has resulted in the lack of uptake of fixed lines.

Table 5: Impact of upgrade in Telkom switches between NIDS Wave 2 and Wave 3

<table>
<tr><th colspan="2"></th><th colspan="4">Wave 3</th></tr>
<tr><th colspan="2"></th><th>Yes, in working condition</th><th>Yes, not in working condition</th><th>No</th><th>Total</th></tr>
<tr><th rowspan="4">Wave 2</th><th>Yes, in working condition</th><td>21</td><td>2</td><td>11</td><td>34</td></tr>
<tr><th>Yes, not in working condition</th><td>3</td><td>0</td><td>3</td><td>6</td></tr>
<tr><th>No</th><td>5</td><td>0</td><td>109</td><td>114</td></tr>
<tr><th>Total</th><td>29</td><td>2</td><td>123</td><td>154</td></tr>
</table>

NIDS question: Household has a landline telephone in the dwelling?

Table 6: Estimation results : Difference in Difference estimation, logit

Variable	OLS (Std. Err.)	Probit (Std. Err.)	Logit (Std. Err.)
TIME	-0.042**	-0.185**	-0.340**
	(0.009)	(0.041)	(0.075)
UPGRADE	0.053†	0.193†	0.340†
	(0.029)	(0.116)	(0.201)
DID	0.010	0.070	0.140
	(0.042)	(0.167)	(0.293)
Intercept	0.168**	-0.963**	-1.601**
	(0.007)	(0.028)	(0.050)

Significance levels : † : 10% ∗ : 5% ∗∗ : 1%

5 Conclusion

The costs to communicate are high in South Africa. Policymakers and regulators are currently evaluating policy choices that need to be made to address these high costs. ICASA and the competition authorities are reviewing proposed merger transactions, which may cause these costs to rise further. ICASA is also considering implementing local loop unbundling and is evaluating whether to assign scarce radio frequency spectrum to new entrants or to incumbents. The optimal policy response to each of these issues depends on the extent to which markets for telecommunications services are competitive.

There is some evidence that suggests that fixed lines still matter in South Africa, where mobile subscriptions outnumber fixed line subscriptions by a considerable margin. Controlling for variables such as household size, income and internet spend, being close to an ADSL enabled exchange means that households are more likely to take up fixed lines. Furthermore, the greater the quality of the fixed line (the shorter the line distance between the household and the nearest switch), the greater the likelihood that households take up fixed lines.

While this result holds for wave 2 of NIDS, it does not hold for wave 3. The reasons for this need to be evaluated. There may be endogeneity problems (in that the explanatory variables might be simultaneously determined, such as in respect of internet spend and income).

The dataset available from broadbandstats.co.za reflects very slow upgrades of ADSL speeds by Telkom, and very limited penetration of 10Mbps ADSL speeds in 2013 (only 731 switches out of 4,338 switches were enabled for 10Mbps). This suggests that Telkom has been under-investing in its fixed line network. The consequence of this, from an econometrics perspective, is that there is very little data available for comparing the impact of speed upgrades on choice of fixed lines. At the same time, it does suggest that the fixed to mobile substitution that we observe might be a consequence of Telkom's own under-investment in broadband infrastructure. This would explain how South Africa has arrived at the very low average speeds relative to its developing country peers.

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