Distribution of the benefits of regulation vs. competition: The case of mobile telephony in South Africa

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November 1, 2020

Abstract

We test for the distributional effects of regulation and entry in the mobile telecommunications sector in a highly unequal country, South Africa. Using six waves of a consumer survey of over 134,000 individuals between 2009-2014, we estimate a discrete choice model allowing for individual-specific price-responsiveness and preferences for network operators. Next, we use a demand and supply equilibrium framework to simulate prices and the distribution of welfare without entry and mobile termination rate regulation. We find that, in the South African context, regulation benefits consumers significantly more than entry does, and that high-income consumers and city-dwellers benefit more in terms of increased consumer surplus.

Keywords: Mobile telecommunications; Regulation; Entry; Termination rates; Discrete choice

JEL Classification: L13, L40, L50, L96

*We thank DataFirst at the University of Cape Town for providing us with the AMPS survey data sets and the University of Cape Town's ICTS High Performance Computing team for providing us with computational facilities.

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1 Introduction

Economists have devoted substantial efforts to study the impact of regulatory interventions on consumers and firms. However, there is little granular evidence on the effects of these decisions on different groups of consumers. In particular in developing countries, where the levels of income inequality are high, the benefits from regulation may not be distributed equally. In this paper, we use a partial equilibrium model to assess the distributional welfare effects of entry and regulation in the mobile telecommunications sector in South Africa, which is the most unequal economy in the world.[1]

The functioning of this sector is typically controlled by the government or independent regulators in two key areas. Firstly, entry is regulated through the licensing of radio frequency spectrum.[2] Secondly, mobile termination rates ('MTRs'), which are the wholesale prices for terminating calls on mobile networks, are usually regulated.[3] The impact of entry and the effects of the regulation of MTRs have been extensively studied in previous papers. For example, Economides et al. (2008) quantify the benefits of entry into local telecommunications service markets. They find that consumers benefit significantly, though rather than resulting in reduced prices, entry results in product differentiation and new plan introductions. In another paper, Genakos et al. (2018) study the impact of market concentration levels on prices and investment in 33 OECD countries in the years between 2002 and 2014. They report that prices and concentration are positively related and that increased concentration may lead to higher investment. Nicolle et al. (2018) use hedonic price regressions to analyse the impact of entry, regulation and investment on prices for mobile services in France. They find that quality-adjusted prices declined between May 2011 and December 2014, mainly due to new entry and investment in 4G networks. The impact of market structure on consumer welfare is also studied by means of merger simulation

[1]South Africa had a Gini coefficient of 0.63 in 2015 (according to World Bank statistics), a consequence of apartheid-era racial discrimination policies (Leibbrandt et al., 2010). The top 10% of income earners earn thirty times more than the bottom 10%.

[2]Typically, regulators make radio frequency spectrum available to licensees by means of auctions or beauty contests and therefore establish the market structure for the sector.

[3]In the theoretical literature, unregulated mobile termination rates may result in monopolistic prices and market foreclosure as a result of on-net discounts (Laffont et al., 1998b) or act as a collusive device (Laffont et al., 1998a).

(see, for example, Nevo (2001) in a study on cereals, Ivaldi and Verboven (2005) in relation to the truck industry and Grzybowski and Pereira (2007) on mobile telecommunications).

Among studies on the impact of regulation on prices of telecommunications services, Genakos and Valletti (2011) analyze how the regulatory intervention to cut fixed-to-mobile (F2M) termination rates impacts mobile retail prices.[4] Using panel data of prices and profit margins for mobile operators in more than 20 countries in a period of over six years, they find that a reduction in F2M termination rates leads to an increase in retail prices, which they call the 'waterbed effect'.[5] In a more recent paper, the same authors estimate the impact of the regulation of F2M and mobile-to-mobile (M2M) termination rates on mobile phone bills using a large panel covering 27 countries (Genakos and Valletti, 2015). They find that the 'waterbed' phenomenon becomes insignificant on average over the 10-year period, 2002-2011. They argue that this is due to the changing nature of the industry, whereby mobile-to-mobile traffic surpassed fixed-to-mobile traffic.

Our paper extends this literature by showing how entry and regulation impact on different segments of society, by studying changes in prices and consumer surplus at the level of the individual. We disentangle the effects of entry and regulation, which occur at the same time, through counterfactual simulations. We are also not aware of any paper which estimates the effect of MTR regulation on consumer welfare. Our paper is relevant for developing economies, where the fixed-line telecommunications infrastructure is poor or non-existent; many people do not have Internet access and use mobile phones to make voice calls. In these countries, the MTR regulation is critical in driving down telecommunications bills. Many developing economies have also high income inequalities, and it is worth investigating how the benefits from regulation are distributed in those societies.[6] Our analysis is less relevant for developed economies, where the

[4]The seminal theoretical papers on the regulation of interconnection charges are: Laffont et al. (1998a), Laffont et al. (1998b).

[5]The "waterbed" effect suggests that pressing down prices in one part of firms' operations causes another set of prices to rise.

[6]Due to lack of fixed-line networks, the mobile telecommunications sector is of particular importance in developing economies including South Africa. A number of papers show the positive developmental impact of mobile telephony including Gruber and Koutroumpis (2011), Aker and Mbiti (2010), Jensen (2007), Aker (2010), and Muto and Yamano (2009)

cost of mobile telecommunications services is low relative to disposable income and there is good coverage by competing networks.

In order to study the effects of entry and regulation, we use six waves of a survey of about 134,000 individuals collected between 2009 and 2014.[7] We estimate a discrete choice model allowing for individual-specific price-responsiveness and preferences for network operators. We take into account the endogeneity of prices by means of a two-stage control function approach following Petrin and Train (2010). In the first stage, we regress retail prices on termination costs and a set of operator and tariff segment dummy variables. We include the residuals from the first stage in the deterministic part of the utility function to account for unobserved quality. Furthermore, we identify the price coefficient by exploiting the availability of operator choices due to entry and price variation between operators and customer segments over time.

We use the estimates of demand parameters and individual price-responsiveness to conduct counterfactual simulations. First, we simulate market outcomes in the absence of a new, fourth entrant, Telkom Mobile, which launched mobile services late in 2010, and in addition without Cell C, a third entrant which launched services in around 2002. Second, we simulate a counterfactual situation without the regulation of termination rates which took place between 2010 and 2014. We find that rich people benefited more from entry and regulation in terms of changes in consumer surplus. This is linked to a greater decline in prices experienced by higher-income consumers. Based on our partial equilibrium model, we find that entry has a limited impact on consumer surplus and mobile adoption overall. In addition, we find that regulation of MTRs results in significantly lower prices. We also find that, absent regulation over the period between 2011 and 2014, mobile penetration would have been eight percentage points lower among low-income consumers compared to four percentage points among high-income consumers.

The remainder of the article is organized as follows. Section 2 describes the market being analysed. Section 3 introduces the econometric framework. Section 4 presents the data which we use in the estimation. Section 5 presents the estimation results and finally, Section 6 concludes.

[7] We use data from the All Media Product Survey (AMPS) survey produced by the South African Audience Research Foundation (SAARF).

2 Mobile Telecommunications Industry in South Africa

We consider the impact of entry and regulation in the mobile telecommunications sector. In respect of entry, we study the distributional effects of the launch of the last two mobile networks in South Africa: Cell C, which entered in 2002, and Telkom, which began offering services in late 2010. They entered in competition with two full-coverage operators, MTN and Vodacom, which began rolling out their Global System for Mobile (GSM) networks in the mid-1990s. Telkom and Cell C roamed on the MTN and Vodacom networks respectively and had full geographic coverage.[8] Nonetheless, the newer entrants had poorer quality networks because roaming was not always seamless and because 3G and 4G roaming was not available, at least in the earlier years in the sample period.[9] As a result of this, the newer entrants have largely captured consumers in cities and towns (see Figure 1). We can thus expect that the benefits of entry accrue largely to urban consumers, who often have higher incomes. It is also important to note that the impact of entry in South Africa may be more limited than elsewhere, as there have been no regulatory interventions in respect of roaming or other open access conditions. Any exclusionary conduct by the incumbent operators, such as refusing or reducing the quality of roaming, was not curtailed.

Our study is focused on voice services, and in particular on the impact of entry and regulation on per minute prices. In South Africa, as is the case in many developing countries, voice services continue to account for a substantial proportion of mobile revenues. At the end of the period under study, in 2014, they accounted for above 60% of revenues and as of 2019 about 40%-50% of revenues are still generated by voice calls.[10] Most consumers in developing countries use prepaid

[8]Roaming is a means for new entrants, such as Telkom and Cell C, to be able to offer services in areas where they have not built any network infrastructure. We dropped subscribers to Virgin Mobile, a Mobile Virtual Network Operator (MVNO), from the analysis due to its small market share which was much below 1% in 2014. In an alternative specification, we estimated a model with subscribers to Virgin Mobile and include this provider in the choice set of all consumers. The estimation results are comparable.

[9]Despite competition between four network operators in South Africa, the prices of mobile services are high compared to other African and developing economies (Calandro and Chair, 2016). Competition in mobile services was subject of recent political debates in South Africa which led to market inquiries into the cost of data services, launched by the South African Competition Commission in 2017 and the Independent Communications Authority of South Africa in 2018. Also, in 2017, the South African government put forward a proposition to award significant amounts of future high-demand spectrum to a regulated wholesale open-access network (WOAN) in which existing operators would be shareholders, instead of providing for new market entry or distributing the licences to current market players. This idea has received mixed responses from mobile operators and other stakeholders.

[10]See, for example, the MTN and Vodacom annual financial reports in relation to South Africa.

services (more than 80% of consumers in South Africa use prepaid), and the price per minute of a call is the key determinant of network choices among consumers.[11]

In respect of regulation, we consider the impact of mobile termination rates. Termination rates are an important cost factor for voice services on mobile networks, as they are the charges that each operator pays for calls to other networks. At the beginning of the period under study (2009), call termination rates during peak hours were R1.25 per minute, and average retail prices were approximately R2.25/minute, and so termination rates were more than 50% of the costs of a call (see Figure 3). The government and the telecommunications sector regulator, Independent Communications Authority of South Africa (ICASA), began reducing mobile termination rates (MTRs) in 2010. At that stage Telkom Mobile, owned partly by government, complained about high MTRs due to their imminent entry.[12] Since then, MTRs have declined by 90% which according to ICASA led to reductions in retail voice prices (see Figure 3).[13]

There are separate ('asymmetrical') termination rates for large and small operators, as the regulations allow smaller operators to charge a higher MTR. In addition, peak and off-peak termination rates were different until 2013. Overall, whether as a result of entry or regulation, mobile penetration grew significantly over the years 2009-2014 (see the fourth panel on Figure 3). The proportion of people that had a mobile phone increased from less than 75% to almost 90% over this period.

South African society is multi-racial, multi-lingual and highly segmented with respect to income, which results in differences in the affordability of mobile telecommunications services. As a result of racial discrimination during apartheid, White consumers have significantly higher incomes compared to other racial groups. Indian and Coloured consumers were discriminated

[11] Even in 2019, prepaid subscribes account for more than 80% of subscribers in South Africa, and voice revenues continue to exceed data revenues (Source: ICASA, March 2020, 'The State of the ICT Sector Report in South Africa'). In addition, in the period of our analysis, the majority of consumers did not use mobile data because they did not have smartphones. As of 2014, the penetration of smartphones as a share of the population in South Africa was about 34% and much lower in the years before. Smartphone ownership is also lower in other countries in Sub-Saharan Africa. Source: Pew Research Center.

[12] Dividends from Telkom, as shown in the annual report of the telecommunications ministry, account for the bulk of incoming funds into that ministry.

[13] ICASA reviewed the effects of lower MTRs in its bi-annual review of prices. See: ICASA, 2018, "Bi-Annual report on the analysis of tariff notifications submitted to ICASA for the period 02 January 2018 to 30 June 2018".

against but benefited from having more access to public resources and from living in urban areas and therefore have higher incomes than Black consumers. Many Black people were forced to live in rural 'homelands' with substantially lower funding for education and healthcare. Mobile services account for up to 5% of the bottom income quartile's spending in South Africa (see Figure 2).[14]

Based on our data, operator market shares vary by race and income group (see Figure 1). There are nine provinces in South Africa which have very different characteristics. The provinces of the Western Cape and Gauteng have significantly more people living in urban areas, while the provinces of the Eastern Cape, KwaZulu-Natal, Limpopo, Mpumalanga and the North-West have large populations living in former 'homelands' which are largely rural areas. The Northern Cape is a sparsely populated province that has a relatively small population.

There are eleven official languages in South Africa.[15] In the dataset, languages sharing common traits or a common geographic region are grouped together. Thus, Zulu is grouped with Swazi and Ndebele ('Zulu+'), while Sesotho, which is the main language spoken in the largest cities of Johannesburg and Pretoria, is grouped together with Northern Sotho, Tswana, Tsonga and Venda ('Sesotho+'). Mobile network choices among language groups follow race group patterns.[16] We expect these variables (race, province, income and language) to have an important impact on price-sensitivity and network choice, and therefore on the distributional consequences of entry and regulation.

[14]Based on authors' computations using the National Income Dynamics Survey (NIDS), which is a nationwide survey of South African individuals and households collected by the Southern Africa Labour and Development Research Unit (SALDRU) at the University of Cape Town (UCT) in four waves: 2008, 2010/2011, 2012 and 2014/2015 (Southern Africa Labour and Development Research Unit, 2008-2016).

[15]These are, ranked by number of speakers: Zulu, Xhosa, Afrikaans, English, Northern Sotho, Tswana, Sesotho, Tsonga, Swazi, Venda and Ndebele.

[16]Note that Indian consumers largely speak English, while approximately three-quarters of Coloured consumers speak Afrikaans.

3 Econometric Model

3.1 Demand

3.1.1 Discrete choice model

In order to estimate the impact of entry and regulation at the level of the individual, we estimate a discrete choice model that allows for consumer-specific preferences in choices of mobile networks. In our model, consumers choose the network operator that maximizes their utility function, or no subscription at all. Discrete choice models were commonly used to estimate demand for telecommunications services (see for example, Train et al. (1987), Pereira and Ribeiro (2011) and Grzybowski et al. (2014)).[17] We allow individuals $i_m = 1, ..., N_m$ belonging to segment m to choose among network operators $j = 1, ..., J$ and an outside option of having no mobile phone denoted by $j = 0$.[18] Individual utility depends on network and consumer characteristics. In what follows, we skip the time subscript for year t. We specify that individual i_m's utility for mobile network j is given by:

$$U_{i_m j} = x_j' \widetilde{\beta}_{i_m} - \widetilde{\alpha}_{i_m} p_{mj} + \epsilon_{i_m j}. \tag{1}$$

Here, x_j is a $J \times 1$ vector of network dummy variables interacted with individual characteristics and $\widetilde{\beta}_{i_m}$ is a $J \times 1$ vector of coefficients denoting the individual-specific valuations for each network, estimated relative to the base of having no mobile service with utility normalized to zero. Furthermore, p_{mj} denotes the price paid by consumer i_m for making a call on network j, and $\widetilde{\alpha}_{i_m}$ is a coefficient for the individual-specific valuation of price. The construction of the price variable is discussed in Section 4. Finally, $\epsilon_{i_m j}$ is an individual-specific valuation for option j, i.e. the "logit error term". It is identically and independently distributed across mobile networks

[17] Train et al. (1987) use data from a US household survey and develop a nested logit model of consumer choices of telephone services. Pereira and Ribeiro (2011) use a mixed-logit model to estimate price elasticities for broadband Internet access using data from a household survey in Portugal. In another paper, Grzybowski et al. (2014) estimate demand for fixed and mobile broadband services in Slovakia using a random coefficients model.

[18] An alternative is to consider access to fixed-line telecommunications services as an outside option. But only approximately 10% of households had access to a fixed-line at home in South Africa over the period under study (9.4% in 2014, for instance). Source: Statistics South Africa, General Household Survey, 2014.

according to the Type I extreme value distribution. An alternative assumption is that the error terms have a multivariate normal distribution, in which case a probit model is estimated.

The vector of coefficients $\widetilde{\beta}_{i_m}$ and the price coefficient $\widetilde{\alpha}_{i_m}$ may depend on observed individual characteristics and unobserved heterogeneity. More specifically, we define:

$$\begin{pmatrix} \widetilde{\beta}_{i_m} \\ \widetilde{\alpha}_{i_m} \end{pmatrix} = \begin{pmatrix} \beta \\ \alpha \end{pmatrix} + \Pi D_{i_m} + \begin{pmatrix} 0 \\ \sigma_\alpha \end{pmatrix} \nu_{i_m} \quad , \qquad \nu_{i_m} \sim N(0,1) \tag{2}$$

where (β, α) refers to a $(J+1) \times 1$ vector of mean valuations, which are the same for all consumer segments. The vector of observable individual characteristics, D_{i_m}, has dimension $d \times 1$. The matrix of parameters Π with dimension $(J+1) \times d$ captures the impact of individual characteristics on the valuations for the J network dummy variables, x_{jt}, and the price variable, p_{jt}. The randomly drawn vector from the standard normal distribution ν_{i_m} captures unobserved individual heterogeneity in respect of price. In addition, σ_α is a vector of standard deviations around the mean valuations.

The vector of observable characteristics D_{i_m} includes gender, age category ($15-25$, $26-50$, $51-65$, 66 and above), race, language, province, income group (below R$3,000$, R$3,000-7,999$, R$8,000-15,999$, R$16,000$ and above, per month), employment status, whether the person is self-employed and whether the person has a telephone at home or work.

In the special case, where $\sigma_\alpha = 0$, there is no unobserved individual heterogeneity and we obtain the multinomial logit model. In a more general framework, we have a mixed or random coefficients logit model, which allows for unobserved heterogeneity between individuals. The utility function specified above allows for flexible substitution between network operators. This allows us to assess which network operators are closer substitutes at the level of the individual.

An individual i_m chooses a utility-maxmizing option j, i.e. $U_{i_m j} = \max_{k \in C_{i_m}} U_{i_m k}$, where C_{i_m} is individual i_m's available choice set. Hence, the probability that individual i_m with given coefficients $\widetilde{\beta}_{i_m}$ and $\widetilde{\alpha}_{i_m}$ chooses option j is given by:

$$\begin{aligned} l_{i_m jt}\left(\widetilde{\beta}_{i_m}, \widetilde{\alpha}_{i_m}\right) &= \Pr\left(U_{i_m j} = \max_{k \in C_{i_m}} U_{i_m k}\right) \\ &= \frac{\exp\left(x_j' \widetilde{\beta}_{i_m} - \widetilde{\alpha}_{i_m} p_{mj}\right)}{\sum_{k \in C_{i_m}} \exp\left(x_k' \widetilde{\beta}_{i_m} - \widetilde{\alpha}_{i_m} p_{mk}\right)} \end{aligned}$$

where the second line arises from the distributional assumptions of the logit error term $\epsilon_{i_m j}$. In the random coefficients model we need to integrate the conditional choice probability $l_{i_m j}\left(\widetilde{\beta}_{i_m}, \widetilde{\alpha}_{i_m}\right)$ over the distribution of $\widetilde{\alpha}_{i_m}$:

$$P_{i_m j} = \int_{\widetilde{\alpha}} l_{i_m j}\left(\widetilde{\beta}_{i_m}, \widetilde{\alpha}\right) f(\widetilde{\alpha}) d\widetilde{\alpha}, \tag{3}$$

The distribution of $\widetilde{\alpha}_{i_m}$ was specified earlier in (2) and consists of an observable part and an unobservable component that is normally distributed, $\nu_{i_m} \sim N(0,1)$. Assuming independence of individual choices, the log-likelihood function can be written as:

$$\mathcal{L}(\theta) = y_{i_m j} \sum_{m}^{M} \sum_{i_m}^{N_m} \sum_{j} \; ln(P_{i_m j}). \tag{4}$$

Here, $y_{i_m j} = 1$ if individual i chose alternative j and $y_{i_m j} = 0$ otherwise, and θ is the vector of all parameters to be estimated. We use a simulation method to approximate the integral entering the choice probabilities $P_{i_m j}$ in (3). Following Train (2009), we take R draws for ν_{i_m} from the standard normal distribution to obtain the average choice probability per individual:

$$\widehat{P}_{i_m j} = \frac{1}{R} \sum_{r=1}^{R} \frac{\exp\left(x_j' \beta - (\alpha + \sigma \nu_{i_m}^r) p_{mj} + (x_j', p_{mj}) \Pi D_{i_m}\right)}{\sum_{k \in C_{i_m}} \exp\left(x_k' \beta - (\alpha + \sigma \nu_{i_m}^r) p_{mk} + (x_k', p_{mk}) \Pi D_{i_m}\right)}. \tag{5}$$

In the special case of no unobserved individual heterogeneity ($\sigma_\alpha = 0$), Equation (5) becomes the multinomial choice probability:

$$\widehat{P}_{i_m j} = \frac{\exp\left(x_j'\beta - \alpha p_{mj} + (x_j', p_{mj})\Pi D_{i_m}\right)}{\sum_{k\in C_{i_m}} \exp\left(x_k'\beta - \alpha p_{mk} + (x_k', p_{mk})\Pi D_{i_m}\right)}.$$

Substituting Equation (5) for $P_{i_m j}$ in Equation (4), the maximum simulated likelihood estimator is the value of the parameter vector θ that maximizes the likelihood function $\mathcal{L}$.

3.1.2 Price Elasticities of Demand

Prices are a key variable influenced by entry and regulation and they have an important impact on network operator choices. We use our discrete choice model to calculate own- and cross-price elasticities for voice calls on mobile networks in the following way. The effect of a one percent price increase by network k on the level of individual i_m's probability of choosing network j is:

$$\frac{\partial P_{i_m j}}{\partial p_{mk}} p_{mk} = \begin{cases} -\widetilde{\alpha}_{i_m} P_{i_m j}(1 - P_{i_m j}) p_{mj} & \text{if k=j} \\ \widetilde{\alpha}_{i_m} P_{i_m j} P_{i_m k} p_{mk} & \text{otherwise} \end{cases}.$$

This could be referred to as individual i_m's semi-elasticity of demand for j with respect to the price of k. Let the aggregate market share for network j in segment m be given by $s_{jm} \equiv \sum_{i_m} P_{i_m j}/N_m$, where N_m is the number of consumers in segment m in our dataset in a given year. The aggregate elasticity of demand for subscriptions to network j with respect to the price of k may then be defined as:

$$\varepsilon_{jk} = \frac{1}{N_m}\left(\sum_{i_m} \frac{\partial P_{i_m j}}{\partial p_{mk}} p_{mk}\right)\frac{1}{s_{jm}} = \begin{cases} \sum_{i_m}(-\widetilde{\alpha}_{i_m}) P_{i_m j}(1 - P_{i_m j}) p_{mj} / \sum_{i_m} P_{i_m j} & \text{if k=j} \\ \sum_{i_m} \widetilde{\alpha}_{i_m} P_{i_m j} P_{i_m k} p_{mk} / \sum_{i_m} P_{i_m j} & \text{otherwise} \end{cases}. \tag{6}$$

3.1.3 Consumer surplus

We use the estimated model to calculate changes in consumer surplus due to regulation or new entry. In discrete choice models, the expected consumer surplus of consumer i_m is given by (see

Small and Rosen, 1981):

$$E(CS_i) = \frac{1}{\widetilde{\alpha}_{i_m}} log\bigg(\sum_j \exp(V_{i_m j})\bigg) + B_{i_m}$$

where α_{i_m} is the individual-specific price coefficient, $V_{i_m j}$ is the observed part of the utility function in Equation (1) and B_{i_m} is an unknown constant representing unmeasured utility. The change in consumer surplus due to an intervention, such as regulating termination rates or introducing new entrants, can be written as:

$$\Delta E(CS_{i_m}) = \frac{1}{\widetilde{\alpha}_{i_m}} \Bigg(log\bigg(\sum_j \exp(V^1_{i_m j})\bigg) - log\bigg(\sum_j \exp(V^0_{i_m j})\bigg)\Bigg) \tag{7}$$

where $V^1_{i_m j}$ denotes the utility after and $V^0_{i_m j}$ before the intervention.

3.2 Supply

We use both the demand and supply-sides to simulate how the entry of mobile operators Cell C and Telkom Mobile impact welfare and how consumer surplus is distributed across consumer segments. For the simulations, we consider marginal costs to be call termination costs, calculated using the termination rates discussed in Section 2.[19] In the optimisation, we consider profits per minute to be price minus termination cost per minute. We also simulate the effect of no regulatory intervention. In order to do this, we compute marginal costs as though the pre-regulation (pre-2010) mobile termination rates applied throughout the period between 2011 and 2014. In this simulation we consider that prepaid consumers choose between prepaid offers from different operators but they do not switch to postpaid offers, and similarly postpaid consumers from each usage segment (low, medium and high) choose from the offers available to them, following the approach above.

[19] We computed the termination costs for each mobile operator as follows. First, we consider that 90% of calls are made to other mobile networks (the other 10% are to fixed networks) and that calls to other mobile networks are distributed according to market shares. We further consider that 50% of calls are made during peak hours and 50% are made off-peak, since termination rates were different for these two time slots. Using this information, we computed an average termination cost per minute paid by each mobile operator in each year.

The profits of network operator j in each consumer segment m are given by:

$$\Pi_{jm}(\mathbf{p_m}) = (p_{jm} - c_{jm}) - F_{jm} s_{jm}(\mathbf{p_m}) N_m \tag{8}$$

where c_{jm} is the marginal cost of firm j in segment m, and $s_{jm}(\mathbf{p_m})$ is firm j's market share as a function of the price vector in each segment, as defined in Section 3.1.2. Market size for each segment is denoted by N_m, and F_{jm} denote fixed costs which are irrelevant for pricing decisions. Assuming that firms choose prices to maximize profits, the first-order conditions that define the interior Bertrand-Nash equilibrium are then given by:

$$s_{jm}(\mathbf{p_m}) + (p_{jm} - c_{jm}) \frac{\partial s_{jm}(\mathbf{p_m})}{\partial p_{jm}} = 0. \tag{9}$$

for network operators $j = 1, \ldots, J$. The choice probabilities and price derivatives of choice probabilities are computed at the individual level, and then an average is calculated for each of the four usage profiles (discussed in section 4) and for each operator and year. The FOCs for each segment can be written in vector notation as:

$$\mathbf{s_m}(\mathbf{p_m}) + (I \odot \mathbf{\Delta}(\mathbf{p_m}))(\mathbf{p_m} - \mathbf{c_m}) = 0. \tag{10}$$

where $\mathbf{p_m}$ and $\mathbf{s_m}(\mathbf{p_m})$ are $J \times 1$ price and market share vectors, $\mathbf{\Delta}(\mathbf{p_m}) \equiv \partial \mathbf{s_m}(\mathbf{p_m})/\partial \mathbf{p_m}'$ is a $J \times J$ matrix of own- and cross-price derivatives. A $J \times J$ block-diagonal identity matrix, I, represents ownership, and $\odot$ denotes element-by-element multiplication of two matrices.

The system of first-order conditions (Equation 10) can be used to perform counterfactual simulations. In the first simulation, we solve the system of equations after removing Telkom Mobile and Cell C from the market, which we do by setting their marginal costs (and equilibrium prices) to a very high number. The solution gives the counterfactual equilibrium price vector $\hat{\mathbf{p}}$, which contains only prices for the remaining mobile operators, Vodacom and MTN. In the second counterfactual, we use the pre-2010 termination rates as marginal costs. In the simulations, we calculate an average price for each segment (prepaid, postpaid low, postpaid medium and postpaid high) per operator per year using the iterated best-response algorithm, which uses our demand model estimates together with marginal costs (termination costs) to arrive at Bertrand-Nash equilibrium prices. We then use this price vector to compute the counterfactual market shares, $\hat{\mathbf{s}}$, and changes in individual consumer surplus given by Equation (7). These can then be aggregated for different population segments.

4 Data

We estimate our discrete choice model using six waves of the All Media Products Survey (AMPS). AMPS is a survey of approximately 25,000 consumers each year between 2009 and 2014.[20] In total, the sample size is more than 134,000 observations. The AMPS dataset contains consumer choices of a range of products and services as well as personal and household characteristics.[21] Table (1) shows summary statistics for variables used in the estimation.

In our model, consumers choose between network operators (or no subscription at all) based on the price per minute of a voice call as a key determinant. In South Africa, most subscribers (approximately 80%) are on prepaid plans. Typically, they are unable to choose between prepaid and postpaid because they do not meet the income and employment requirements for a postpaid contract. This is a result of low levels of employment and participation in the labour force.[22] As a consequence, consumers have to purchase a handset independently of their mobile subscription and the price of a handset does not determine the choice of network operator.[23]

Prices were obtained from Research ICT Africa and Tarifica.[24] In addition, we used an online

[20] An exception is the year 2013, when only half that number is available due to a questionnaire change halfway through the year. This meant that certain questions (such as cellphone spend) were not asked in the second half of the year, which means it was not possible to use those observations.

[21] This is an annual survey conducted by the South African Advertising Research Foundation (SAARF) on buyers of a range of products, in order to match media companies (such as newspapers, TV stations and radio stations) and advertisers of the various products surveyed.

[22] According to the "Quarterly Labour Force Survey" undertaken by Statistics South Africa (publication P0211), the employed population divided by the number of adults in South Africa (aged 15-65 years), i.e. the 'labour absorption rate', varied between 41% and 46% over the period between 2009 and 2014. The unemployment rate varied between 22% and 26% using the official definition (active job seekers) while the expanded definition (i.e. including discouraged work seekers) varied between 30% and 36%.

[23] Network locked handsets are not permitted by the regulator in South Africa, and so handsets are not typically provided on any prepaid plans.

[24] Research ICT Africa is a non-governmental organisation that collects data and conducts research on telecom-

archive service, the Internet Archive's Wayback Machine, to complete the pricing database.[25] We collected prices on a national basis. However, there is some degree of local pricing based on time and location promotions. At the same time, these offers are only available upon request and it is not clear how widely they are used. We combine the price and survey data to arrive at a set of operator-specific prices per minute for each consumer segment. In doing this we divide consumers in two main segments based on the payment method (prepaid and postpaid). All prepaid consumers, which account for 80% of mobile subscribers, belong to one segment. Postpaid consumers, which account for the balance, were divided into three groups: low, medium and high voice users, according to their declared monthly cellphone spend. Low-usage consumers are assumed to have monthly bills in the range R1-R150 per month, medium-usage is in the range R151-500 and high-usage is above R500 per month.[26]

Next, we computed average prices per minute for the four consumer segments for which we rely on usage profiles. Usage profiles are a common means of modelling consumer decisions in telecommunications services as well as comparing prices across countries and over time.[27] Using the call distribution pattern described below, we computed the average price per minute for all prepaid tariffs and picked the lowest for each operator in a given year. We assume that these are the prices that prepaid consumers face when choosing a service. In a similar way, we computed the average price per minute faced by postpaid consumers belonging to the three segments. Importantly, consumers which belong to each segment choose between operators by comparing prices from the same segment. We tested our results against different calling patterns and our

munications in Africa. Tarifica is a market intelligence firm which collects information on prices of telecommunications services worldwide.

[25]The Internet Archive, whose website is archive.org, is a non-profit organisation that records snapshots of websites over time and makes these available to the public.

[26]The South African currency is highly volatile but as of December 2018 one US dollar was approximately 14.6 Rands. Classifying consumers into high, medium and low usage groups is a standard approach to segmenting telecommunications subscribers. The spending bands were selected to broadly reflect regular intervals and available mobile packages, and so as to ensure a large number of observations would fall within each category. Approximately 25% of postpaid customers fall within the first group, around 53% fall within the second category and the remaining 22% fall within the highest spend group. The second category has a greater proportion since almost 25% of postpaid customers spend between R271-R500 per month. Since there are many more packages advertised in the R151-R500 spend level than above R500, it made more sense to allocate the R271-R500 category to the medium-spend group.

[27]See OECD (2017): "Revised OECD Telecommunications Price Baskets".

estimates of elasticities are comparable in these different specifications. Our prices for prepaid and postpaid services are shown on Figure 3. In total, for each of the four segments we have four price observations per year, which for the years 2011-2014 yields 64 observations. In the years 2009 and 2010, there are 3 firms only which gives an additional 24 observations. There are therefore 88 price observations in total.

We assumed different monthly usage volumes for each segment: 30 minutes for prepaid users (1 minute per day), 180 for low-usage postpaid consumers (6 per day), 540 for medium-usage postpaid consumers (18 per day) and 1,080 for high-usage postpaid consumers (36 per day).[28] In South Africa, prices differ depending on whether calls are on the same network (on-net), to other mobile networks (off-net) or are terminated on fixed lines. We assumed that 10% of minutes are terminated on fixed lines and 90% are terminated on mobile networks, for all consumers. Calls terminated on mobile networks are distributed according to operator market shares. We also assumed that 50% of calls are made in 'peak' periods and 50% were 'off-peak', for which there are different prices.[29]

We tested the proposition that new entrants choose higher-income areas in towns and cities by means of reduced-form regressions on a proxy for entry, the Herfindahl-Hirschman Index (HHI). A lower HHI indicates a greater degree of entry.[30] As we can expect, new entrants focus on areas that have a higher share of richer consumers, where they deploy own network infrastructure (see Figure 4 and Table 2). In the less profitable poorer areas they rely on national roaming agreements with the incumbents. They are disadvantaged in these areas as second movers with

[28]These usage categories are similar to the OECD mobile voice call baskets cited below, of 30, 100, 300 and 900 calls per month. The groups are also not far from minutes of use reported by Vodacom in its annual reports between 2009 and 2014, for example, for prepaid and postpaid customers. Prepaid customers on the Vodacom network used between 52 minutes and 116 minutes per month on average, depending on the year, while postpaid consumers used between 182 and 240 minutes per month.

[29]This is also in line with the OECD usage baskets, which assume that 46% of calls are made during the day, 27% are made during the evening and 27% over the weekend. In South Africa, weekend and evening calls are grouped together under the 'off-peak' period.

[30]The HHI is calculated as a sum of squared market shares at different geographic locations in a given year. AMPS reports the locations of respondents in each year by province, by parts of the large cities of Cape Town, Durban, Johannesburg and Pretoria, by secondary cities and towns (Bloemfontein, Kimberley, Pietermaritzburg, Port Elizabeth, East London, Vaal) and by community size (metropolitan areas (250 000+), cities (100 000 - 249 999), large towns (40 000 - 99 999), small towns (8 000- 39 999), large villages (4 000- 7 999), small villages (500 -3 999), settlements (less than 500), non-urban (rural)). In total, there are 509 such location-years. We dropped location-years that had fewer than 50 observations, and arrive at a sample size of 420.

more limited distribution capabilities (airtime is sold through small, often informal retailers), and thus have fewer incentives to invest in own network infrastructure and compete for consumers. Market concentration levels are lower in towns and cities, and among high-income consumers, whether measured by mean household incomes or the share of high-income individuals in a location. Income, race and language group are correlated in South Africa. Therefore, higher-income races (Coloureds, Whites and Indians) experience lower levels of market concentration, and a similar pattern is found among higher-income language groups (English and Afrikaans-speakers). This suggests that new entrants target higher-income locations and population groups.

5 Results

5.1 Identification

We use our discrete choice model to estimate mobile penetration and consumer surplus with and without entry or regulation. As discussed above, price is the key determinant of mobile network choices. When estimating the model we need to account for the endogeneity of the price variable. This is because consumer choices also depend on quality differences which may be partly unobserved and quality also influences the price level. Without accounting for endogeneity, the estimated price elasticities will be biased towards zero. Following Petrin and Train (2010), we use the control function approach to account for this in two stages. The idea behind the control function correction for endogeneity is to derive a proxy variable that conditions on the part of price that depends on the error term, so that the remaining variation in the endogenous variable is independent of the error.[31]

In the first stage, we regress the prices on a set of controls. In particular, we use call termination charges to approximate the marginal cost of calls. Termination rates differ by destination and are zero for on-net calls. We compute the cost of termination based on the market shares

[31] An alternative approach involves estimating a model in the first stage which includes fixed effects for all the products in the choice set (see Goolsbee and Petrin (2004)). In the second stage, the fixed effects are regressed on price and other product characteristics. This approach is not possible in our case because consumers choose only between 3 or 4 operators depending on the year.

of each operator. We apply the same split between calls to mobile (90%) and to fixed (10%), and between peak and off-peak (50% each), which we used in respect of usage profiles (Section 4). In the regression, we also use a set of dummy variables for operators and type of tariff, and their interaction terms. Our first-stage regression is shown in Table (3). The estimation results show that call termination costs have a significant impact on prices. An increase in termination cost by 1 cent increases the retail price by 1.3 cents, which is a greater pass-through than found in earlier literature (see for instance Genakos and Valletti (2011), Grzybowski, 2008, Wernick et al., 2010, and Hawthorne, 2018). However, the first two studies analyzed respectively fixed-to-mobile and fixed-to-fixed termination rates. Furthermore, in addition to reducing marginal costs, lower MTRs also reduce the exclusionary effects of on-net discounts (Laffont et al., 1998b), and weaken any remaining incentives to collude (Laffont et al., 1998a), resulting in more aggressive competition and lower prices.[32] The residuals from the first stage regression (control variable) are added to the observed portion of utility in the second stage estimation. Furthermore, we identify the price coefficient by exploiting the availability of operator choices due to entry and price variation between operators and customer segments over time.

5.2 Demand estimation

The estimation results for the multinomial and random coefficients models are shown in Table (4). We present our results in three main categories: price, having a mobile service, and operator choice. First, we show the price coefficients, including the random coefficient on the price variable and the control variable from the first stage (Panel 1a).[33] The coefficients for price interacted with individual characteristics (income, race and language group) are shown in Panel (1b). The price coefficient is highly significant and negative in both models. There is significant unobserved heterogeneity in responsiveness to price, as shown by a significant standard deviation for the

[32]In South Africa, the incumbents MTN and Vodacom are regularly accused of being a duopoly, and were accused in the past of collusion, particularly in relation to hiking MTRs prior to the entry of Cell C.

[33]We have also estimated a version of the model in which we use a prepaid dummy among our explanatory variables. In another specification, we used a set of year dummy variables. However, the price coefficient becomes insignificant in both models because these included dummy variables absorb price variation, and we therefore do not use these alternative model specifications.

price variable. The estimated coefficient on the control variable is positive and significant, which indicates a positive correlation between the unobserved quality and price. The price coefficient increases in absolute terms, as compared to a model without the control variable, which we do not report in the paper. Price sensitivity varies significantly among income, race and language groups.

Second, we show coefficients for having a mobile service interacted with a range of demographic variables (Panel 2). Being older than 50 and having a landline telephone at home makes taking up a mobile service less likely. There is some variability in the uptake of mobile services depending on the province; living in the Eastern, Western and Northern Cape provinces is associated with a lower probability of taking up a mobile service than being in Gauteng. Consumers in the North West, Limpopo and Mpumalanga are more likely to take up a mobile service than consumers in Gauteng. Being employed, and self-employed in particular, as well as having a telephone at work and being young all make it more likely to take up a mobile service.

Third, our results for operator fixed effects and operator choice interacted with being in a town or city are shown on the third set of panels. Consumers who live in cities and towns are significantly more likely to choose Telkom and Cell C than Vodacom and MTN (Panels 3b and 3c), after controlling for the quality of networks using operator dummy variables (Panel 3a).

We use the estimates to compute individual-level price elasticities and then aggregate them using the equations shown in Section 3.1.2. The demand for mobile services is relatively elastic in respect of prepaid prices, shown in Table (5, panel 1) but somewhat less so in respect of postpaid services (panel 2). The own-price elasticities of demand are the highest for Telkom Mobile's services, equal to -1.77 in respect of prepaid services for example. Vodacom faces the lowest own-price elasticity of demand. These are average elasticities for the period 2011-2014, since Telkom Mobile was in the market in these years. The cross-price elasticities show relatively small differences in the degree of substitution between mobile operators.

Furthermore, we show average own-price elasticities by demographic segment in Table (7). Overall, the average own-price elasticity for having a mobile service is -0.25, which is in line with previous research which shows elasticities for mobile calls to be between -0.18 in developing countries and -0.5 in general (Vogelsang, 2010).[34] Furthermore, there is considerable variation in elasticities of demand between income groups. As can be expected, high-income consumers are less price sensitive than low-income consumers, and similarly consumers in rural areas are more price-sensitive than consumers in towns and cities. This suggests that a price discrimination strategy based on income segment is rational for operators to follow, and indeed we observe this in the market. Higher income consumers face higher average prices than low income consumers, as shown in Table (8), even though marginal costs for calls are similar across all segments.

We use our demand estimates and termination costs to compute prices under the assumption of Nash-Bertrand equilibrium using Equation (10). The marginal costs, average prices and mark-ups are shown for prepaid prices in Table (6, panel 1) and for postpaid prices (on average) in panel 2. Vodacom and MTN have higher mark-ups (more than 75% in respect of prepaid) compared to Cell C and Telkom (62-63%). Prices imputed from our model are similar to market prices. This means that our estimates of price elasticities are reasonable.

5.3 Counterfactual simulations

We simulate how entry and regulation affect consumer welfare in different population segments, in the following three counterfactuals. First, we remove Telkom from the market. Telkom had a subscriber market share of around three percent by 2014, having entered in 2011, which suggests a very small impact on consumer welfare. In the second case, we also remove Cell C from the market, which leaves just two main competitors, MTN and Vodacom. Cell C had a market share of around sixteen percent in 2014 and therefore had a much bigger impact on consumer welfare. Third, we simulate a 'no regulation' scenario, in which termination rates remain as they were in 2009. The simulations are conducted for the period between 2011 and 2014 using the iterated best responses algorithm. Average prices and changes in consumer surplus are reported in Table (8), weighted by the number of consumers in each demographic category.

[34] This elasticity refers to the impact on the market share of all the inside options if the prices of all networks increase by 1%.

In the first scenario, we find that the entry of Telkom had minimal impact on equilibrium prices and consumer surplus. In the absence of Telkom, the average welfare loss per minute is approximately one cent, which is very little compared to the average price of a call, which was approximately one Rand per minute. For this reason we do not report this in Table (8).

In the second scenario, the average loss in consumer surplus in the absence of Cell C and Telkom is estimated at almost sixteen cents per minute, as shown in Table (8). If we assume that customers on average make 30 minutes of calls per month, which is the usage profile for prepaid customers, at an average price of R1.15 per minute, then an average's customer's bill is R35 per month. In this case, the average gain from entry represents 14% of the bill but less than 1% of the average income of households (R9,758 per month).

Overall, the consumer welfare effect of the entry of Telkom is close to zero while that of Cell C is relatively small. This is likely because termination rates were very high at least at the beginning of the period under study and entrants were not able to price aggressively and acquire large market shares. Moreover, due to on-net discounts that generate 'tariff-mediated network effects', customers prefer larger networks. This creates a barrier to entry. It may also be that exclusionary conduct by offering limited roaming services impeded entry. For instance, by not permitting seamless roaming for callers, customers on the Cell C and Telkom networks experienced dropped calls. Furthermore, the regulator did not intervene to provide access to incumbent facilities, such as high sites. In our model, Telkom and Cell C are less valued by consumers as reflected by the operator fixed effects and their interaction terms.

The increase in consumer surplus as a result of regulation was significantly larger, at 26 cents per minute on average. Assuming, as above, an average price of R1.15 per minute, 30 calls per month and a monthly average bill of R35 per month, regulation resulted in a consumer surplus gain of 23% of monthly bills but less than 1% of monthly incomes. While this gain is relatively small, the effect of regulation of termination rates resulted in a more meaningful impact than introducing new entrants. Previous research has also found gains from call termination rate regulation (such as by Genakos and Valletti, 2015). However, the effects on consumer surplus have not been quantified before as far as we are aware.

It is important to consider how consumer surplus from entry is distributed across income segments in the population. According to our estimates, the benefits of entry are not distributed equally in absolute terms. As shown in Table (8), the poorest consumers earning less than 3,000 Rands per month gained on average 12 cents per call. Consumers earning 16,000 Rands or more per month gained 18 cents per minute. Relative to usage intensity, since high-income consumers tend to use mobile services more intensively, they benefit even more. There are also differences in gains in consumer surplus across race groups, as shown in Table (8). Black people gain 17 cents per minute, Coloured people benefit on average 13 cents, Indian people gain 14 cents and White people gain 16 cents. We see a similar picture when computing changes in consumer surplus by language groups, as shown in Table (8).

There are substantial geographic disparities in the benefits from entry, which reflects the distribution of income in South Africa. While consumer surplus among city-dwellers increases by 18 cents per minute from entry, consumers in rural areas benefit by only 11 cents per minute. These results are consistent with our reduced-form analysis, which shows that entrants target geographic areas that have higher-income consumers (see Section 4). There are also significant differences within race and income groups between geographic areas (see Table 9). For example, while due to entry and regulation low-income consumers benefit from an increase in consumer surplus of 12 cents per minute on average, in rural areas this falls to 9 cents per minute, less than half the benefit accruing to high-income consumers in cities (19 cents per minute).

The effects of regulation are also not evenly distributed. In the absence of regulation, consumer surplus among low-income consumers (earning less than R3,000 per month) declines by 21 cents per minute while those earning R16,000 or more per month lose 30 cents per minute. This is consistent with rich consumers benefiting from steeper overall price decreases than poor consumers. As can be seen on Table (8), prices for high-income consumers decline by 19.2% (from R1.56 to R1.26 per minute) with regulation, while prices for low-income consumers decline by only 17%.

There are also differences in losses between race and language groups, as shown in Table (8). White consumers gain most and Coloured people least due to regulation, but Black consumers gain most due to entry. Also, English-speaking consumers gain most due to regulation while Xhosa-speaking consumers gain most due to entry. Again, the geographic differences are significant, since consumers in rural areas benefit by approximately 23 cents per minute while mobile users in the city benefit from regulation by 27 cents per minute. Geography has an even greater impact when comparing income groups (see Table 9). For example, while consumer surplus among low-income consumers in rural areas declines by 20 cents per minute without regulation, the decline among high-income consumers in cities is 30 cents per minute.

The impact of entry and regulation on the uptake of mobile subscriptions in different population segments is linked to differences in price elasticities for mobile subscriptions between demographic groups, shown on Table (7). We find that in the absence of Telkom, the uptake of mobile services over the period 2011-2014 does not change (we do not report this result on Table (10) because of this). In the absence of Telkom and Cell C, the penetration of mobile phones would be a bit lower, declining from 86% to 84%. As shown in Table (10), mainly poor people subscribed to mobile services after entry. Among people earning less than R3,000 per month, the lack of entry reduces penetration from 74% to 71%. At the same time, in the segment of people earning R16,000 and above, penetration declined from 95% to 93%. Entry also had divergent effects on subscriptions among people from different race and language groups. The increase in uptake as a result of entry (between 2 and 3 percentage points) was reasonably evenly spread across provinces and between urban and rural areas, likely as a result of the national pricing policies of the mobile operators. Therefore, competition introduced by new entrants to attract consumers in the towns and cities likely resulted in lower prices and greater uptake across South Africa.

While the changes as a result of entry and regulation may be evenly spread among geographies, it is important to note the large disparities within and between race and income groups in respect of uptake across geographies (see Table 11). Using model prices (the baseline scenario), 89% of Black people in cities are connected, which is close to connectivity among White people in cities, at 92%. However, only 79% of Black people in rural areas are connected, while 92% of White people in rural areas are. This means that there are significant disparities in connectivity between race groups and within historically disadvantaged racial groups, particularly once geography is considered. Entry and regulation have done little to reduce these inequalities.

The effects of regulation on the uptake of mobile services were more pronounced than the effects of entry, and again low-income consumers benefited more. Overall, mobile penetration absent regulation declines to 80% from 86% on average between 2011 and 2014. Without regulation, mobile penetration among low-income consumers would be 66% rather than 74%. Among high-income consumers, mobile penetration would have been 91% absent regulation rather than 95%. Thus, while high-income consumers benefit more from entry and regulation from a consumer surplus perspective, low-income consumers benefit more from a mobile uptake perspective. At the same time, high levels of inequality in the uptake of mobile services persist across geographic and racial lines. Our results suggest that introducing new entrants may be less important than direct interventions that support lower retail prices, such as lowering mobile termination rates.

6 Conclusion

We study the distributional welfare effects of entry and regulation in the mobile telecommunications sector in South Africa, which has the highest level of inequality in the world. We use six waves of survey data on 134,000 individuals collected between 2009 and 2014. We estimate a discrete choice model allowing for individual-specific price-responsiveness and preferences for network operators. We find that the price-sensitivity of subscriptions to mobile networks is affected by income and by factors linked to this, such as race and language. We use the estimates of the demand parameters and individual price-responsiveness to simulate market outcomes in the absence of the last two entrants, Telkom and Cell C. We then simulate the effects of eliminating the regulation of mobile termination rates, which are the prices that mobile operators charge one another for incoming calls.

Based on our partial equilibrium model of demand and supply, we find that the adoption of mobile phones in South Africa would be lower by about two percentage points on average over the period between 2011 and 2014, without the entry of Telkom and Cell C. Thus, entry led to a relatively small increase in the total number of adopters. On the other hand, the regulation of mobile termination rates had a more significant impact on uptake. Absent regulation, mobile penetration would have been six percentage points lower. The positive effect of entry and regulation on the uptake of mobile services is higher for low-income groups. First, without entry, mobile penetration among low-income consumers would have been three percentage points lower, compared to a reduction of two percentage points for the high-income group. Second, without regulation, mobile penetration among low income consumers would have been eight percentage points lower, compared to four percentage points among high-income earners. At the same time, substantial differences in the uptake of mobile services in rural areas and cities in South Africa persist, and these differences vary between race and income groups. For example, while 95% of high-income consumers in cities are connected, only 72% of low-income consumers in rural areas are connected. Greater competition through entry, and regulation, have done little to narrow this 'digital divide'.

We also use the model to simulate changes in consumer welfare for different income groups and segments of society. We find that while a 'rising tide lifts all boats', in that all consumers benefit from entry and regulation, high-income consumers benefit more in respect of consumer surplus. These effects are particularly stark once geography is taken into account. Poor consumers in rural areas experience less than half the benefits from entry accruing to high income earners in cities.

The results of our paper are relevant for developing economies, which usually have high income inequalities, in that the effects of regulation may not be equally distributed among different consumer segments. In these countries, the fixed-line telecommunications infrastructure is poor or non-existent; many people do not have Internet access and use mobile phones to make voice calls. Therefore, the MTR regulation is still critical in driving down telecommunications bills.

Even though regulation and entry may not be tools for reducing income inequality, it is important to understand their distributional effects in these economies. Our analysis is less relevant for developed economies, where the cost of mobile telecommunications services is low relative to disposable income and where there is good coverage by competing networks.

We contribute to the literature by providing a partial equilibrium-based assessment of the distributional welfare effects of entry and regulation in the mobile telecommunications sector. Our analysis contributes to this discussion by demonstrating that the two latest market entrants in South Africa were relatively ineffective in generating and distributing welfare among consumers. Wholesale price regulation had a greater effect on consumer surplus but also benefited higher-income consumers more than low-income earners. There may be reasons why entry was less beneficial in South Africa, such as the lack of any pro-competitive measures supporting new entrants. This suggests that the regulator should consider means by which new entrants might have a greater positive impact, particularly on low-income consumers. In particular, there is a need for solutions to ensure that new entrants provide coverage and compete more fiercely in rural areas.

References

Aker, J. C. (2010). "Information from markets near and far: Mobile phones and agricultural markets in Niger". In: *American Economic Journal: Applied Economics* 2.3, pp. 46–59.

Aker, J. C. and I. M. Mbiti (2010). "Mobile phones and economic development in Africa". In: *Journal of Economic Perspectives* 24.3, pp. 207–32.

Calandro, E. and C. Chair (2016). "Policy and regulatory challenges posed by emerging pricing strategies". In: *Information Technologies & International Development* 12.2, pp–13.

Economides, N., K. Seim, and V. B. Viard (2008). "Quantifying the benefits of entry into local phone service". In: *the RAND Journal of Economics* 39.3, pp. 699–730.

Genakos, C. and T. Valletti (2015). "Evaluating a decade of mobile termination rate regulation". In: *The Economic Journal* 125.586.

— (2011). "Testing the waterbed effect in mobile telephony". In: *Journal of the European Economic Association* 9(6).

Genakos, C., T. Valletti, and F. Verboven (2018). "Evaluating market consolidation in mobile communications". In: *Economic Policy* 33.93, pp. 45–100.

Goolsbee, A. and A. Petrin (2004). "The consumer gains from direct broadcast satellites and the competition with cable TV". In: *Econometrica* 72.2, pp. 351–381.

Gruber, H. and P. Koutroumpis (2011). "Mobile telecommunications and the impact on economic development". In: *Economic Policy* 26.67, pp. 387–426.

Grzybowski, L. (2008). "The impact of regulation on the retail prices in fixed-line telephony across the European Union". In: *Telecommunications Policy* 32.2, pp. 131–144.

Grzybowski, L., R. Nitsche, F. Verboven, and L. Wiethaus (2014). "Market definition for broadband internet in Slovakia - Are fixed and mobile technologies in the same market?" In: *Information Economics and Policy* 28, pp. 39 –56.

Grzybowski, L. and P. Pereira (2007). "Merger Simulation in Mobile Telephony in Portugal". In: *Review of Industrial Organization* 31.3, pp. 205–220.

Hawthorne, R. (2018). "The effects of lower mobile termination rates in South Africa". In: *Telecommunications Policy* 42.5, pp. 374–385.

Ivaldi, M. and F. Verboven (2005). "Quantifying the effects from horizontal mergers: Comments on the underlying assumptions". In: *International Journal of Industrial Organization* 23.9, pp. 699–702.

Jensen, R. (2007). "The digital provide: Information (technology), market performance, and welfare in the South Indian fisheries sector". In: *The Quarterly Journal of Economics* 122.3, pp. 879–924.

Laffont, J.-J., P. Rey, and J. Tirole (1998a). "Network competition: I. Overview and nondiscriminatory pricing". In: *The RAND Journal of Economics*, pp. 1–37.

— (1998b). "Network competition: II. Price discrimination". In: *The RAND Journal of Economics*, pp. 38–56.

Leibbrandt, M., I. Woolard, A. Finn, and J. Argent (2010). "Trends in South African Income Distribution and Poverty since the Fall of Apartheid". In: *OECD Social, Employment and Migration Working Papers* 101.

Muto, M. and T. Yamano (2009). "The impact of mobile phone coverage expansion on market participation: Panel data evidence from Uganda". In: *World development* 37.12, pp. 1887–1896.

Nevo, A. (2001). "Measuring market power in the ready-to-eat cereal industry". In: *Econometrica* 69.2, pp. 307–342.

Nicolle, A., L. Grzybowski, and C. Zulehner (2018). "Impact of competition, investment and regulation on prices of mobile services: evidence from France". In: *Economic Inquiry.*

Pereira, P. and T. Ribeiro (2011). "The impact on broadband access to the Internet of the dual ownership of telephone and cable networks". In: *International Journal of Industrial Organization* 29.2, pp. 283–293.

Petrin, A. and K. Train (2010). "A control function approach to endogeneity in consumer choice models". In: *Journal of Marketing Research* 47.1, pp. 3–13.

Research ICT Africa (2010-2015). *RIA African Mobile Pricing 2010-2015.* [dataset]. Cape Town: DataFirst [distributor]. International Development Research Centre [funding agency].

Small, K. A. and H. S. Rosen (1981). "Applied welfare economics with discrete choice models". In: *Econometrica: Journal of the Econometric Society*, pp. 105–130.

Southern Africa Labour and Development Research Unit (2008-2016). *National Income Dynamics Study 2008 - 2015, Waves 1-4.* [dataset] versions 6.1(w1), 3.1(w2), 2.1(w3), 1.1(w4). Cape Town: DataFirst [distributor], 2016. Cape Town: Southern Africa Labour and Development Research Unit [implementer], 2016. Pretoria: Department of Planning Monitoring and Evaluation, SA Presidency [funding agency].

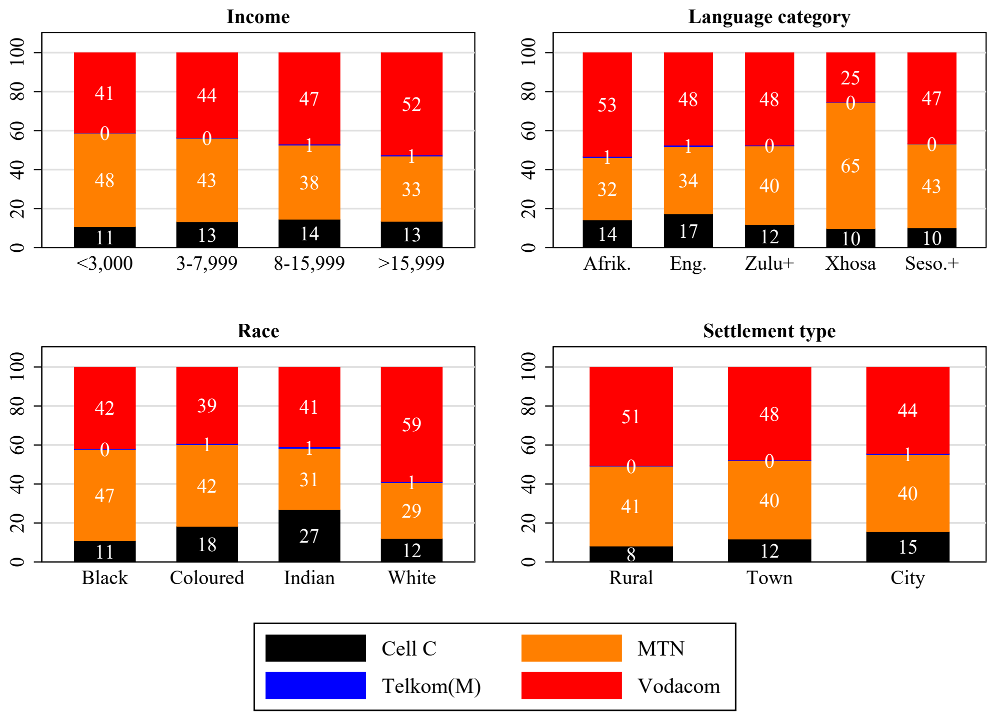
Train, K. E., D. L. McFadden, and M. Ben-Akiva (1987). "The demand for local telephone service: A fully discrete model of residential calling patterns and service choices". In: *The RAND Journal of Economics*, pp. 109–123.

Train, K. (2009). *Discrete choice methods with simulation.* 2nd. Cambridge University Press.

Vogelsang, I. (2010). "The relationship between mobile and fixed-line communications: A survey". In: *Information Economics and Policy* 22.1, pp. 4–17.

Wernick, C., C. Growitsch, and J. S. Marcus (2010). "The Effects of Lower Mobile Termination Rates (MTRs) on Retail Price and Demand". In: *Communications and strategies* 80.

Figure 1: Operator market shares by demographic segments (AMPS, 2009-2014)

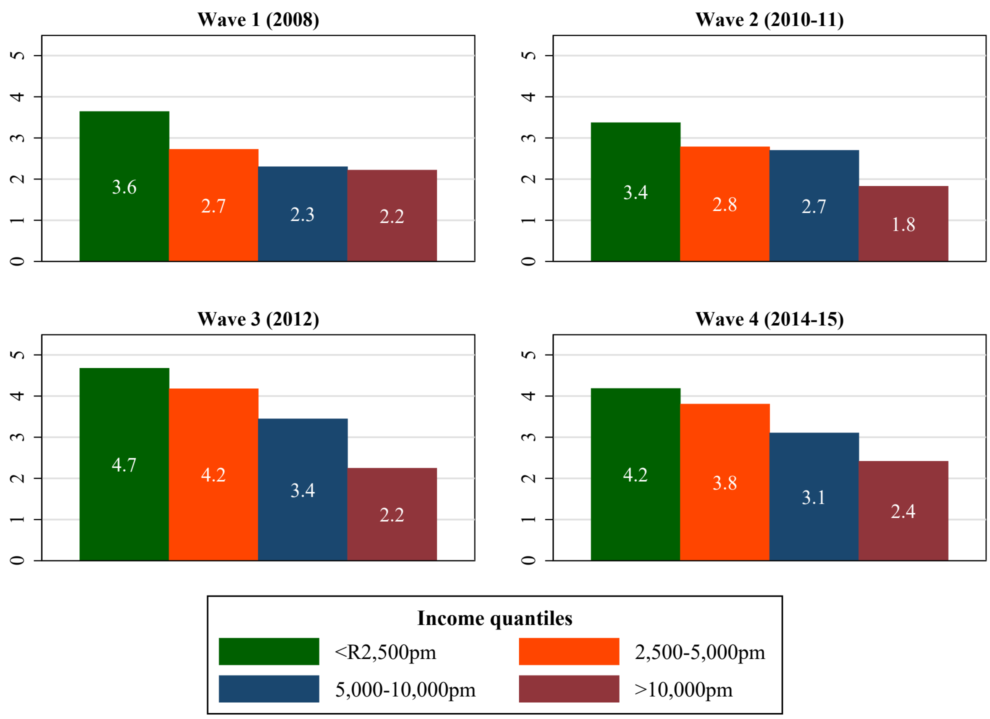


Source: AMPS survey market shares for all observations over the period 2009-2014.

A Appendix

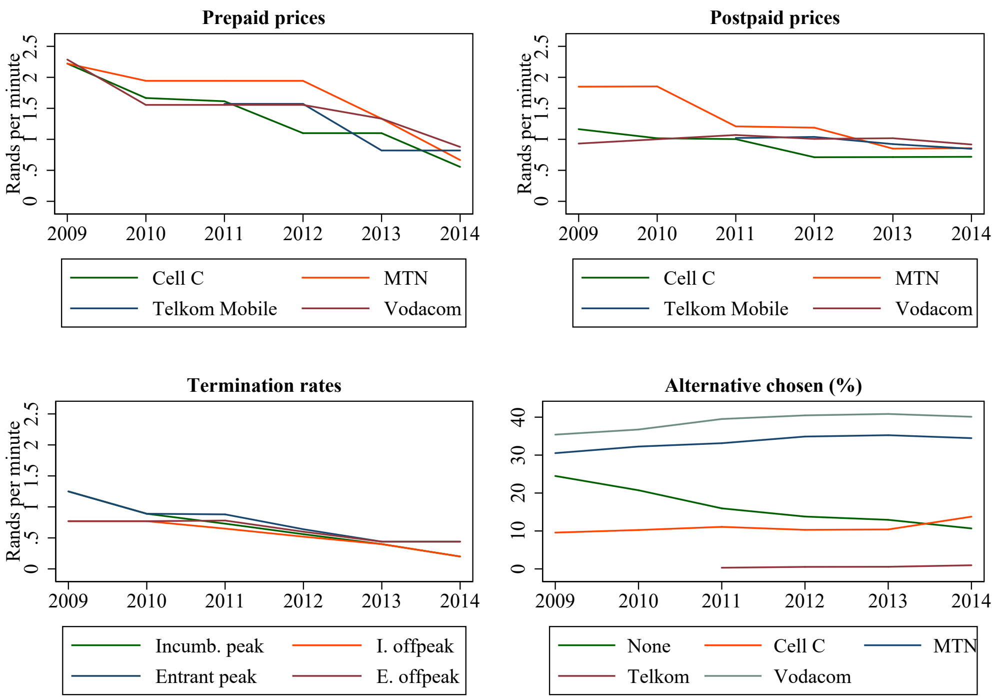
A.1 Figures

Figure 2: Share of spend on mobile by income segments (NIDS, 2008-2015)



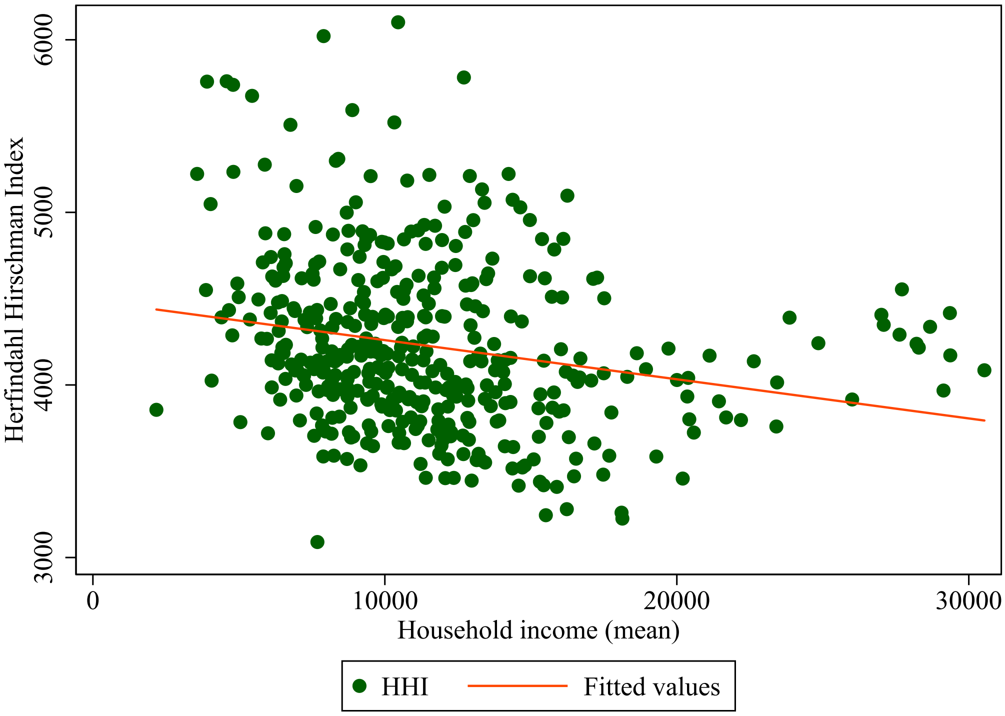
Source: NIDS survey waves 2008-2015. Net income levels per month are shown on the graph.

Figure 3: Average mobile prices, termination rates and penetration (2009-2014)



Note: Postpaid prices are an average for high, medium and low usage consumers. Sources: Prices from Research ICT Africa, Tarifica and the Internet Archive, termination rates from government gazettes and network choices from the AMPS survey.

Figure 4: Relationship between market concentration (HHI) levels and income (2009-2014)



HHI calculated from AMPS sample (N = 420).

A.2 Data tables

Table 1: AMPS demographic variables, by operator (entire sample)

Variable	None		Cell C		MTN		Telkom(M)		Vodacom		N
	N	%	N	%	N	%	N	%	N	%	
Income											
<R3,000	9,821	31	2,351	7	10,453	33	51	0	8,979	28	31,655
R3-7,999	7,274	19	4,160	11	13,425	35	114	0	13,676	35	38,649
R8-15,999	3,918	12	4,302	13	11,281	34	161	0	13,937	41	33,599
>R15,999	1,943	6	4,228	13	10,512	31	199	1	16,511	49	33,393
Race											
Black	12,244	17	6,368	9	27,641	39	177	0	24,717	35	71,147
Coloured	5,122	26	2,697	14	6,185	31	93	0	5,810	29	19,907
Indian	1,585	17	2,013	22	2,359	26	64	1	3,079	34	9,100
White	4,005	11	3,963	11	9,486	26	191	1	19,497	52	37,142
Language											
Afrikaans	6,935	19	4,278	11	9,715	26	172	0	16,125	43	37,225
English	4,073	13	4,804	15	9,559	30	197	1	13,187	41	31,820
Zulu+	3,306	16	2,121	10	7,223	34	63	0	8,514	40	21,227
Xhosa	3,618	23	1,205	8	8,002	50	20	0	3,140	20	15,985
Sotho+	5,024	16	2,633	8	11,172	36	73	0	12,137	39	31,039
Settlement type											
Rural	5,085	24	1,340	6	6,776	31	46	0	8,363	39	21,610
Town	8,334	18	4,485	10	15,354	33	148	0	18,265	39	46,586
City	9,537	14	9,216	13	23,541	34	331	0	26,475	38	69,100
Province											
Western Cape	3,337	18	2,335	13	6,167	34	86	0	6,479	35	18,404
Northern Cape	1,891	28	743	11	1,821	27	17	0	2,295	34	6,767
Free State	1,726	16	958	9	3,901	36	32	0	4,243	39	10,860
Eastern Cape	4,866	25	1,743	9	8,113	42	55	0	4,340	23	19,117
Kwazulu-Natal	3,992	16	3,867	15	8,045	32	101	0	9,178	36	25,183
Mpumalanga	786	11	485	7	1,812	26	21	0	3,962	56	7,066
Limpopo	1,303	17	585	7	2,042	26	20	0	3,897	50	7,847
Gauteng	3,870	11	3,737	11	11,173	32	180	1	15,741	45	34,701
North-West	1,185	16	588	8	2,597	35	13	0	2,968	40	7,351
Age category											
Age $<$ 26 years	6,505	16	5,504	14	13,909	35	125	0	14,033	35	40,076
Age 26-50 years	7,158	12	6,631	11	21,850	36	289	0	24,885	41	60,813
Age 51-65 years	4,618	20	2,065	9	6,999	30	82	0	9,705	41	23,469
Age $>$ 65 years	4,675	36	841	7	2,913	23	29	0	4,480	35	12,938
Additional											
Unemployed	18,228	22	8,941	11	25,954	31	276	0	29,244	35	82,643
Employed	4,728	9	6,100	11	19,717	36	249	0	23,859	44	54,653
Not self-empl.	21,998	18	13,678	11	41,229	33	448	0	46,881	38	124,234
Self-employed	958	7	1,363	10	4,442	34	77	1	6,222	48	13,062
No home tel.	17,186	17	10,945	11	35,415	35	331	0	37,681	37	101,558
Home telephone	5,770	16	4,096	11	10,256	29	194	1	15,422	43	35,738
No work tel.	22,216	18	13,195	11	40,600	33	450	0	46,342	38	122,803
Work telephone	740	5	1,846	13	5,071	35	75	1	6,761	47	14,493
Female	10,681	16	7,386	11	23,618	34	217	0	26,919	39	68,821
Male	12,275	18	7,655	11	22,053	32	308	0	26,184	38	68,475

Table 2: Relationship between market concentration (HHI) and income measures

	(1) b/se	(2) b/se	(3) b/se	(4) b/se
Towns	-311.28***	-318.98***	-236.02***	-249.74***
	(68.77)	(68.46)	(62.45)	(62.64)
Cities	-408.07***	-424.06***	-276.15***	-221.09**
	(80.50)	(78.82)	(73.41)	(76.02)
Household income (mean)	-0.01*		-0.00	0.01+
	(0.01)		(0.01)	(0.01)
High income % of population		-360.27+		
		(183.39)		
Coloured % of population			-724.27***	
			(107.89)	
White % of population			-376.44*	
			(180.03)	
Indian % of population			-2074.03***	
			(239.04)	
English % of population				-1333.12***
				(138.78)
Afrikaans % of population				-402.52***
				(90.80)
Constant	4660.84***	4615.95***	4805.16***	4712.46***
	(75.63)	(66.47)	(72.83)	(76.20)
R-Square	0.11	0.11	0.29	0.28
Number of obs	420	420	420	420

+ $p<0.10$, * $p<0.05$, ** $p<0.01$, *** $p<0.001$

Note that the shares of race groups in the AMPS sample are as follows: Black (51.8%), Coloured (14.5%), Indian (6.6%), White (27%).

Table 3: Control function estimation results - voice services

		Coeff.	(SE)
Termination cost		1.30***	(0.16)
MTN		0.80***	(0.16)
Telkom		0.36*	(0.18)
Vodacom		0.50**	(0.16)
Prepaid		0.68***	(0.16)
Postpaid*	Medium	0.18	(0.16)
	High	0.44**	(0.16)
MTN*	Prepaid	-0.28	(0.22)
	Postpaid medium	-0.21	(0.22)
	Postpaid high	-0.22	(0.22)
Telkom*	Prepaid	-0.42+	(0.25)
	Postpaid medium	-0.21	(0.25)
	Postpaid high	-0.27	(0.25)
Vodacom*	Prepaid	-0.07	(0.22)
	Postpaid medium	-0.14	(0.22)
	Postpaid high	-0.19	(0.22)
Constant		-0.02	(0.14)
Number of obs	88		
R-squared	0.68		

+ p<0.10, * p<0.05, ** p<0.01, *** p<0.001

Table 4: Estimation results

	Cond.	(SE)	Mixed	(SE)	Cond.	(SE)	Mixed,	(SE)
	(1a) Price							
Price	-2.14***	(0.08)	-2.00***	(0.09)				
SD Price			0.76***	(0.03)				
Control function	1.78***	(0.04)	1.47***	(0.04)				
	(1b) Price interactions				**(2) Mobile interactions**			
Income 3-7,999	0.14***	(0.03)	0.23***	(0.04)	0.26***	(0.06)	0.24***	(0.06)
Income 8-15,999	0.07*	(0.03)	0.20***	(0.04)	0.79***	(0.06)	0.82***	(0.07)
Income 16,000+	0.03	(0.04)	0.16***	(0.04)	1.27***	(0.07)	1.35***	(0.07)
Black	0.36***	(0.07)	0.50***	(0.08)	-0.89***	(0.13)	-1.15***	(0.14)
Coloured	0.26***	(0.04)	0.26***	(0.04)	-1.20***	(0.07)	-1.37***	(0.07)
Indian	-0.24***	(0.05)	-0.32***	(0.06)	-0.59***	(0.10)	-0.70***	(0.10)
Afrikaans	-0.10	(0.08)	-0.13	(0.08)	0.06	(0.14)	0.10	(0.15)
English	0.11	(0.07)	0.10	(0.08)	0.01	(0.13)	0.07	(0.14)
Zulu+	-0.03	(0.04)	-0.03	(0.04)	0.02	(0.07)	0.02	(0.08)
Xhosa	0.57***	(0.04)	0.62***	(0.05)	-0.90***	(0.08)	-0.93***	(0.08)
Age 26-50					0.05**	(0.02)	0.07**	(0.03)
Age 51-65					-0.50***	(0.02)	-0.61***	(0.03)
Age 65+					-1.25***	(0.03)	-1.55***	(0.04)
Western Cape					-0.05+	(0.03)	-0.08+	(0.04)
Northern Cape					-0.42***	(0.04)	-0.51***	(0.05)
Free State					0.01	(0.04)	0.03	(0.04)
Eastern Cape					-0.46***	(0.03)	-0.59***	(0.04)
KwaZulu Natal					-0.03	(0.03)	-0.04	(0.04)
Mpumalanga					0.47***	(0.05)	0.57***	(0.06)
Limpopo					0.09*	(0.04)	0.15**	(0.05)
North West					0.07+	(0.04)	0.10+	(0.05)
Male					-0.35***	(0.02)	-0.43***	(0.02)
Working					0.54***	(0.02)	0.68***	(0.03)
Self-employed					0.25***	(0.04)	0.28***	(0.05)
Telephone-home					-0.25***	(0.02)	-0.30***	(0.03)
Telephone-work					0.53***	(0.04)	0.62***	(0.05)
	(3a) Operator fixed effects				**(3b) Operator * Cities**			
Cell C	1.92***	(0.15)	2.08***	(0.17)	1.03***	(0.04)	1.11***	(0.04)
MTN	4.12***	(0.16)	4.14***	(0.17)	0.40***	(0.03)	0.49***	(0.03)
Telkom	-1.13***	(0.21)	-0.97***	(0.22)	1.16***	(0.16)	1.23***	(0.16)
Vodacom	4.04***	(0.15)	4.14***	(0.17)	0.26***	(0.03)	0.35***	(0.03)
					(3c) Operator * Towns			
Cell C					0.62***	(0.04)	0.67***	(0.04)
MTN					0.27***	(0.03)	0.33***	(0.03)
Telkom					0.66***	(0.17)	0.71***	(0.17)
Vodacom					0.19***	(0.03)	0.25***	(0.03)
N (LL)	636,891 (-166,357)		636,891 (-166,227)					

+ p<0.10, * p<0.05, ** p<0.01, *** p<0.001

Omitted (base) categories are: Income <3,000, White, Sotho+, Age <26, Gauteng, Female, Unemployed, Not self-employed, No telephone-home, No telephone-work, No operator (outside option), Rural.

Table 5: Own-price & cross-price elasticities, by operator & segment (2011-2014)

	Cell C	**MTN**	**Telkom**	**Vodacom**
(1) Prepaid				
Cell C	-1.44	0.77	0.01	0.76
MTN	0.19	-1.38	0.01	0.73
Telkom(M)	0.21	0.77	-1.77	0.75
Vodacom	0.19	0.76	0.01	-1.22
(2) Postpaid				
Cell C	-1.13	0.59	0.01	0.81
MTN	0.21	-1.17	0.01	0.81
Telkom(M)	0.22	0.60	-1.64	0.81
Vodacom	0.21	0.60	0.01	-0.92

Aggregate elasticities are calculated for each year between 2011 and 2014 (when Telkom Mobile was present). The elasticities shown on the table are the average over the four year period.

Table 6: Operator prices, marginal costs and mark-ups, by segment (2011-2014)

	Marginal costs ZAR/min	**Market prices** ZAR/min	**Market mark-ups** %	**Model prices** ZAR/min	**Model mark-ups** %
(1) Prepaid					
Cell C	0.41	1.09	63	1.09	63
MTN	0.29	1.47	79	1.30	77
Telkom(M)	0.46	1.20	62	1.06	58
Vodacom	0.27	1.33	80	1.23	78
(2) Postpaid					
Cell C	0.41	0.80	48	1.09	64
MTN	0.29	1.07	72	1.22	76
Telkom(M)	0.46	0.98	53	1.04	57
Vodacom	0.27	1.03	74	1.29	80

Table 7: Own-price elasticities by demographic segment (2011 - 2014) - mixed logit

Category	Demographic	Elasticity	N
Income	Income <3,000	-0.50	18,379
	Income 3-7,999	-0.29	24,610
	Income 8-15,999	-0.19	21,638
	Income >15,999	-0.10	23,080
Settlement type	Rural	-0.34	13,840
	Towns	-0.27	29,105
	Cities	-0.21	44,762
Race	Black	-0.22	45,452
	Coloured	-0.43	12,434
	Indian	-0.34	5,925
	White	-0.19	23,896
Language	Afrikaans	-0.32	23,620
	English	-0.21	20,475
	Zulu, Swazi, Ndebele	-0.23	13,511
	Xhosa	-0.20	10,137
	Sth, Tsw, Tsn, Ven, Oth	-0.24	19,964
Province	Western Cape	-0.27	11,882
	Northern Cape	-0.46	4,307
	Free State	-0.26	6,848
	Eastern Cape	-0.32	12,172
	Kwazulu-Natal	-0.26	16,042
	Mpumalanga	-0.17	4,574
	Limpopo	-0.25	4,998
	Gauteng	-0.18	22,090
	North-West	-0.25	4,794
Overall		-0.25	87,707

Table 8: **Change in prices & consumer surplus after entry & regulation (2011-2014)**

	Model price	**No Telkom, Cell C**		**No regulation**		**N**
		Price	ΔCS	Price	ΔCS	
Income						
Income $<$3,000	1.08	1.11	-0.12	1.30	-0.21	18,379
Income 3-7,999	1.19	1.24	-0.15	1.45	-0.25	24,610
Income 8-15,999	1.25	1.32	-0.17	1.53	-0.27	21,638
Income $>$15,999	1.26	1.36	-0.18	1.56	-0.30	23,080
Total	1.20	1.27	-0.16	1.47	-0.26	87,707
Settlement type						
Rural	1.16	1.21	-0.11	1.40	-0.23	13,840
Town	1.20	1.26	-0.14	1.46	-0.25	29,105
City	1.21	1.29	-0.18	1.49	-0.27	44,762
Total	1.20	1.27	-0.16	1.47	-0.26	87,707
Race						
Black	1.23	1.29	-0.17	1.49	-0.26	45,452
Coloured	1.09	1.12	-0.13	1.34	-0.23	12,434
Indian	1.12	1.16	-0.14	1.40	-0.26	5,925
White	1.22	1.30	-0.16	1.50	-0.28	23,896
Total	1.20	1.27	-0.16	1.47	-0.26	87,707
Language						
Afrikaans	1.15	1.21	-0.14	1.41	-0.25	23,620
English	1.19	1.27	-0.17	1.48	-0.28	20,475
Zulu+	1.25	1.32	-0.15	1.52	-0.26	13,511
Xhosa	1.16	1.21	-0.21	1.40	-0.24	10,137
Sotho+	1.25	1.31	-0.15	1.51	-0.26	19,964
Total	1.20	1.27	-0.16	1.47	-0.26	87,707
Province						
Western Cape	1.18	1.24	-0.16	1.44	-0.26	11,882
Northern Cape	1.06	1.10	-0.12	1.31	-0.23	4,307
Free State	1.22	1.29	-0.15	1.49	-0.26	6,848
Eastern Cape	1.10	1.14	-0.17	1.34	-0.23	12,172
Kwazulu-Natal	1.19	1.26	-0.15	1.47	-0.26	16,042
Mpumalanga	1.29	1.36	-0.14	1.56	-0.28	4,574
Limpopo	1.26	1.32	-0.13	1.52	-0.26	4,998
Gauteng	1.25	1.33	-0.18	1.53	-0.28	22,090
North-West	1.24	1.30	-0.14	1.50	-0.26	4,794
Total	1.20	1.27	-0.16	1.47	-0.26	87,707

Iterated best responses is used to simulate prices for each scenario in each year between 2011 and 2014. The simulations are run using termination costs as marginal costs, applying termination rates in 2009 for the whole period in the 'no regulation' scenario.

Table 9: Change in consumer surplus after entry & regulation by race, income & area (2011-2014)

	Rural	Town	City	Mean
No Telkom, Cell C				
Income <3,000	-0.09	-0.11	-0.16	-0.12
Income 3-7,999	-0.12	-0.14	-0.18	-0.15
Income 8-15,999	-0.13	-0.15	-0.18	-0.17
Income >15,999	-0.13	-0.16	-0.19	-0.18
Black	-0.11	-0.15	-0.20	-0.17
Coloured	-0.08	-0.11	-0.15	-0.13
Indian	-0.09	-0.13	-0.15	-0.14
White	-0.12	-0.14	-0.17	-0.16
No regulation				
Income <3,000	-0.20	-0.21	-0.23	-0.21
Income 3-7,999	-0.25	-0.24	-0.25	-0.25
Income 8-15,999	-0.27	-0.27	-0.28	-0.27
Income >15,999	-0.28	-0.29	-0.30	-0.30
Black	-0.23	-0.25	-0.27	-0.26
Coloured	-0.21	-0.22	-0.25	-0.23
Indian	-0.24	-0.26	-0.27	-0.26
White	-0.27	-0.27	-0.29	-0.28

Iterated best responses is used to simulate prices for each scenario in each year between 2011 and 2014. The simulations are run using termination costs as marginal costs, applying termination rates in 2009 for the whole period in the 'no regulation' scenario.

Table 10: Impact of entry and regulation on mobile penetration (%, 2011-2014)

	Uptake - model prices	**No Telkom, Cell C**	**No regulation**	**N**
Income				
Income <3,000	74	71	66	18,379
Income 3-7,999	84	81	77	24,610
Income 8-15,999	90	88	85	21,638
Income >15,999	95	93	91	23,080
Total	86	84	80	87,707
Settlement type				
Rural	80	78	74	13,840
Town	85	83	79	29,105
City	89	86	83	44,762
Total	86	84	80	87,707
Race				
Black	85	83	80	45,452
Coloured	79	76	72	12,434
Indian	86	82	78	5,925
White	91	89	86	23,896
Total	86	84	80	87,707
Language				
Afrikaans	85	82	78	23,620
English	90	87	84	20,475
Zulu+	87	85	82	13,511
Xhosa	79	77	75	10,137
Sotho+	87	84	81	19,964
Total	86	84	80	87,707
Province				
Western Cape	86	83	79	11,882
Northern Cape	77	74	69	4,307
Free State	87	84	81	6,848
Eastern Cape	77	75	72	12,172
Kwazulu-Natal	87	84	81	16,042
Mpumalanga	91	89	86	4,574
Limpopo	87	84	81	4,998
Gauteng	91	88	86	22,090
North-West	87	84	81	4,794
Total	86	84	80	87,707

Iterated best responses is used to simulate prices for each scenario in each year between 2011 and 2014. The simulations are run using termination costs as marginal costs, applying termination rates in 2009 for the whole period in the 'no regulation' scenario.

Table 11: Mobile uptake absent entry & regulation by race, income & area (%, 2011-2014)

	Rural	**Town**	**City**	**Mean**
Model prices (baseline)				
Income <3,000	72	74	77	74
Income 3-7,999	82	83	85	84
Income 8-15,999	89	90	90	90
Income >15,999	94	94	95	95
Black	79	86	89	85
Coloured	74	76	82	79
Indian	80	84	86	86
White	92	89	92	91
No Telkom, Cell C				
Income <3,000	69	70	72	71
Income 3-7,999	80	80	82	81
Income 8-15,999	87	87	88	88
Income >15,999	93	93	93	93
Black	76	83	86	83
Coloured	71	73	78	76
Indian	77	81	83	82
White	90	87	90	89
No regulation				
Income <3,000	64	66	69	66
Income 3-7,999	76	77	79	77
Income 8-15,999	84	84	85	85
Income >15,999	90	90	91	91
Black	72	81	84	80
Coloured	65	68	75	72
Indian	71	76	79	78
White	87	84	87	86

Iterated best responses is used to simulate prices for each scenario in each year between 2011 and 2014. The simulations are run using termination costs as marginal costs, applying termination rates in 2009 for the whole period in the 'no regulation' scenario.